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An Introduction and the Pitfalls of LED Site and Landscape Illumination

by Dean MacMorris, Night Light, Inc.

Learning Objectives:

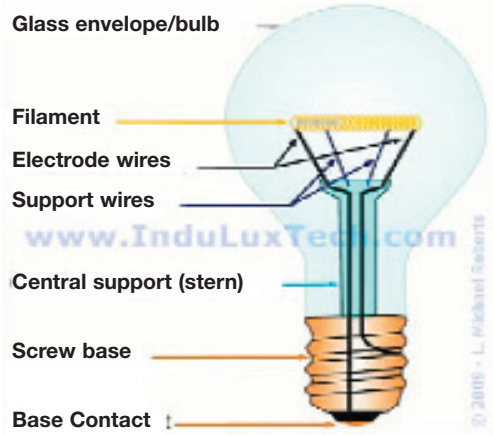
After reading this article participants will be able to:

1. Identify the five main light sources available for site and landscape illumination - incandescent, fluorescent, HID (high intensity discharge), LED (light emitting diode) and induction - as well as evaluate which is most appropriate for a given application.
2. Determine the color in degrees Kelvin and CRI (color rendering index) of light that applies to the design parameters of a given situation.
3. Assess how "green" or sustainable the five main light sources are and compare and contrast them to the cost and performance of LED fixtures and lamps available on the market today.
4. Evaluate and rank LED lamp and fixture technology by comparing the AC (alternating current) and DC (direct current) options and applying the energy act of 2005 to site and landscape illumination.

The five main light sources used today are incandescent, fluorescent, HID (high intensity discharge), induction and LED (light emitting diode). The three main types of HID are mercury vapor, metal halide and high-pressure sodium.

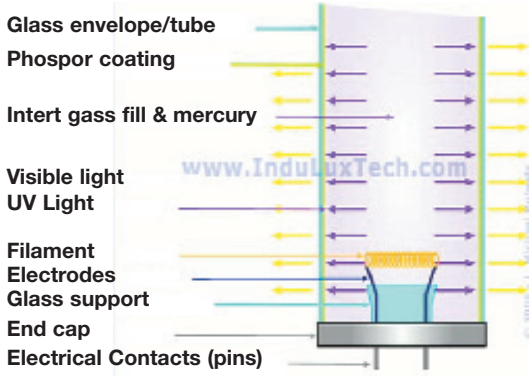
Incandescent lights are those we all know as the common household and commercial light bulbs, along with quartz halogen. There have been some attempts to ban these, but because they are so popular and there has been much push back - a more efficient incandescent bulb most likely will be developed.

Example: Incandescent light

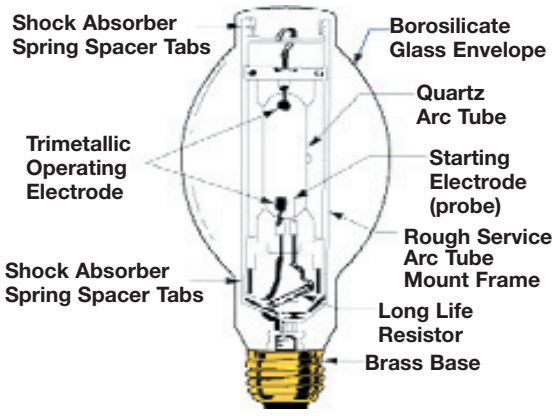


Fluorescent lights are also common household and commercial lights but typically light tubes and CFL's (compact fluorescent lights). These are more efficient than incandescent lights, but not nearly as efficient and long lasting as the LED. There is also an issue with the disposal of all fluorescents.

Example: Fluorescent light



HID lights are commonly used for commercial and industrial light bulbs and the three main types of HID are mercury vapor, metal halide and high-pressure sodium. In most cases, these types of lights are used for illuminating large areas such as gymnasiums, parking lots, warehouses, signage and large landscape elements, etc.



Example: Mercury Vapor light

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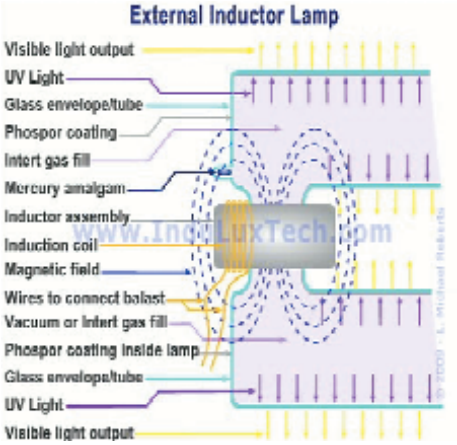
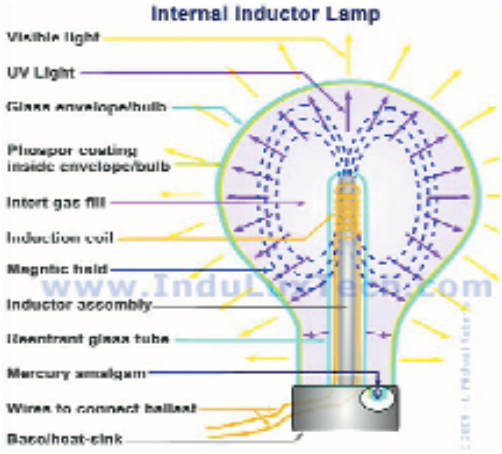
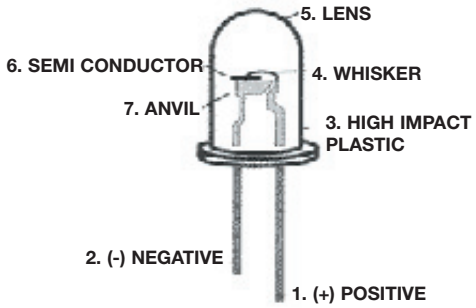
Induction lights are limited to commercial and industrial light bulbs and they can be either internal or external induction lamps. Generally, induction lights are effective where there is a need for high intensity and efficiency, however they are not very common.



Examples: Induction lights



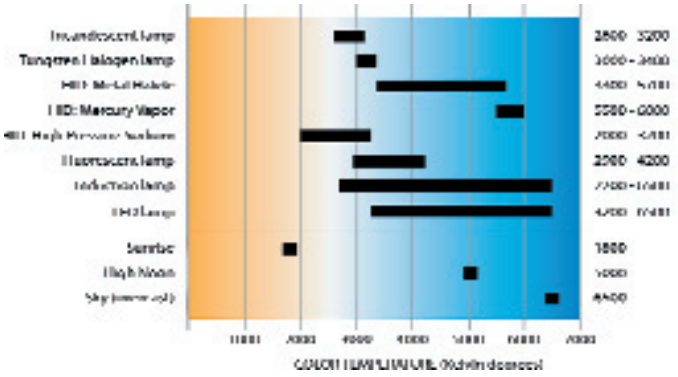
LED lights are becoming more common commercially and residentially. The technology is changing daily, making them more appealing to a broader market by being brighter, more efficient, and in color ranges closer to what consumers are used to.



Example: LED light

Light comes in many color ranges. Each type of lamp emits its own color range for which individuals have become accustomed to over the years, positively or negatively. See the chart below for the color ranges in degrees Kelvin for most common lamps along with sunrise, high noon and an overcast sky. Many of the lamps closely mimic natural light colors.

LEDs hit the market in a significant way when they were introduced as Christmas lights several years ago. Most all of them were in the 5,500 degree Kelvin range because they were the cheapest to manufacture, most efficient, and bright enough to compete with their incandescent counterparts. Unfortunately, many people were turned off by the bluish color versus the warm white color of incandescent bulbs. To this day, many people think that LEDs only come in the blue color. Although, the cooler color is still available, technology has come a long way towards producing warmer colors that are more pleasing to the general population without sacrificing brightness. Manufacturers are readily producing 3,200 degree (warm white) lamps for wide spread use.



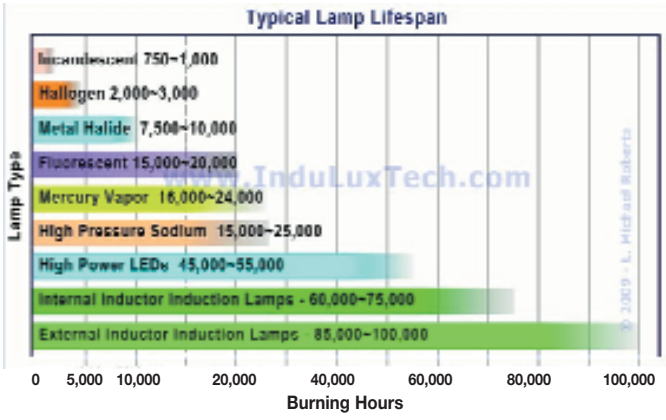
There's also what is called the Color Rendering Index, or CRI, which is understood to be a measure of how well light sources render the colors of objects, materials, and skin tones. There is some controversy regarding CRI since the baseline is incandescent lamps which are what most people are used to. Therefore other types of lights score a lower CRI number even though they may actually represent colors, objects, materials and skin tones more accurately. See chart below for those ranges.

SOURCE	CRI
Incandescent lamp	100
Tungsten Halogen lamp	100
HID: Metal Halide	65 - 80
HID: Mercury Vapor	15 - 55
HID: High Pressure Sodium	22 - 75
Fluorescent lamp	52 - 79
Induction lamp	80 - 90
LED lamp	27 - 85

Lumen-to-watt ratios are a measure of the efficiency, or more properly, "efficacy" of a light source. Efficacy is easily translated by taking the lumen output of a lamp and dividing by the lamp watts. Since most of the research attention is now being focused on LED, the lumen-to-watt ratio is improving quickly. Because of this, lamps (bulbs) are now being manufactured to retrofit into existing fixtures. Several years ago the technology did not exist to do so. See the chart below for common lumen-to-watt ratios.

SOURCE	Lumen/Watt Ratios
Incandescent lamp	17 - 20
Tungsten Halogen lamp	17 - 20
HID: Metal Halide	65 - 115
HID: Mercury Vapor	50 - 60
HID: High Pressure Sodium	85 - 150
Fluorescent lamp	50 - 100
Induction lamp	60 - 90
LED lamp	30 - 100

Lamp life span is the average time a lamp will function at its potential. The chart below shows the average burning hours of the common types of lamps. As you can see, the LEDs have a much longer lamp life than all the others, excluding induction lamps.

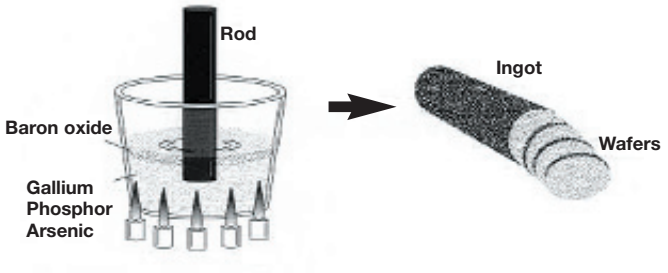


There is a significant range of lighting costs according to the individual site and landscape illumination fixtures. As you can imagine, there are costs ranging from the very inexpensive fixtures to the more expensive high wattage fixtures. Working closely with a lighting professional who is knowledgeable about the value and performance of fixtures can avoid efficiency and budget issues. In the case of LED, new fixtures are being developed that are more efficient, with a higher lumen-to-watt ratio, on a regular basis. The chart below shows the general cost ranges you can expect.

SOURCE	GENERAL COST
Incandescent fixtures	$5-100 (becoming obsolete)
Tungsten Halogen fixtures	$5-100 (becoming obsolete)
HID fixtures	$100-400 (becoming obsolete)
Fluorescent fixtures	$25-100 (becoming obsolete)
Induction fixtures	$250-500 (early development stages)
LED fixtures	$50-600 (current industry focus with limited availability)

What is an LED? Rather than heating up wires or exciting a gas, an LED emits light by electronic excitation rather than by heat generation. Diodes are electrical valves that allow electrical current to flow in only one direction, similar to a one-way valve in a water pipe. When the valve is "on", electrons move from a region of high electronic density to a region of low electronic density. This movement of electrons is accompanied by the emission of light. The more electrons that pass across the boundary between layers, known as a junction, the brighter the light.

To make the semi-conductor wafers, gallium, arsenic, and/or phosphor are first mixed in a chamber and forced into a solution. To keep them from escaping into the pressurized gas in the chamber, they are often covered with a layer of liquid boron oxide. Next, a rod is dipped into the solution and pulled out slowly. The solution cools and crystallizes on the end of the rod as it is lifted out of the chamber forming a long, cylindrical crystal ingot. The ingot is then sliced into wafers. The different semi-conductor materials (called substrates) and impurities result in different colors of light from the LED. The most efficient LEDs, to produce the highest lumen output, are those that are in the 5,500° Kelvin spectrum. Generally, the warmer the color of light (or the lower the degrees Kelvin), the lower the lumen output. For instance a 5,500 degree Kelvin LED lamp will be considerably brighter than a 3,200 degree Kelvin lamp.



LED fixtures are available as AC (alternating current) and DC (direct current) as well as 12 volt and 120 volt. DC LEDs are more efficient, but require drivers to convert AC current to DC current. This process generates heat, which is detrimental to the diodes and can reduce their lifespan. The drivers can be combined in the bulb assembly or separately and remotely.

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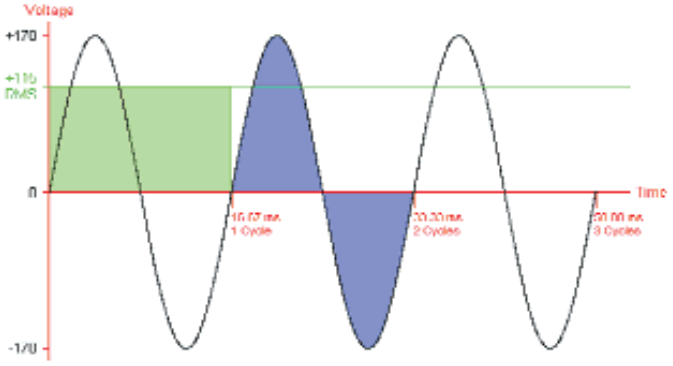
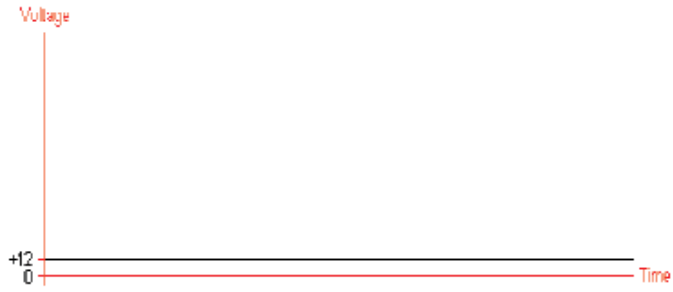
Combining the driver with the lamps creates issues because once the wattage reaches a certain point, the drivers create more heat than the fixture can dissipate. It is common to find replacement LED lamps that fit into a regular light bulb socket that are not nearly as bright as the original bulb they are replacing because the wattage is limited due to heat buildup by the driver. The DC LED lamps are fed with low voltage power and the drivers are typically remotely located. 120-volt power is brought to the driver but does not have to continue onto the fixture. As you can see from the diagram below, the amount of energy needed for direct current is significantly reduced. Much of the excess energy is burned off in the form of heat. Not only is that energy wasted, but in an indoor situation it also taxes the cooling system.





When selecting a fixture you must consider whether the installation is a retrofit or if you're starting new. These are two very different situations in the marketplace. A retrofit is typically converting an existing lighting system from incandescent, fluorescent or HIV to LED by retrofitting the existing fixtures. The lamp choices are limited due to size constraints of the existing fixture and the need to combine the driver and diodes as mentioned earlier. The second option is installing a completely new LED system. This requires all new fixtures and wiring along with a location for the drivers. The high cost and lack of lumen output of LED retrofit lamps limit the conversion from common lamps to LED. However, this will change as new lamps are developed and the technology changes.

There are many factors that influence the fixture selection. Some of those are the intensity of light required, the color of light required, the beam spread of the fixtures required, sustainability requirements, and the budgetary requirements.

The most obvious LED "green" characteristics are: low to moderate energy usage, moderate to high lamp life, lack of hazardous materials, small to moderate fixture sizes, relatively low maintenance cost, low heat generation and solid-state construction.

The technology is changing rapidly in LED lighting and many lighting companies and manufacturers are racing to develop the standard. It seems as though each time a company comes up with a better option, the next company is already working on the next generation! The key elements they are striving for are maximum lumen output for wattage of electricity consumed, variety of color options (warm 2,700-3,200 K, white 3,300-4,200 K & cool 4,300-6,000 K), and increased lifespan of the lamp beyond 50,000 hrs. The cost per lamp is decreasing as the technology improves.

The law of supply and demand will kick in at a point when the LEDs come more closely aligned with the costs associated with everyday incandescent and fluorescent bulbs. As the improvements are made, all of us benefit. The manufacturers are in a quandary because they cannot afford to manufacture large quantities of a product that may become obsolete very quickly. A large inventory in a warehouse that is no longer marketable is worthless. The cost will remain high until large quantities can be manufactured and sold before changes are made to the design.

A pitfall in this scenario is to an uninformed consumer or someone who specifies products; there are so many options on the market that it is easy to make a selection that is inappropriate. It is best to educate yourself on the latest LED technologies or work closely with a lighting professional who stays current on the whirlwind of changes happening regularly.

The good news is that LEDs have arrived and they will be here for the foreseeable future. You can be assured that the costs will drop, the efficiencies will improve, and all of us will be better off for it.■

If you are interested in more information or a lunch and learn on this topic please contact **Dean MacMorris**, Vice President of Night Light, Inc. at dean@nightlightinc.net or 847-627-1111.

Association of Licensed Architects
Continuing Education

ALA Continuing Education Questionnaire -

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Program Title:

An Introduction and the Pitfalls of LED Site and Landscape Illumination

ALA/CEP Credit: This article qualifies for 1.0 HSW LU of State Required Learning Units and may qualify for other LU requirements. (Valid through September 2013.)

Instructions:

- Read the article using the learning objectives provided.
- Answer the questions.
- Fill in your contact information.
- Sign the certification.
- Submit questions with answers, contact information and payment to ALA by mail or fax to receive credit.

QUIZ QUESTIONS

1. How is the color of light measured?
   a. Light Meter
   b. In degrees Kelvin
   c. Color spectrum scope
2. LED is an acronym for Light Emitting Diode?
   a. True b. False
3. The three main ingredients used when making the semi-conductor wafers are Gallium, Arsenic & Potassium?
   a. True b. False
4. What causes a LED to emit light?
   a. The gases emit light when they are ignited.
   b. The glowing of the wires as they heat up.
   c. Electronic excitation which causes the electrons to move from a region of high electronic density to a region of low electronic density.
5. DC type LED light fixtures are typically most efficient?
   a. True b. False
6. What type of lamps have the longest lifespan, but have a limited use in the industry?
   a. LED
   b. Induction
   c. HID
7. Which of these three colors of LED light is the most efficient?
   a. 3,000 degrees Kelvin
   b. 4,200 degrees Kelvin
   c. 5,500 degrees Kelvin
8. LED fixtures have both transformers & ballasts?
   a. True b. False
9. Three main reasons why LED fixtures are more "Green" or Sustainable than most other fixtures?
   a. They are manufactured close to the point of sale, made of cheaper materials & made in the USA.
   b. They are Low energy usage, high lamp lifespan & lack hazardous materials.
   c. They are low maintenance, low heat generation & made from biodegradable plastics.
10. The limiting factor of retrofitting existing lighting fixtures to LED is that lamp choices are limited due to the size constraints of the existing fixture and the need to combine the driver and diodes, which limits the lumen output?
    a. True b. False

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