# THE PROMISE AND CHALLENGE OF LED LIGHTING A PRACTICAL GUIDE

## A PUBLICATION OF THE INTERNATIONAL DARK-SKY ASSOCIATION

**The light-emitting diode (LED) is transforming the way we light our cities and towns**, **offering a once-in-a-lifetime chance to radically improve how we use energy and our outdoor spaces at night**. With this opportunity comes an obligation to manage these changes responsibly and sustainably. The stakes are high and the potential rewards great, but outcomes depend critically on policymakers and the public having access to reliable information. IDA developed this document to provide planners, lighting designers, and public officials an overview of the most important aspects of LED lighting and the choices and challenges involved in its municipal implementation.

### What is LED?

LEDs use solid-state technology to convert electricity into light. Put simply, LEDs are very small light bulbs that fit into an electrical circuit. Unlike traditional incandescent bulbs, they don't have a filament that burns out, and they don't get very warm. Initially, LEDs only emitted red, yellow, or green light, but now white LEDs are widely available. Early LEDs were also energy-inefficient and emitted relatively little light, but due to technological advances LED efficiency and light output have doubled about every three years. Because of their improved quality and falling prices, LEDs are now replacing conventional high-intensity discharge (HID) lamp types for outdoor lighting in communities around the world.

### Why Adopt This Technology?

The improved energy efficiency of LEDs means that coupled with modern luminaire design, these lights allow for lower illumination levels without compromising safety. LEDs help lower carbon emissions by reducing the demand for electricity, which is still largely generated by burning fossil fuels. Another LED benefit is better control over the color content of light.

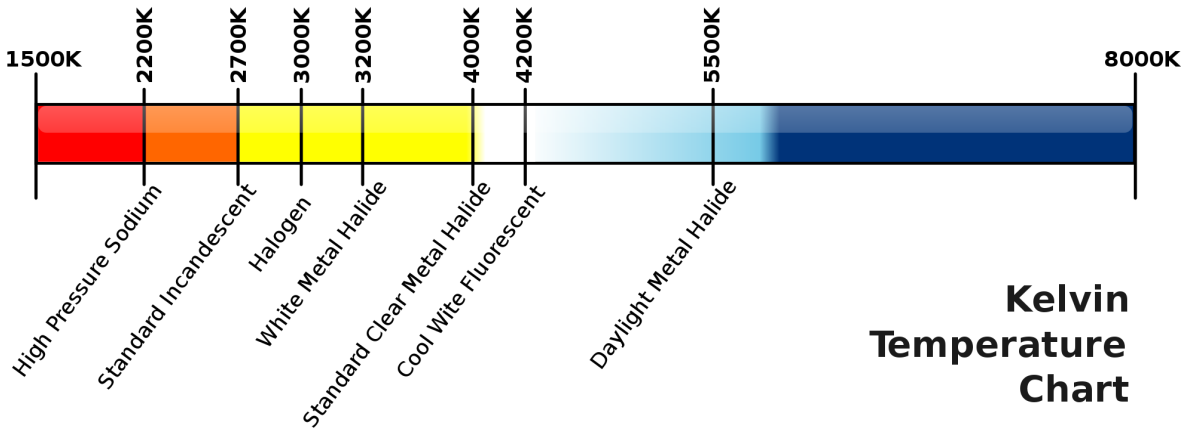
Manufacturers now produce LEDs with “warm” color qualities at high energy efficiency, rendering old arguments about the perceived inefficiency of warm white LEDs moot. These same LED options also provide accurate color rendition without emitting excessive amounts of potentially harmful blue light (see below).

Relative to other outdoor lamps, LEDs are thought to be extremely long-lived. When switched on, LEDs are instantly at full brightness, unlike HID lamps that have a significant time delay to begin emitting light. LEDs also have very low minimum electricity thresholds to produce light, meaning they can be dimmed to much lower illumination levels when less light is needed and resulting in further energy savings.

## Blue Light Can Be Bad

New technical capabilities often come with unanticipated challenges. Most white LED lighting has significant levels of potentially harmful blue light. IDA published a report in 2010 detailing the known and suspected hazards of blue-rich white light sources.[i] In the years since scientific evidence has coalesced around its conclusions. Blue-rich white light sources are known to increase glare and compromise human vision, especially in the aging eye.[ii],[iii] These lights create potential road safety problems for motorists and pedestrians alike. In natural settings, blue light at night has been shown to adversely affect wildlife behavior and reproduction when exposed to it at the wrong time of day.[iv],[v] This is particularly true in cities, which are often stopover points for migratory species such as birds.

Concerns about blue light reach far beyond biology. Outdoor lighting with strong blue content is likely to worsen skyglow because it has a significantly larger geographic reach than lighting consisting of less blue. According to the 2016 “New World Atlas of Artificial Night Sky Brightness” street lighting and outdoor lighting retrofits using 4000-kelvin white LED lamps could result in a factor of 2.5 increase in light pollution.[vi] Given that the rate of increase of lighting as seen from Earth orbit is about 2 percent per year,[vii] it is all the more important to address this problem.



The promise of cheaper outdoor lighting based on electricity and maintenance savings from LED conversion should be weighed against other factors, such as the blue light content of white LEDs. Blue-rich white LEDs are among the most efficient light sources in terms of the conversion of electricity to light and therefore have the lowest electricity cost to produce a given amount of light compared to “warmer,” less efficient white LED lamps. At the same time, we should make every effort to diminish or eliminate blue light emission and exposure after dark.

## Product Selection Considerations

Choosing LED products for outdoor lighting applications involves a series of considerations and tradeoffs. These include:

- **Luminous Efficacy** (Watts-to-lumens): How much light is produced per input Watt of electricity?
- **Lumen Output**: How much light is produced relative to the amount required for a particular task? When replacing existing fixtures, it is important to use the only level of illumination needed and not to adopt unneeded increases in brightness.
- **Correlated Color Temperature** (CCT): Does the light have a “warm” (lower Kelvin value) or “cool” (higher Kelvin value) quality?
- **Color Rendering Index** (CRI): How accurately does the light render colors to the human eye? A high CRI is not needed for all situations. The need for good color rendition should be considered relative to the lighting application in question.
- **Adaptive Control Integration**: Does the lighting make use of adaptive controls such as dimmers, timers, and/or motion sensors? These controls are the wave of the future in outdoor lighting and achieve additional energy savings, improve light source efficacy and increase visual task performance. It is important to build in the ability to make use of adaptive controls during the adoption of designs for new lighting installations, even if they will not immediately be implemented.
- **Lumen Depreciation**: How robust is the lamp against efficacy loss over time? Manufacturers typically quote “L70,” the expected use time until a bulb reaches 70% of its initial light output.

Closely related to all these factors is expense: How much will LED replacement solutions cost? The price of commercial LED lighting products continues to drop, and capital cost recovery times for new LED street light installations, once 10 years or more, are now typically less than two years and continue to decline. As barriers to implementation fall, LED is gaining momentum as the lighting technology of choice in both new outdoor installations and existing replace-on-failure installations. Already many white LED options are available on the outdoor lighting market and that number will only rise in the future.

## IDA Recommends

IDA and the Illuminating Engineering Society (IES) have developed a joint document that outlines excellent lighting practices with their "Five Principles for Responsible Outdoor Lighting." These should always be considered as part of any lighting installation.

If light is deemed useful and necessary, follow these guidelines to prevent, or when that's not possible, minimize light pollution:

- **Useful – All light should have a clear purpose.**
  Before installing or replacing a light, determine if light is needed. Consider how the use of light will impact the area, including wildlife and the environment. Consider using reflective paints or self-luminous markers for signs, curbs, and steps to reduce the need for permanently installed outdoor lighting.
- **Targeted – Light should be directed only to where needed.**
  Use shielding and careful aiming to target the direction of the light beam so that it points downward and does not spill beyond where it is needed.
- **Low Light Levels – Light should be no brighter than necessary.**
  Use the lowest light level required. Be mindful of surface conditions as some surfaces may reflect more light into the night sky than intended.
- **Controlled– Light should be used only when it is useful.**
  Use controls such as timers or motion detectors to ensure that light is available when it is needed, dimmed when possible, and turned off when not needed.
- **Color – Use warmer color lights where possible.**
  Limit the amount of shorter wavelength (blue-violet) light to the least amount needed. Light where you need it, when you need it, in the amount needed, and no more.

In addition, **give the community a chance to have a say** in what they will be living with for a generation, with test installations for soliciting public input and feedback.

Learn more about outdoor lighting, blue light at night, and dark skies on the IDA website at www.darksky.org.

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