



# Guide to new, energy-efficient lighting technologies for your business

**Commercial lighting systems are changing rapidly, with new or improved technologies continuously becoming available.** Whether you're constructing a new building or upgrading lighting at your existing location, this guide highlights how your business can take lighting to the next level. It will help you explore options you might consider now or in the future. The information will prepare you to work effectively with contractors, lighting vendors, designers and other lighting professionals. You'll also have a stronger understanding of everything from the color quality of light, to what technologies work best in different applications, to how lighting controls affect other energy-using systems in your business.



## DAYLIGHTING

*Well-designed lighting systems, including daylighting with advanced controls, save additional energy while enhancing visual comfort, reducing eye fatigue and improving performance, which can lead to higher productivity and sales.*

**PHOTO:** Light shelves direct daylight deeper into a space



## AESTHETICS

*Quality lighting makes a space pleasant and inviting for employees and customers, opening the door to lower absenteeism and more business. Coupled with energy savings, these benefits can make today's lighting technologies a profitable investment.*

**PHOTO:** Recessed fluorescent fixtures and decorative accent lights



## SAFETY/SECURITY

*Garage and exterior lighting often use LED technology to provide security for building users.*

**PHOTO:** LED security lighting

# Brighten your business and bottom line



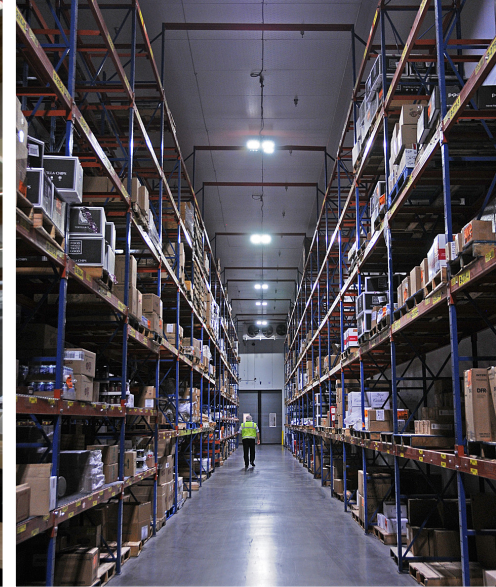
## KNOW YOUR TERMS

The lighting industry uses the term **lamp** when referring to the light source (what you may think of as the bulb) and often uses the word **luminaire** when referring to the fixture. This guide uses the terms **lamp** and **fixture**.

**In the typical U.S. commercial building, lighting accounts for close to 35 percent of electricity use, taking a bite out of profits.** Fortunately, recent technological advances have launched a new era of energy-efficient lighting products. When you take advantage of the most advanced light sources, fixtures and controls, you could save 50 percent or more on lighting energy, while benefiting from the best in lighting quality. With good design, energy-efficient lighting typically pays for itself in energy savings within a few years.

An energy-efficient lighting system offers additional benefits, including reducing the load lighting puts on air conditioning, ventilation, refrigeration and your overall electrical system. Today's options come in a variety of styles and functionalities, offering flexibility for your design and business. Explore this guide and find out how lighting can put your products, services, customers and employees in a better light.





PHOTOS LEFT TO RIGHT: Linear fluorescent; LED high-bay fixtures

# Getting started

## PLAN AHEAD FOR SUCCESS

Review your goals: Do you want low operating costs? Are you trying to keep maintenance to a minimum? Is reducing your carbon footprint important? Have you been unhappy with lighting in the past? Have you seen lighting in other businesses that you do or don't like?

## A COMPREHENSIVE LIGHTING DESIGN CAN MAXIMIZE VALUE

Comprehensive lighting system design is critical to the design of new buildings and major renovations, and it is increasingly used during lighting retrofits because it goes beyond simply replacing lamps or fixtures. Comprehensive lighting design looks holistically at lighting systems in your building. A lighting professional prepares a lighting layout and a technology and controls approach that factor in aesthetics, how lighting integrates with other building systems, light levels suitable to each application and location, uniformity of light, available daylight, glare, safety, total operating cost of the lighting systems, the appropriate integration of lighting controls and more. Comprehensive lighting design can maximize energy savings and provide better comfort, health and productivity for occupants.

## EXPAND YOUR DEFINITION OF COST

Think beyond first cost. With rising energy costs, the decisions you make today will affect operating costs for years. Lighting influences the aesthetics of your business as well as comfort, productivity, health and safety, and profit. Today's lighting technologies are extremely long lasting and can lower maintenance costs by drastically reducing the need to replace lamps.

## KNOW YOUR TERMS

### *Think lumens not watts.*

The total quantity of light produced by a lamp is measured in lumens.

**Lumens per watt**, also called lumen efficacy, measures light delivered per watt. Today's technologies deliver more lumens per watt than older lamps and fixtures.

**A foot candle** is the amount of light that falls on a surface and is equal to one lumen per square foot as measured by a light meter.

**Lumen maintenance** is the standard lighting term for the percent of initial lumens a light source maintains over time. Lumen maintenance is often specified as L70, L80 or L90. "L" stands for lumen maintenance and the number is the percent of light output remaining.

**Lighting power density** is calculated as watts per square foot and varies by how a space is used and its occupancy.

**Fixture efficiency** accounts for how much of a lamp's light gets out of the fixture. A fixture that's 90 percent efficient delivers 50 percent more light than one that's 60 percent efficient. Dedicated LED luminaires are tested outside the fixture, delivering 100 percent of the stated lumens.



#### COLOR TEMPERATURE IN DEGREES KELVIN

|                                   |      |      |                      |
|-----------------------------------|------|------|----------------------|
| Common Fluorescent<br>& LED Range | Cool | 6500 | Daylight             |
|                                   |      | 5000 | Sunlight             |
|                                   |      | 4100 |                      |
|                                   |      | 3500 |                      |
|                                   |      | 3000 | High pressure sodium |
|                                   |      | 2700 | Incandescent         |
|                                   |      | 2200 | Halogen IR           |
| Warm                              |      | 1500 | Candle               |

## Balancing lighting quantity, quality & color

Successful lighting design begins with assessing how occupants use a space and their resulting lighting needs. The lighting system should deliver the quantity and quality of light according to those needs.

The quantity of light needed, measured in foot candles, varies by task. For example, lighting professionals recommend a lobby have 10 foot candles, a classroom 40 and a retail space 50.

Good lighting quality requires an experienced lighting professional who takes steps to maximize uniformity, maximize daylight, minimize glare, provide appropriate color quality and address other factors. The most energy-efficient light sources mounted in the best fixtures will not provide value if they are not applied correctly.

Color quality is critical in most businesses. Lighting experts use two color metrics to evaluate color from a light source.

#### COLOR RENDERING INDEX, CRI

Color rendering is a scale that measures the ability of a light source to show true color of objects realistically. The CRI is expressed on a scale from 0-100, where 100 is the best in producing vibrant color in objects. A CRI of 80 or more is considered excellent for most interior applications.

#### CORRELATED COLOR TEMPERATURE, CCT

If you've tried to match white paint, you know there are many shades. Similarly, incandescent, fluorescent, LEDs, and other lighting sources all emit "white" light. But the color can appear different—even between two lamps of the same source. Color temperature, measured in degrees Kelvin, or °K, (upper left) accounts for this color appearance of light sources. The higher the color temperature, the cooler or bluer the light. The "right" color temperature varies with the application.



#### TIPS FOR ENSURING GOOD COLOR QUALITY

Ask your lighting professional or supplier to bring a sample of the fixture and lamp that you are considering to your business to see how the lighting looks in your space. Although the metrics to the right are important, there is no substitute for visual evaluation.





**PHOTOS LEFT TO RIGHT: LED downlight and LED accent lights; high-bay fluorescent and LED track lighting; LED high-bay fixtures**

## Go for the layered look

Layers of interior lighting can work together to illuminate an area according to function and style.

- **Ambient** (*top*) – Provides overall illumination to the space.
- **Task** (*middle*) – Provides auxiliary illumination, when needed, for specific tasks. Task lighting should be free of glare and shadows but bright enough to avoid eyestrain.
- **Accent** (*bottom*) – Provides a focal point of illumination that highlights products or features or adds drama to a space.
- **Vertical** – Can help balance light or provide accent lighting in some applications.

The type of lamp, fixture and amount of light can vary significantly depending on whether it is supplying ambient, task, accent or vertical lighting.

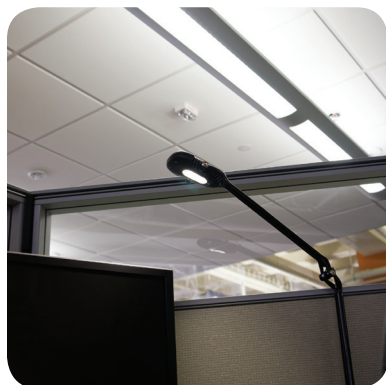
### FACTOR IN FIXTURES

Light fixtures can deliver their light downward (called direct lighting), upward (indirect), or a combination (direct/indirect).

**Direct lighting** typically uses reflectors to help direct light out of the fixture. A diffuser, lens or louver also covers the face of the fixture to help guide the light and conceal the lamp from view. Today's designs for lenses and louvers are more efficient than old-technology diffusers, which caused significant light loss.

**Indirect lighting** can make a space feel brighter with less light because it illuminates the ceiling and tops of walls. When these surfaces are light-colored, little light is lost resulting in even illumination. Indirect lighting works well with a task-ambient lighting scheme. Indirect lighting or a direct/indirect combination also offers excellent glare control and visual comfort.

**Direct/indirect lighting** combines both approaches. Fixtures can be specified to provide a blend of direct and indirect lighting.





PHOTOS LEFT TO RIGHT: LED exterior parking lot lights; LED security lighting



## KNOW YOUR TERMS

**LEDs, or light emitting diodes,** produce visible light when an electrical current is passed through a semiconductor.

**High Intensity Discharge, HID,** lamps have an intense point source of light used in outdoor, high-bay and some retail applications. Today's efficient electronic HID's use metal halide lamps with electronic ballasts.

**Numbers on linear fluorescent lamps** refer to eighths of an inch and T stands for tubular. A **T8 lamp** is 1.0 inch in diameter, a **T12** is 1.5 inches, and a **T5** is 5/8 of an inch. HO stands for high-output.

# Don't overlook outdoor lighting

Outdoor lighting should direct light where it is needed, distribute it evenly, avoid glare and reduce light trespass, without putting light where it's unnecessary or unwanted.

LED technology is the preferred option for the majority of today's exterior lighting applications. LEDs offer instant to full brightness even in cold temperatures, a long service life, minimal light trespass and flexible control options such as continuous dimming. LED technology can offer good color quality and superior performance compared to older technologies. Today's efficient LED technology is quickly replacing older HID technology and provides opportunities for adding more controls.

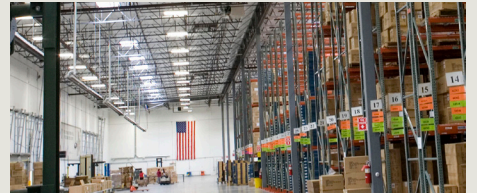


# Examples of fixture applications

**Ceiling fixtures** using T8 or T5 fluorescent lamps are a common source of ambient lighting. They often use grid lay-in fixtures, such as 2x4s and 2x2s. LED lay-in fixtures have become a preferred option because they typically save additional energy, more easily connect to controls and reduce maintenance over the life of the fixtures. Fluorescent and LED fixtures can be direct, indirect, or a combination.



**LED, T8, T5HO and high-bay fixtures** can be mounted at 15 feet or higher.



**Pendant-hung fixtures**—another ambient lighting strategy—commonly use fluorescent lamps and LEDs.



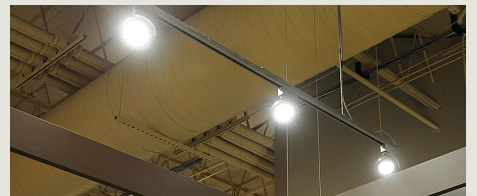
**Recessed downlights** are a real workhorse in commercial buildings, providing ambient or accent lighting. LEDs are an energy-efficient option for recessed downlights, outperforming CFL fixtures in most cases.



**Wall sconces** provide accent lighting in select areas such as hallways. LEDs are a good option for most wall sconce applications.



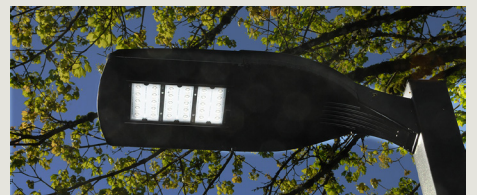
**Track lighting** is used primarily for accent to highlight product. LEDs are an energy-efficient choice in track lighting.



**Exterior wall-mount fixtures** provide ambient light for walkways and safety on a building's exterior. LEDs are typically the most energy-efficient choice and generally provide several control options.



**Outdoor lighting** offers safety and security, but should also reduce light trespass. LEDs are typically the best option especially when combined with controls that reduce light levels when minimal security lighting is needed, but instantly switch to 100 percent output when motion is sensed.



# Lighting Chart

| LAMP TYPE   | LUMENS PER WATT <sup>a</sup> | RATED LIFE (HOURS) <sup>b</sup> | COLOR RENDERING INDEX, CRI | COLOR TEMPERATURE IN °K |
|---|------------------------------|---------------------------------|----------------------------|-------------------------|
| <b>LED, new fixtures</b>  | 60 to 100+                   | 50,000 to 100,000+              | 80 to 90+                  | 2,700 to 6,000+         |
| <b>LED replacement lamps</b>                                    | 50 to 100+                   | 25,000 to 50,000+               | 80 to 90+                  | 2,700 to 6,000+         |
| <b>T8 high-performance fluorescent with electronic ballasts</b> | 86 to 96+                    | 24,000 to 42,000+               | 80 to 85                   | 3,000 to 6,500          |
| <b>T5 with electronic ballasts</b>                              | 86 to 96+                    | 30,000 to 40,000                | 80 to 85                   | 3,000 to 5,000          |
| <b>T5HO with electronic ballasts</b>                            | 86 to 96+                    | 30,000 to 40,000                | 80 to 85                   | 2,700 to 5,000          |
| <b>HID</b>  | 90 <sup>b</sup>              | 18,000 to 24,000                | 22 to 90                   | 2,100 to 4,000          |

<sup>a</sup>For many lamps, lumens per watt refers to the lamp only—the fixture's efficiency reduces the effective lumens per watt. For new LED fixtures, the fixture efficiency is factored in already. LED replacement lamps may be affected by fixture efficiency depending on the fixture.



| TYPICAL APPLICATIONS  | FEATURES  |
|---|---|
| <ul style="list-style-type: none"> <li>• Ambient, task and accent lighting</li> <li>• Track lighting</li> <li>• Recessed can or downlights</li> <li>• Floodlights, outdoor applications, landscape lighting, parking lots, sports arenas</li> <li>• Fixtures that are on for long periods</li> <li>• High-bay</li> <li>• Cold environments</li> <li>• Fixtures that are frequently switched on and off</li> </ul> | <ul style="list-style-type: none"> <li>• Can be either highly directional or omni-directional</li> <li>• Extremely long life, big maintenance savings</li> <li>• Energy efficient</li> <li>• Achieve full brightness instantly</li> <li>• Most are dimmable</li> <li>• Dim-to-warm options create ambiance</li> <li>• Very little heat; no ultraviolet light</li> <li>• Most fixtures are highly controllable</li> <li>• Many have become very cost competitive</li> </ul>  |
| <ul style="list-style-type: none"> <li>• Ambient, task and accent lighting</li> <li>• Track lighting</li> <li>• Recessed can or downlights</li> <li>• Decorative fixtures</li> <li>• Fixtures that are on for long periods</li> <li>• Fixtures that are frequently switched on and off</li> </ul>   | <ul style="list-style-type: none"> <li>• Can be either highly directional or omni-directional</li> <li>• Durable, don't "break" like bulbs, shock resistant</li> <li>• Extremely long life, big maintenance savings</li> <li>• Energy efficient</li> <li>• Achieve full brightness instantly</li> <li>• Most are dimmable</li> <li>• Dim-to-warm options create ambiance</li> <li>• Very little heat; no ultraviolet light</li> <li>• Very cost competitive</li> <li>• Excellent replacement for halogen lighting, saving up to 75 percent in energy costs</li> </ul> |
| <ul style="list-style-type: none"> <li>• General ambient lighting of all kinds with low-to-medium ceiling height: offices, classrooms, storerooms, retail</li> <li>• Excellent replacement for T12s</li> <li>• Low-bay and certain high-bay applications</li> </ul>   | <ul style="list-style-type: none"> <li>• Excellent lumen maintenance</li> <li>• Many wattages</li> <li>• Low initial cost</li> <li>• Requires hazardous disposal</li> </ul>   |
| <ul style="list-style-type: none"> <li>• General ambient lighting of all kinds with low-to-medium ceiling height: offices, classrooms, storerooms, retail</li> <li>• Excellent option for indirect, direct/indirect combination and suspended or pendant fixtures</li> <li>• Low-bay and certain high-bay applications</li> </ul>   | <ul style="list-style-type: none"> <li>• Smaller lamp size offers better optical control</li> <li>• Excellent lumen maintenance</li> <li>• Requires hazardous disposal</li> </ul>   |
| <ul style="list-style-type: none"> <li>• High-bay applications</li> <li>• Large spaces, high-ceilinged areas (&gt;15 ft)</li> <li>• Warehouses, gymnasiums, service shops</li> </ul>  | <ul style="list-style-type: none"> <li>• Improved lighting uniformity over older HID</li> <li>• Can use occupancy sensors and other lighting controls</li> <li>• Instant-on</li> <li>• Requires hazardous disposal</li> </ul>   |
| <ul style="list-style-type: none"> <li>• Outdoor and parking lot lighting</li> <li>• High-bay applications</li> <li>• Some low-bay applications</li> <li>• Sports arenas</li> </ul>   | <ul style="list-style-type: none"> <li>• Provides intense point-source of light when needed in space</li> <li>• Has start-up delay</li> <li>• Requires hazardous disposal</li> </ul>  |

<sup>b</sup> For all but LEDs, this is the time at which 50 percent of a group of lamps has failed. For LEDs, it's the time at which output has degraded to 70 percent of original.



## Controls: Essential, easy, adaptable

The most efficient lamps and fixtures still waste energy and money if they're left on when not needed, making controls an essential part of your lighting system. Today's options make it easy. Automatic controls can switch or dim lighting based on time, occupancy, vacancy, light levels, daylight availability or a combination. Most now are available in wireless options and many come pre-installed in new fixtures and retrofit kits.

### OCCUPANCY AND VACANCY SENSORS

**Occupancy sensors** detect occupancy, turning lights on automatically when someone enters. If no motion is detected after a specified time, lights switch off.

**Vacancy sensors** are like occupancy sensors except they require a manual button press to turn on. This prevents false-on events and saves more energy. Most occupancy sensors can be programmed to be vacancy sensors.

Occupancy and vacancy sensors work by sensing motion, heat, sound or ultrasonic signals. They are effective in spaces where occupants move in and out frequently in unpredictable patterns. Examples include private offices, stairwells, warehouses, restrooms and conference rooms. They can cut lighting energy use by 25 percent or more in these applications.

Sensors can be mounted on ceilings and walls or even integrated in light fixtures. Wireless sensors can be very easy to install, making them great for retrofit applications.



**PHOTOS TOP TO BOTTOM: Linear fluorescent with occupancy sensor; ceiling-mount dual-tech occupancy sensor; wall-mount occupancy sensor**





**PHOTOS LEFT TO RIGHT: Daylighting and photo sensors with linear fluorescent; LED with wireless control**

## PHOTO SENSORS

**Photocells or photo sensors** sense a change in light levels so fixtures can be turned on or off. This is a common way to control outdoor lighting.

## DAYLIGHT CONTROLS

**Daylight controls** use available daylight through windows and skylights and adjust electric light output. When there is sufficient daylight, light output adjusts according to light levels that can be set for each application.

## INTEGRATED CONTROLS

**Intelligent lighting control systems** can integrate lighting and building controls for one room, a whole building or even multiple campuses. These networked systems are able to learn building use trends and optimize comfort and energy savings by automatically adjusting lighting and other systems as patterns change over time, often providing control right down to an individual's workspace. Integrated controls can also provide complete facility energy usage information as well as remote operation and control capabilities. Integrated controls can be incorporated into a retrofit or specified during the planning stages of a new building.

**BACK COVER PHOTO: LED track lighting**

**FRONT COVER PHOTOS LEFT TO RIGHT:**  
**Pendant-hung linear and direct/**  
**indirect linear fluorescent lighting;**  
**high-powered LED recessed downlights**  
**and cove lighting with daylight controls**



# Energy Trust can help illuminate your world

Energy Trust of Oregon offers cash incentives on the installation of qualified energy-efficient lighting equipment that can help you lower energy use and reduce operating costs. We also offer technical assistance and can connect you with a lighting professional to meet your goals.



Get more from your energy.

Visit [www.energytrust.org](http://www.energytrust.org) or call **1.800.326.2917**

*This guide is a collaborative effort of Energy Trust of Oregon, the Northwest Energy Efficiency Alliance (NEEA) and the Lighting Design Lab in Seattle, Washington.*