Verde Solutions - Intro to Light Emitting Diodes

What makes LED so effective?

LEDs are "solid-state" technology. While an incandescent or fluorescent light bulb uses a vacuum or gas to produce light, an LED uses solid matter. The production of light by an LED depends on passing electrons across a semi-conducting diode. On this small strip of metal, some electrons will transfer onto the positive side into gaps in the conducting diode until stimulated by a current. When stimulated, electrons move from negative to positive on the diode, passing from higher to lower orbitals, and back again. When they go from high to low orbitals, the electrons produce visible light. This transfer of electrons explains why different metals, with different electron configurations, produce different colored light when stimulated by a current.

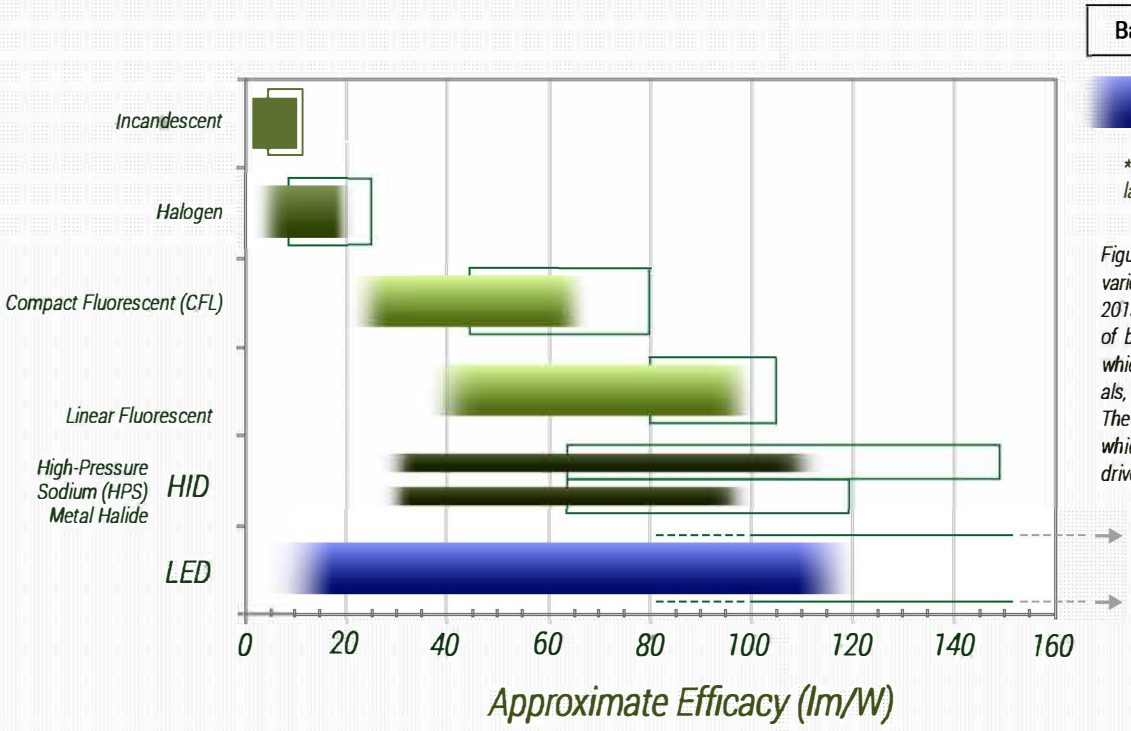


Figure1. Approximate range of efficacy for various common light sources, as of January 2013. The black boxes show the efficacy of bare conventional lamps or LED packages, which can vary based on construction, materials, wattage, or other factors. The shaded regions show luminaire efficacy, which considers the entire system, including driver, thermal, and optical losses.

Without heating a gas or metal to produce light, LEDs save more energy than traditional bulbs. A typical light bulb with a filament relies on running electric current through the filament to produce light. Filament bulbs need a constant input of electric current to maintain brightness and they waste energy in the form of heat. LEDs only require a slight current to emit light, and will stay cool even after extended use.

Qualities and Advantages of LEDs

LEDs are reliable and last a long time. In 2013 LEDs offered operating lives 50x longer than incandescent sources. Frequent lamp replacements can be costly from a maintenance perspective, and failed lamps can be liabilities. Maintenance savings makes LEDs highly appealing as streetlights and parking lights.

- Long operating life
- Reduced radiated heat
- Minimal light loss
- Dimmability and controllability
- Durability
- Safety improvements
- Smaller package size
- Uniform illumination
- Enhanced product appearance
- Improved color rendition and
- Lower lumen depreciation.

LED Lifetime Characteristics

How do the lifetime projections for today's white LEDs compare to traditional light sources?

Light Source	Typical Lifetime (Hours)
Incandescent	750-2,000
Halogen incandescent	3,000-4,000
Compact flourescent	8,000-10,000
Metal halide	7,500-20,000
Linear flourescent	20,000-30,000
High-Power white LED	50,000-80,000**

*Source: Lamp manufacturer data.
**Depending on drive current, operating temperature, etc. some manufacturers are claiming useful life (L_{70}) values greater than 100,000 hours.

How Often Does Your Business Have to Change Bulbs? (years)

***Operation Hours (Lights on each day)	Bulb Lifetime (hours)						
	80,000	60,000	40,000	20,000	10,000	5,000	2,000
8 hours/day	32,05	24,04	16,03	8,01	4,01	2,00	0,80
12 hours/day	21,37	16,03	10,68	5,34	2,67	1,34	0,53
18 hours/day	14,25	10,68	7,12	3,56	1,78	0,89	0,36
24 hours/day	16,68	8,01	5,34	2,67	1,34	0,67	0,27

***Assume 6 days / week and 52 weeks / vr

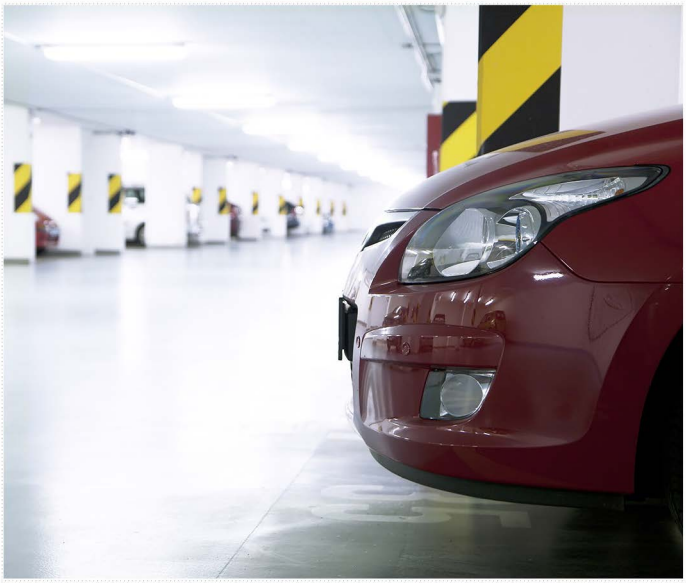
Reduced Radiated Heat

LED conversion efficiency, or efficacy, is always improving. LEDs exceed efficacies of fluorescent and HID sources. A higher proportion of electricity is used to generate light and a smaller portion wasted as heat. In some cases, the heat from LED lights is harnessed to reduce the heating or power loads of other energy system components, like HVAC.

More LED Advantages

Durability

LEDs are encased in a tough epoxy plastic resin instead of a glass bulb so they are more resistant to shattering and impact damage.



Safety Improvements

LEDs improve the safety of a building tenfold. LED luminaires consist of multiple diodes that don't typically fail at the same time. More secure lighting lead to less downtime for streetlights, industrial buildings and parking lots.

Smaller Package Size

Unlike compact fluorescent technology, LEDs can be designed for decorative and practical fixtures, from christmas lights to MR16 lamps.

Enhanced Product Appearance

LED fixtures are ideal for retail lighting because they shine in specific, controllable directions and operate at low heat. Jewels and gems, for example, sparkle more brightly under LED due to the multiple diodes that create many reflections off the jewel's facets instead of a single reflection from incandescent or fluorescent bulbs with equal lumen output.

Kelvin Color Temperature

Most LED outdoor area and streetlights in the market have: color temperatures of 3,000 to 6,000 Kelvin (K)

	2700K	3000K	3500K	4100K	5000K	6500K
Associated Effects and Moods	Ambiant Intimate Personal	Calm Warm	Friendly Inviting	Precise Clean Efficient	Daylight Vibrant	Daylight Alert
Appropiate Applications	Living/Family Rooms Commercial/ Hospitality	Living/Family Rooms Commercial/ Hospitality	Kitchen/Bath Light Commercial	Garage Commercial	Commercial Industrial Institutional	Commercial Industrial Institutional

With these color characteristics, LED outdoor area and streetlights are superior to high pressure sodium (HPS) lamps that have color temperatures of approximately 2,000 K, providing a yellow/orange light.

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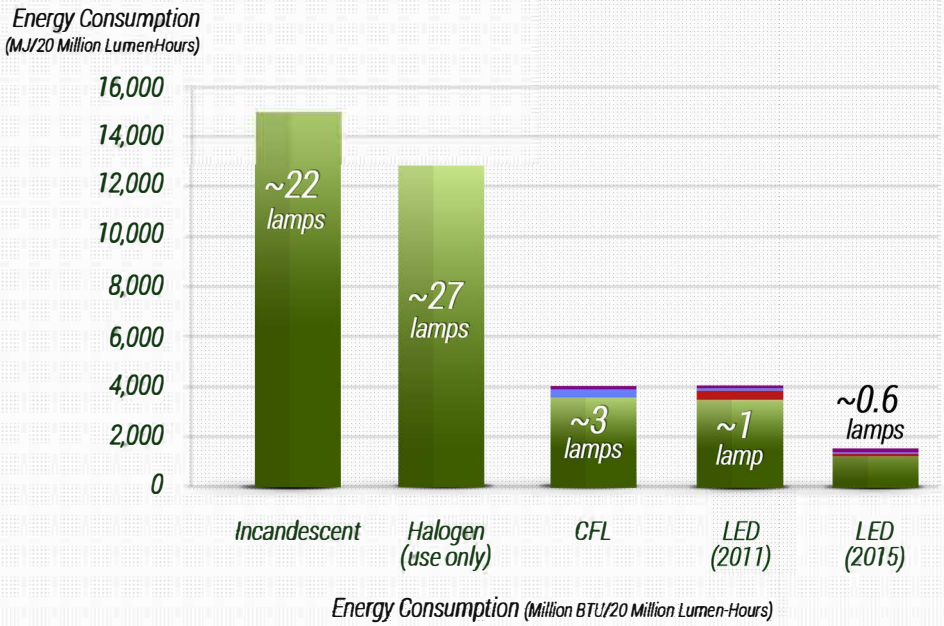
LED's Waste Less

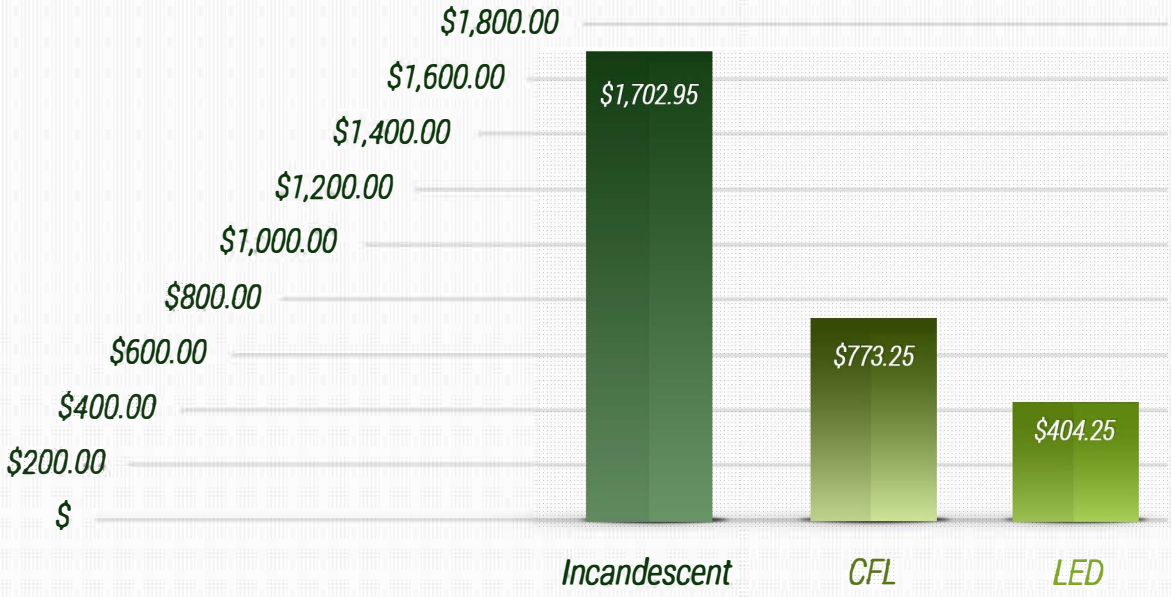
Over the course of a year, the traditional 60-watt light bulb that is on 10 hours a day will cause nearly 300 pounds (136 kg) of CO2 emissions. The equivalent LED, which is only a 6-watt bulb, will cause 37 pounds (17 kg) annually. By replacing all existing incandescent lights with LEDs, the carbon footprint of a given building can be reduced by up to 85%.



This figure doesn't only highlight the efficiency of LED lights in terms of power usage, packaging and transport, it also highlights the number of traditional lighting fixtures it takes to compare to one LED. For instance, 27 Halogen lamps are needed to reach the same lumen output as 1 LED, and they use about 6x as much energy to do so.

Navigant Consulting. Life-Cycle Assessment of Energy and Environmental Impacts of LED Lighting Products. August 2012.

Costs Compared Over 5 Years



*based on 30 incandescent bulbs equivalent for energy and equipment.

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