LED Lighting Systems
In Sustainable Building Design

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INTRODUCTION

Today, around the world, there is an unprecedented level of interest and effort focused on implementing "green" designs for sustainable buildings. This extraordinary movement is in reaction to several important facts regarding the impact of buildings on the world's environment.

Experts estimate that by themselves, buildings consume:
+40% of the world's energy
+40% of the world's virgin materials

At the same time, it is estimated that buildings produce:
+40% of all global waste
+40% of all greenhouse gases

By improving how we design and construct new buildings and how we remodel existing buildings, we can greatly reduce their environmental impact.
The desire to build more sustainable buildings is a worldwide phenomenon. In 1995, the European Commission launched the Green Building Program (GBP), a voluntary effort aimed at improving the energy efficiency of non-residential buildings throughout Europe.

In November, 1999 the founding meeting of the World Green Building Council was held in San Francisco. This first meeting was attended by representatives of green building councils from Australia, Japan, Russia, Spain, United Arab Emirates, the United Kingdom and the United States.

In the United States, the movement is being driven by the U. S. Green Building Council (USGBC), which has developed a national standard for sustainable building design, known as LEED (Leadership in Energy and Environmental Design).
Through LEED, the USGBC offers a set of well-documented, scientifically proven performance criteria and a point system for attainment of LEED certification.

It is important to recognize that LEED certification requires the building designer to incorporate "green technology" in many areas of the structure and that certification cannot be attained through the use of any single technology or product. Rather, a holistic approach to the building's overall design is required.

Lighting considerations are an important part of designing an environmentally sound structure.

The use of Light Emitting Diode (LED) luminaires can provide certification points in a number of key areas within the point structure methodology of the LEED certification process, but cannot by itself guarantee LEED certification.

LED: The next generation of lighting technology

LEDs – A Little History

Light Emitting Diodes (LEDs) have been around since the 1960s. For the first few decades, the relatively low light output of LEDs and narrow range of colors limited their role to specialized applications such as indicator lamps.

As LED output improved, the devices found their way into signage of all types (think LED exit signs and traffic signals) and into smaller, more decorative luminaires. LED light output levels gradually increased over time.

The past few years have seen white LEDs more than triple their light output. These improvements have set the stage for LEDs to become the light source for the next generation of general lighting products.

The State of LED Technology Today

LEDs are solid-state semi-conductor devices that produce light. Because of the way they are constructed, the light they produce is highly directional. As with any light source, LEDs have certain characteristics and limitations which need to be understood before the technology can be utilized to its maximum potential. LEDs that are designated for general lighting use are expected to produce a suitable level of light output to allow for the replacement of the existing lighting technologies in use today; incandescent, fluorescent, mercury, metal halide and high pressure sodium.

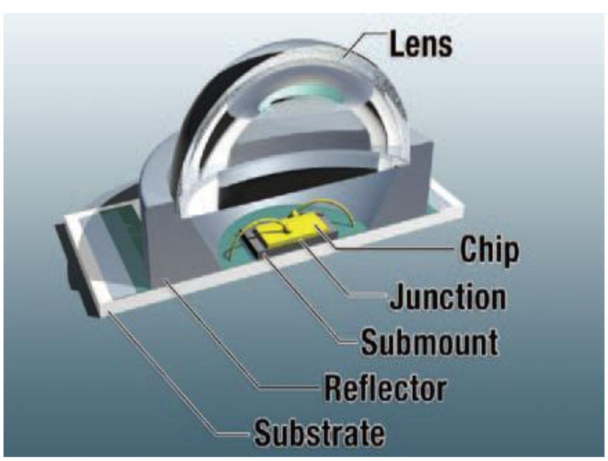
For most general lighting applications, white light is preferred. An LED can produce white light in one of two ways:

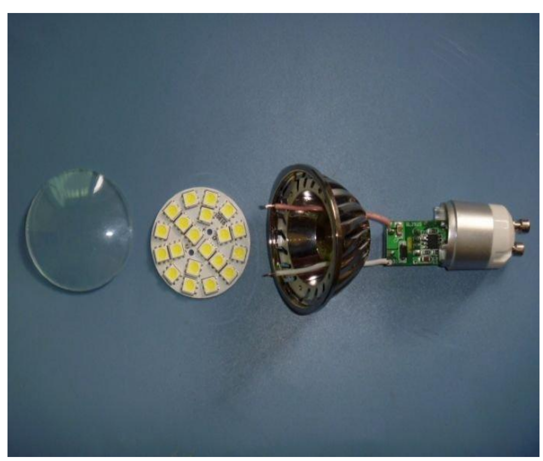
- Phosphor conversion in which the LED chip emits blue or near ultraviolet light. The LED chip is coated with phosphor, which interacts with the emitted light to produce white light. This is similar to the way in which light is generated by a fluorescent lamp.
  Most of the discussions in this brochure pertain to high brightness or power LEDs using blue light conversion.

- RGB (Red, Green, Blue) systems mix the light output from three or four monochromatic LEDs (amber can also be used to increase the color palette) producing white light that is "tunable" to many different colors of light, including white light of various color temperatures.

LEDs have some significant characteristics making them excellent general lighting sources: high source efficacy, optical control, extremely long operating lives and exceptional delivered lumens when used in a properly designed lighting system. In addition,

LEDs also have a number of other favorable attributes. However, there are important technical limitations that must be understood in order to properly utilize these marvelous light sources in luminaires.





Some types of LED s:

Understanding LEDs and LED Lighting

What's SSL lighting?

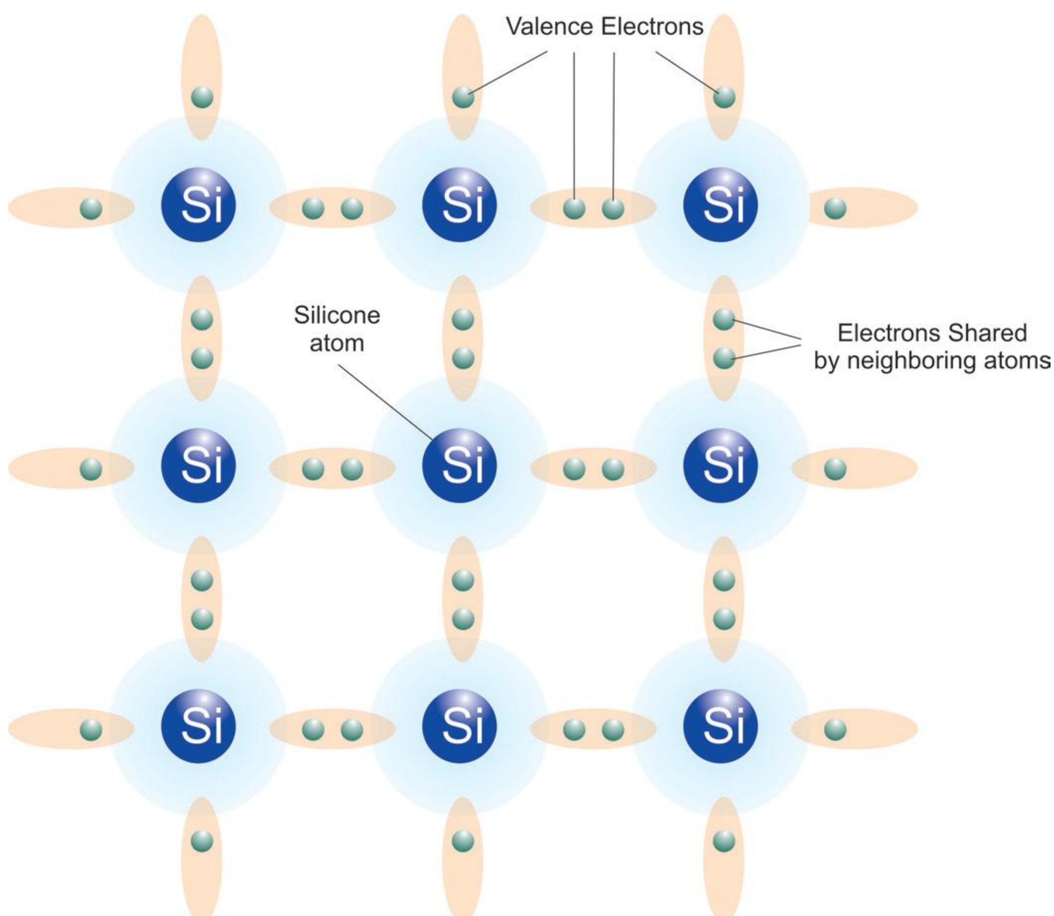
SSL is short for Solid State Lighting. Most of us come into direct contact with light-emitting diodes (LEDs) every day. LED is a solid-state technology. This means there are no glass bulbs, no pressurized gases, no toxic chemicals and no burning filaments. They work by flowing electrical energy through a semi-conductor.

Used as indicators in automotive dashboards, numeric displays on consumer electronic devices, or as low power flashlights, LEDs have been perceived as low output, monochromatic light sources. Not surprising considering that for many years, there were no advancements in LED technology and very little changes in lighting technology overall. In recent years, LED technology has completely changed by reinventing the light bulb and the way we think about lighting in general. This was not really possible prior to the technological revolution of the '90s and the rapid advancement of semiconductors. The same advancements that spurred the computer to reach dizzying levels of efficiency have done the same for the LED. Just as computers have become faster and cheaper, LED lights have become brighter, smaller, less expensive, and more sophisticated. Today, there is little debate over the effectiveness of LED lamps vs. traditional incandescent bulbs. With up to eight times greater efficiencies than traditional incandescent bulbs and easily conquering those of fluorescent lamps, LEDs are becoming preferred light sources for today's lighting community. According to the U.S. Department of Energy, "No other lighting technology offers the Department and our nation so much potential to save energy and enhance the quality of our building environments."

Where does LED light come from?

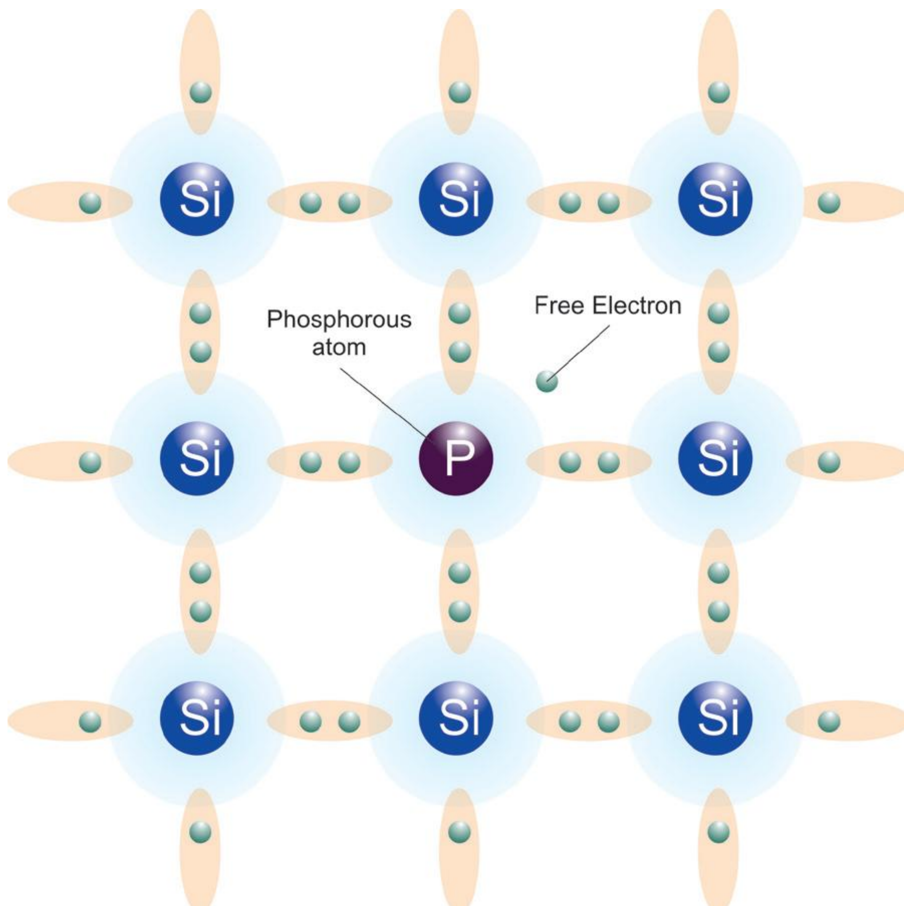
LEDs are solid-state (P-N junction semiconductor) devices that convert electrical energy directly into light by a process called electroluminescence.

We will try to explain, in layman terms, what makes LED the light source of the future. To better understand LEDs, we have to start with an explanation of what is a basic diode.

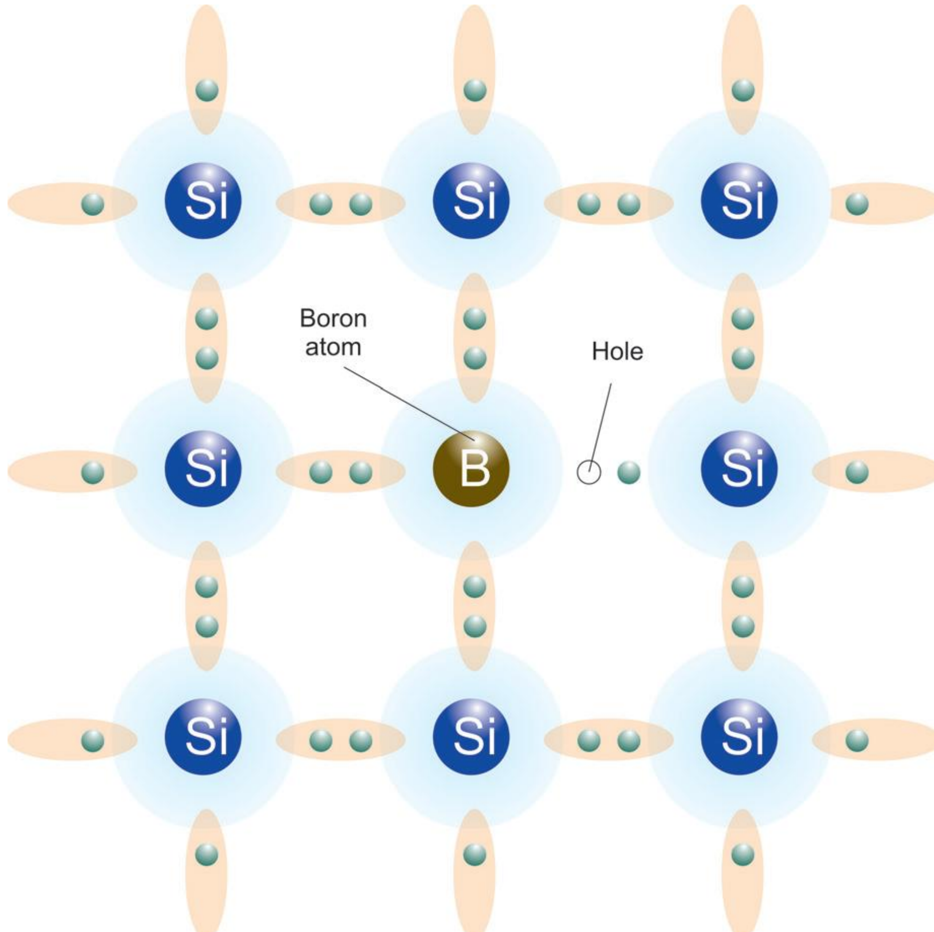


It all starts with silicon. This is the same silicon that is the main element in sand and quartz. Silicon has four "free" electrons in the outermost shell of an atom. Valence electrons, as they are scientifically called, dictate the electrical and chemical nature of every solid matter. Valence electrons in base substrates share covalent bonds with their neighbors.

By adding a small amount of impurities to silicon, you can change its behavior and turn it into a conductor. An N-type (negative) impurity is an element with five "free" outer electrons so they're out of place when they get into the substrate lattice.



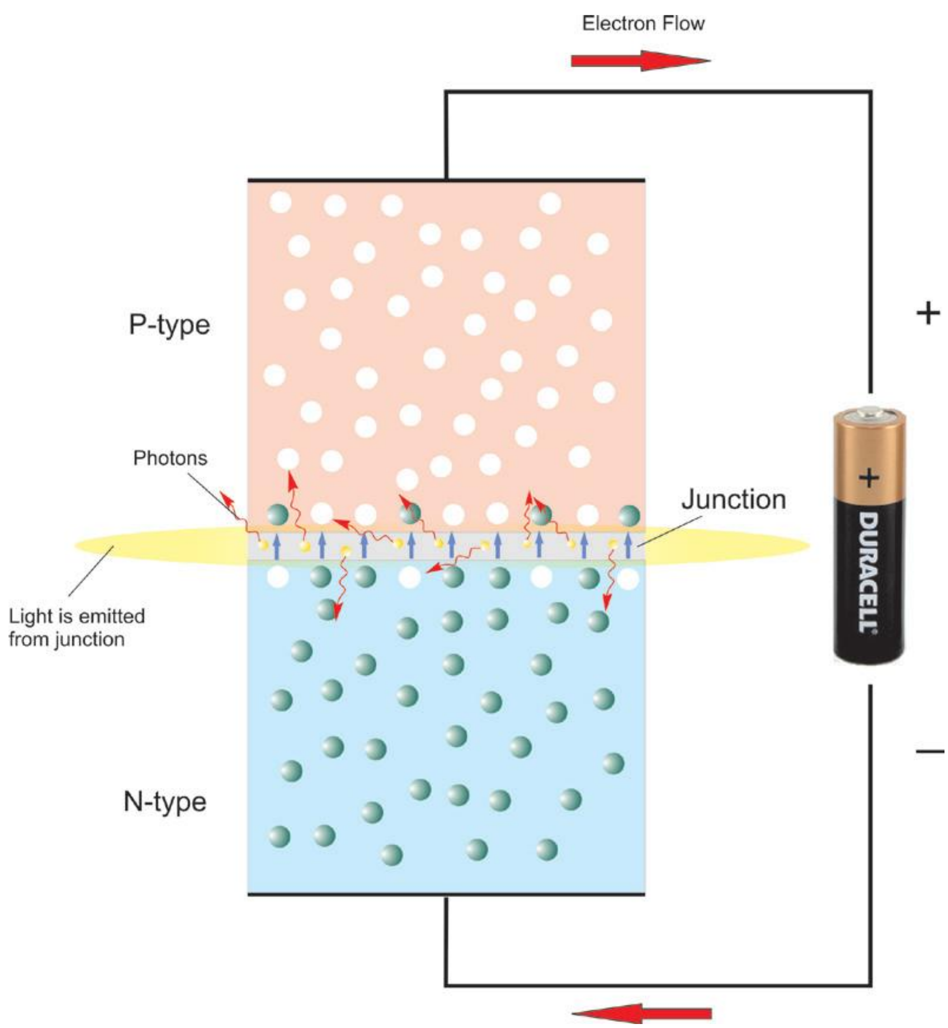
The fifth electron has nothing to bond to, so it's free to move around.
A P-type (positive) impurity is an element with three "free" outer electrons. The absence of a fourth electron creates a "hole".



A hole happily accepts an electron from a neighbor, moving it from hole to hole. By introducing N or P type impurities into silicon, we change the electrical behavior of the substrate from a perfect insulator to a conductor called a semiconductor.

Sandwiching N-type and P-type semiconductors together creates a device called a diode. When you connect such a device to an electrical energy source, a very interesting phenomenon occurs.

By connecting a positive battery terminal to the N-type side of the diode and a negative terminal to the P-type side of the diode, electrons and holes near the junction will repel from each other. Although N-type and P-type elements by itself are conductors, the diode connected in reverse does not conduct any electricity. On the other side, if we connect a positive battery terminal to the P-type side of the diode and a negative to the N-side, free electrons in the N-type semiconductor will be repelled (pushed) away from the negative terminal, and holes in the P-type will be repelled away from the positive terminal. In the junction region electrons will cross from the negative side to the positive side filling the holes.



So where is the light coming from? Well, crossing the border comes with a hefty price tag. During the jump (scientifically called recombination) an electron looses a portion of its energy. In a regular diode, this energy is emitted in the form of heat. By utilizing specific N and P type semiconductors such as gallium phosphide (GaP), this energy "weight loss" produces photons (light) instead of heat. The amount of energy lost defines the color of the light. For example red is a low energy light and blue is a high energy light.

A Typical High Brightness LED in its package

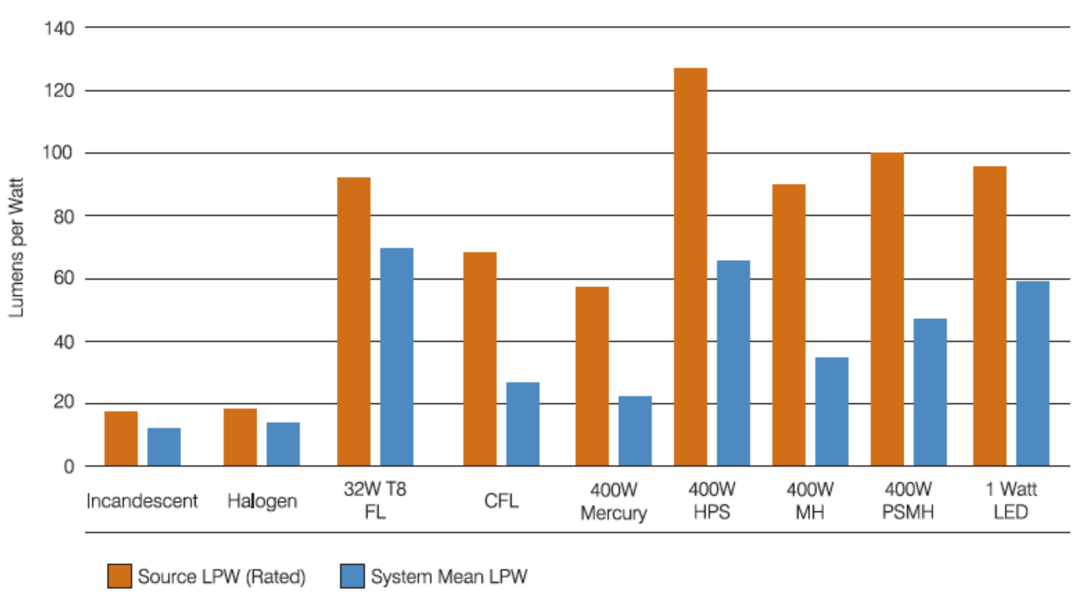
The most important measurement for any LED system is the temperature at the point within the LED package labeled as the junction. The junction temperature is the primary determinant of the potential operating life and performance for an LED.

The LED manufacturer designs the LED package for optimal heat removal from the junction. Once the luminaire manufacturer has the packaged LED, the junction temperature is controlled by the design of the luminaire and the ambient temperature environment in which it operates.

High Source Efficacy

Over the past few years, LEDs have become more efficacious. Recently, blue-white phosphor conversion LEDs have approached the 100 lumens per watt level (see graph below).

comparison of Source and system efficacies (LPW) for LED and Traditional lighting technologies



The US Department of Energy estimates that by 2010, white LEDs utilizing phosphor conversion will rival the efficacy of the most efficient light sources currently in use.

Already today, many of the traditional lighting technologies can be easily replaced with LEDs in a wide variety of applications with resulting energy reductions. Incandescent, halogen, compact fluorescent, and mercury lamps are the easiest to replace.

Even highpressure sodium and metal halide are capable of being replaced with resulting energy savings depending upon the wattage and application.

It is critical to understand the importance of luminaire design to LED performance. A welldesigned luminaire must remove heat from the junction.

The proper use of heat sinks and passive cooling technology is essential to obtaining optimum performance. Both LED lumen output and ultimately, the operating life are dependent upon luminaire design. There is no other lighting technology in use today where thermal effects are as critical.

What is the Efficacy of an LED ?

When an LED manufacturer produces an LED chip, the light output is measured by applying a suitable current for 25 milliseconds.
This measurement is the standard reference point for all modern LEDs. The steady state lumens produced by the LED will typically be less due to the increased junction temperature at steady state operation. The junction temperature is the temperature in the LED at the point where light is generated.

Also, this initial efficacy number does not include efficiency losses from the driver or optics. When evaluating mean system efficacy, the lumen depreciation of the LED over life must also be taken into account.

The graph compares the initial light source efficiencies for many of the common lighting technologies in use today. Also shown is the mean delivered lumens per watt (LPW) for the system, taking into account all typical losses.

Optical Control

Most light sources, when utilized in luminaires, produce uncontrolled light – resulting in "hot spots" and other discontinuities in the illumination. The elimination of uncontrolled light results in incredible uniformity.

BetaLED luminaires are designed with patented NanoOptic® product technology, which controls the photometric distribution of the LED luminaire. NanoOptic product technology uses precision, injection molded acrylic plastic covers over the LED package.
BetaLED luminaires closely match the light distribution achieved with traditional reflectors and with the other light sources in use today.

The increased uniformity allows the lighting designer to specify lower average light levels in a layout while maintaining or improving the minimums.
The result: Increased energy savings and a better quality of lighting design.

Without NanoOptic Product Technology	With NanoOptic Product Technology
	

A computer rendering of the NanoOptic™ altering the original packaged LED's photometric distribution.

Application Comparison

A computer rendering comparing the uniformity of lighting in a parking garage application using metal halide and LED lighting systems.

150W MH Solution		LED Solution		Notes
AVG	7.77 fc	AVG	7.59 fc	Same Level of Illumination
MAX	19.1 fc	MAX	11.6 fc	39% Lower MAX with LED
MIN	1.9 fc	MIN	2.3 fc	21% Higher MIN with LED
MAX/MIN	10:1	MAX/MIN	5:1	Much Improved Uniformity
LLF	0.75 (@ 6,000 Hrs.)	LLF	0.95 (@ 50,000 Hrs.)	Superior Lumen Maintenance for LED
Power	185 Watts	Power	128 Watts	31% Energy Savings for LED

Extremely Long Operating Life

With proper attention to detail, LED operating life can be expected to range from 50,000 to more than 100,000 hours.
Actual operating life of an LED will depend on three variables:

Junction Temperature :

The temperature in the LED at the point where the light is generated (the junction).
This temperature cannot be measured directly by the luminaire manufacturer, since the LED received by the manufacturer has already been encased within a sealed package. LED device manufacturers publish data that provides luminaire manufacturers with reference points on the LED package whose temperature correlates to the junction temperature.

Ambient Operating Temperature:

The temperature environment in which the fixture will be operated. All life measurements reported by the LED device manufacturers are performed over a range of ambient temperatures. For a given luminaire, higher ambient temperatures will result in a shorter operating life; lower temperatures will allow the LED to operate even longer than anticipated.

Luminaire Design:

Luminaire design has a significant effect on LED operating life. In fact, two luminaires may show radically different operating lives in the same ambient, due to how well they are designed and how efficiently they remove heat from the LED.
The adjacent chart shows the predicted operating life for the BetaLED area light luminaire in various ambient temperature conditions. Most luminaire manufacturers quote expected operating lifetimes based upon a 25° C ambient. When predicting LED operating life, it is essential that both ambient operating temperature and luminaire design be evaluated, since both have an impact on the junction temperature.

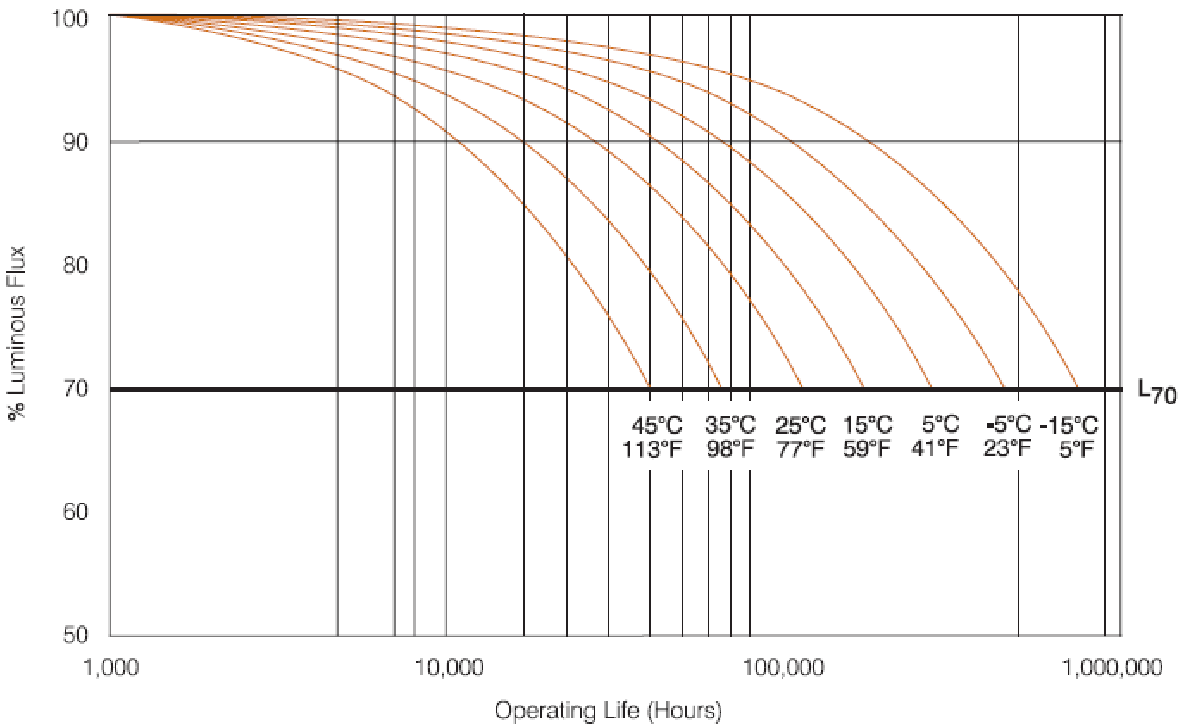
While fixture design is the primary determinant of junction temperature, the ambient temperature can have a significant impact on the life expectancy of the LED.

What is th e Expected Operating Life of an LED System?

The Illuminating Engineering Society of North America (IESNA) is in the process of developing a document: Approved Method for Measuring Lumen Depreciation of SSL Light Sources (LM-80).
The definition of end-of-life for an LED luminaire is when the total luminous flux depreciates to a value of 70% of original.
Once this data is collected, LED luminaire manufacturers will then be able to publish curves such as the one shown in the next sheet:

Beta LED Operating Life

350mA Lumen Maintenance Predictions vs. Ambient Temperature



This graph shows the expected operating life of one particular BetaLED lighting system based upon its operation over a range of ambient temperature environments.

In a properly designed luminaire, the LEDs should operate for a minimum of 50,000 hours in a 25° C environment and longer if the ambient temperatures are less.

Important:

This data is specific to Beta LED luminaires only and cannot be used to estimate the life of LED products from other manufacturers. Each manufacturer should generate their own predictive operating life curves based upon the luminaire design and junction temperature of their LEDs.

Delivered Lumens

All light sources experience lumen loss from one or more of the following:

Lumen Depreciation:

Over their operating life, all light sources lose their capability to produce light. Lighting design calculations use average or mean lumens when determining a lighting layout.

Control Gear Losses:

All discharge lamps (fluorescent and HID) utilize ballasts to regulate the current to the lamp. LEDs use drivers. All of these auxiliary devices use energy and decrease luminaire efficiency.

Optical Losses:

Most luminaires use reflectors to control the direction of the light coming from the lamps. Optical losses can be very high, depending upon the design and the light source.

In addition, LEDs experience some lumen loss due to steady state operation in a luminaire

As discussed earlier, LED efficacy is measured with a very short burst of power. While this is fine as an industry standard practice, it is not indicative of how the LED will be used in general lighting applications. When the LED is inserted in a continuously operating luminaire, the LEDs will experience a junction temperature rise, resulting in a lower light output, thereby lowering the efficacy. LED fixture data must be corrected for this in order to allow them to be compared to other lighting technologies in an unbiased manner.

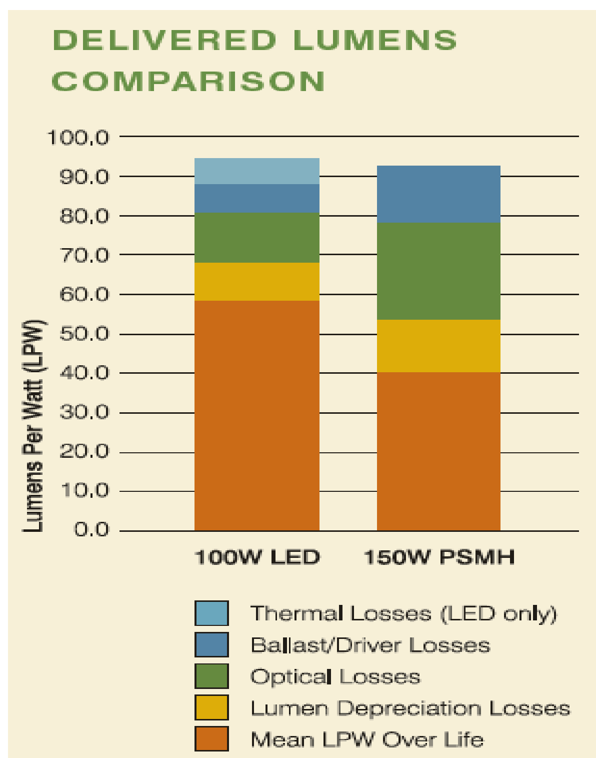
Delivered Lumens

In order to evaluate a lighting system objectively, one must take into account all of the losses that the system will experience over its life as described above. Once these system losses are taken into account, the lumens per watt (efficacy) of the lighting system can be accurately calculated.
The IESNA is also working on another document, Guide for Electrical and Photometric Measurement of Solid State Lighting Products (LM-79). Following the procedures outlined in this document will allow manufacturers to accurately publish photometric data for their LED luminaires.

The end result will also be more consistent and credible reporting between manufacturers.

The chart at left shows a comparison between an LED system containing 100 one-watt (nominal) high-power LEDs and a 150 watt pulse start metal halide system. While both systems start at a similar efficacy, each one loses lumens due to the variables discussed above.

The result is the LED system operates on average with 40% better luminous efficacy than the pulse start metal halide system. This system performance improvement allows the LED system to deliver equal mean lumens and save about 30% in energy over the 100,000 hours of LED system life. For a specific project, the actual level of savings depends upon the many variables associated with each lighting design.



Other LED Attributes and Advantages:

Environmentally Friendly

As a light source, LEDs contain no mercury and no lead. Many of the LED luminaires being designed today are made from aluminum, which can be recycled. Beta LED luminaires are also RoHS compliant.

Variety of Color Temper tures

LEDs are available in correlated color temperatures (CCTs) ranging from 10000K to 2500K.
This range of CCTs allows LEDs to be used in a wide range of applications. With the warmer color temperatures, the efficacy of the LEDs decreases. Consult manufacturer literature for the specific reductions. (Figure 1)

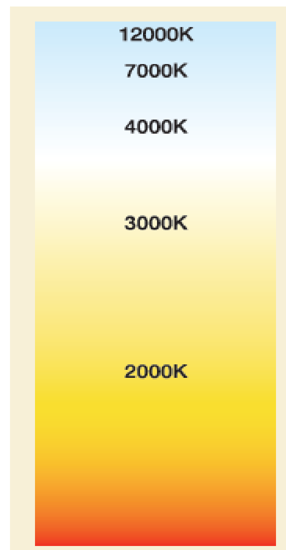


Figure 1 – General Illumination Color

Color Rendition

The color rendition in the blue-white LEDs used in BetaLED luminaires is 72 at the higher color temperatures (>5000K).
Other color rendering options are available for white light systems depending upon the LED and method of light generation selected: phosphor conversion or RGB.

Low Maintenance and Disposal Costs

The long operating life of LED products translates to lower maintenance labor costs, as well as a reduction in expenditures for fuels and maintenance vehicles. Disposal costs are also proportionately less than other lighting technologies. (Figure 2)

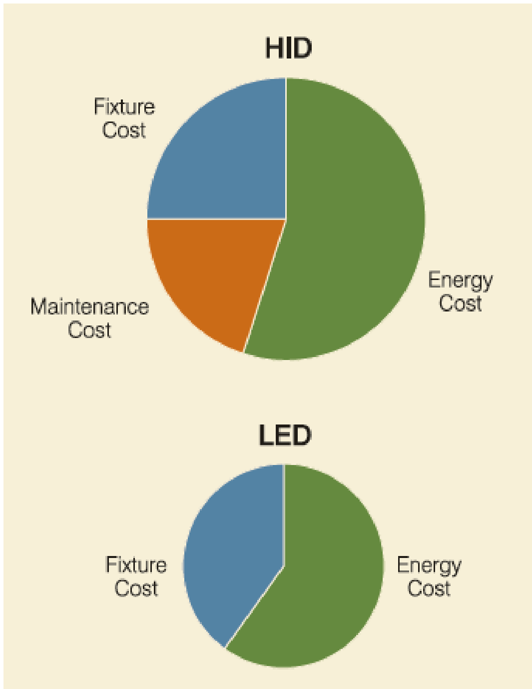


Figure 2 – Total Cost of Ownership

Compatible with Photovoltaics

LEDs are low voltage devices and have low power consumption, making them very compatible in off-grid solar energy systems.

Compatible with Lighting Control Systems

LEDs are highly compatible with lighting control systems, since they have no re-strike times, excellent color stability with dimming, and no negative impact on life from frequent starts.

LEDs Can Be Dimmed

LEDs can be dimmed using either a two-level scheme or continuous dimming with 0-10 volt control input. Their efficacy (LPW) actually increases when they are dimmed due to lower junction temperatures.

LED Lighting's Potential Impact on LEED Scoring and Certification

LED lighting can be a significant contributor to obtaining LEED certification for a new building or building remodel. The use of one technology or product cannot guarantee LEED certification as it is based upon a holistic approach to building design. LED lighting systems can contribute to LEED certification in four areas: Energy and Atmosphere, Sustainable Sites, Indoor Environmental Quality and Innovation.

Energy & Atmosphere (EA)

The optimization of energy performance is worth 1 to 10 points in the LEED certification for new construction and renovation. This is the primary area where LED lighting can have an impact. Energy savings are a very important part of the criteria for certification in most LEED projects.

Sustainable Sites (SS)

Light pollution reduction has the potential for 1 point toward LEED certification. Beta LED outdoor luminaires are designed to be full cut-off and therefore can earn the light pollution credit.

Indoor Environmental Quality (EQ)

Control of the lighting system by individual occupants or specific groups in multi-occupant spaces can potentially earn 1 point toward LEED certification. LED luminaires provide the opportunity to work as part of a lighting control plan. They provide light instantaneously once power is applied, requiring no warm up time. LED lighting systems can also be dimmed to provide variable light output depending upon the needs of the occupants.

Innovation & Design Process (ID)

The utilization of innovative products and processes may earn between 1 and 4 point toward LEED certification. As LED lighting systems for general lighting represent new, innovative technology, they should qualify for LEED certification credit.

LED Lighting Systems are Green

- ✓ LEDs contain no mercury or lead
- ✓ LED luminaries often utilize die cast and extruded aluminum parts, totally recyclable materials.
- ✓ The increased efficiency of LED lighting systems results in less heat into the space, reducing the load on the air conditioning system. Impact? Even more energy savings.
- ✓ The improved uniformity of the distribution of the LED luminaires allows for reduced average lighting levels while maintaining the minimum light level requirements. This will further reduce lighting costs.
- ✓ Dimming, either continuous or stepped, can further reduce energy consumption.
- ✓ Each 1 million kWh in energy savings will reduce CO2 emissions by an estimated 777 metric tons.

Are LEDs Ready for General Lighting?

We have discussed the many advantages of LEDs and the lighting systems in which they are utilized:

1 – High Source Efficacy
2 – Optical Control
3 – Extremely Long Operating Life
4 – Delivered Lumens

They are very capable of being used to make excellent general lighting sources that can replace many of the traditional lighting technologies in use today. In addition to these major advantages, LEDs also have a number of other favorable attributes as discussed earlier.
However, in order to benefit from all of these great characteristics, one must first develop a luminaire which takes into account the need for LEDs to be cooled.
First and foremost, it will be properly designed lighting systems that will allow LEDs to reach their potential.

Today's Benefits of LEDs – Improved Lighting Performance With Significant Savings !

The bottom line for LED lighting systems is that they have the potential to save a substantial amount of energy cost for lighting over the lifetime of a project. In addition to the energy savings, the long lives of LEDs in well-designed systems will result in substantial savings in both labor and material costs for maintenance.

LED Lighting and LEED Certification

There is a worldwide focus today on the "greening" of our planet. LED lighting systems do not represent the total answer for that, but they can play a significant role in reducing the estimated 20% of our electrical energy that is used for lighting.
We have seen that LED lighting systems can help in obtaining LEED certification in key areas:

Energy & Atmosphere (EA)
Energy reduction potential makes this the most significant category.

Sustainable Sites (SS)
Light pollution reduction.

Indoor Environmental Quality (EQ)
Individual lighting control.

Innovation & Design Process (ID)
A brand new technology for lighting.

LED lighting systems are a part of the solution!

LED advantages
- No abrupt burnout like incandescent bulbs
- On/off cycling doesn't diminish lifespan as with CFLs
- Instant on; no warm up time needed as in HID lamps
- Produce greater light per watt than incandescent bulbs
- Easily dimmed
- Have a usable life 30 to 50 times longer than incandescent bulbs and 3 to 5 times longer than CFLs
- Do not contain dangerous mercury, unlike CFLs

- Very small size gives them more design options
- Solid-state components make them shock resistant and virtually unbreakable
- Deliver efficient directional light, unlike incandescent bulbs and CFLs

A Bright Future for LED Lighting

LED lighting systems are available today for both interior and exterior general lighting applications. The range of product choices is expanding daily and is expected to increase dramatically over the next five years.

With the growth of this important new technology, LED systems will be applied in new and
innovative ways:

Spectrally Enhanced Lighting

Research has been completed that promotes the concept of spectrally enhanced illumination. These studies have shown that people have better visual acuity in higher color temperature environments.
LED lighting systems are available in color temperatures ranging from 3000K to 10000K. It is at those color temperatures above 4000K where the effect is most pronounced. One benefit of this research could be in the reduction of light levels while maintaining excellent visual acuity.
As this modification to the standards has not yet been adopted by the IESNA in the United States, we have not used any of these factors in our calculations.

Multiple Level Lighting

Many applications do not require full lighting levels all of the time. LEDs are fully capable of being dimmed, either continuously or with discreet levels. Warehouses, office buildings and parking structures are just some of the applications where multiple level lighting could be used to save substantial amounts of energy.

Off-Grid Lighting Systems

There are many areas where electrical power is not readily available and the disruption to the environment and cost do not make it attractive to make it available. These areas are perfect candidates for solar powered off-grid lighting systems. LEDs are a perfect light source for these applications as they are low voltage, high efficacy devices.

Discussions:

Why are color LEDs much more vibrant?

LED emits color in a very narrow spectrum. As we mentioned before, once the electron crosses the junction between the N-type and P-type semiconductors, it releases a very specific amount of energy. Think of it as paying a crossing toll where electrons producing blue photons must always pay a quarter and use only quarters.

"Red" electrons have to pay a dime and use only dimes. In contrast, an incandescent lamp produces a much wider color spectrum (though less vibrant) because it can pay its toll in a variety of denominations. So for their $0.25 toll, incandescent lamps can use dimes, pennies or quarters. A very good example of color purity is found in Christmas lights. LED based decorations will be significantly more vibrant.

How are white LEDs created?

As strange as it may sound, white light does not exist. What is perceived as white light is actually a combination of red, blue and green. White LEDs can be created in two different ways. Less common is a combination of green, blue and red LED chips. The most common way is a combination of a blue LED chip and a phosphorous coating. In this process, called fluorescence, a blue photon is absorbed by the phosphorous coating which triggers the emission of a less energetic photon (red, green). Different phosphorous coatings will produce different hues of white color – warm white, natural white, cool white, etc.

Are LEDs cool light sources?

A common misconception is that LEDs do not produce any heat. In fact they do. Electrons crossing the P-N junction produce not only photons, but also heat. It is very important to thermally manage LED devices because heat decreases the efficiency and lifespan of the LED. Compare it to an athlete. If you are running in an un-breathable jersey you overheat very easily and your performance goes down. If you run for a longer time, you may hurt yourself. It makes sense then, that a cooler environment, increases the athlete's efficiency and performance. LED light sources produce dramatically less heat than conventional incandescent lamps, however, the heat output needs to be thermally managed to achieve optimum efficiency. There are many LED lamps on the market with improper or no thermal management of junction heat. Such LED lamps will experience a very dramatic intensity decrease and a very short life span.

What is the main difference between a fluorescent and LED light source?

Fluorescent lamps generate light by a high voltage arc passing through mercury vapor. The arc generates high energy ultraviolet light that is absorbed by a phosphor coating inside the lamp, causing it to glow, or fluoresce. Every fluorescent lamp contains highly poisonous mercury, so if the lamp breaks, the surrounding environment will be exposed to it. Linear fluorescents have life spans of approximately 10,000 to 20,000 hours. Compact fluorescent (CFL) life span varies from 1,200 to 20,000 hours.

I heard that LED life is over 100,000 hours. Is it true?

No, it is not. LEDs may go over 100,000 hours, but only in perfect laboratory conditions. Real life environments are substantially different. Before we answer the lifespan question, let's first define what lifespan of an LED really means. In traditional incandescent lamps, lifespan is defined as a time to the point where 50% of all sampled lamps will go defective. LED is very different. If designed properly, LEDs will work for decades without catastrophic failure. However, the light output will slowly decrease. New industry standards define LED lifespan as a time where luminous intensity reaches 70% of its initial value.

As we mentioned before, the lifespan of the LED depends on thermal management of the LED lamp and/or system. With proper thermal management, smaller lamps like the GU10 will easily reach 30,000 hours and larger lamps (PAR30, street lights, etc.) will go beyond the 50,000 hour mark. Compared to the 2,000 hours lifespan of incandescent lamps or 10,000 hours of compact fluorescents, LEDs are the very clear winners.

Aren't all LEDs the same?

No. LEDs, LED lamps, and LED lighting systems are quite different in design and quality. A good LED lamp or system design is much more efficient than incandescent or compact fluorescent lighting. Unfortunately, most LED lighting available for consumers today is of marginal quality and expensive. Poorly designed luminaries can be relatively inefficient, fail, or deliver poor light characteristics.

Are LED lamps dimmable?

Properly designed LED lamps and/or systems are fully dimmable. However, there are many LED lamps on the market without dimming capabilities that may lead to shortened lifespans. It is important to mention that dimming characteristics of LED lamps are different compared to incandescent. Usually the slope of LED dimming is much steeper.

Does turning an LED lamp on and off shorten its lifespan?

No. Unlike fluorescent light sources (compact or linear), LED light sources are "switch" friendly. Turning them on and off extends their lifespan. A fluorescent lamp's lifespan will be dramatically shortened if turned on and off.

Why do white LED light sources have such a blue hue?

White LED light sources should not have a blue hue unless it is purposely designed in such a way. Some LED systems, for example parking lot lights, are designed to have a blue hue mainly because modern security cameras are more sensitive to bluish white (cooler white). However, a bluish hue is usually a sign of an improperly designed system. If you exceed the maximum power an LED can handle, or if the LED thermal management is designed improperly, an LED light will slowly turn to the blue spectrum. A good example is found in many LED based flashlights. LEDs within flashlights are overdriven on purpose and thermal management is usually very basic in order to make them more affordable. Overdriving will increase intensity but lifespan goes down to under 3,000 hours. Even so, 3,000 hours is still 30 times more than an incandescent counterpart.

I do not like the quality of light generated by fluorescent light sources. Are LEDs different?

Definitely. LED light sources generate much more pleasant and vibrant light. However, color-rendering properties are not as good as incandescents, especially in the red spectrum.

How efficient are white LEDs?

LED light sources are extremely efficient. Today's best commercially available LED sources can generate close to 90 lumens per watt. Incandescent lamps are typically 10 to 12 lumens per watt, halogen lamps 20 to 25, and fluorescent lamps 40 to 60.

Will LED lighting become more efficient over time?

Yes. Even today we are experimenting with LEDs that are generating close to 150 lumens per watt. We can expect to see such LED light sources on the market within the next 5 years.

Who is Once Innovations™?

A fast growing Minnesota company that's changing the world. Pure and simple, Once Innovations™ designs LED lighting that's better for people and the world they live in.

Products from Once Innovations™ are affordable, made from recycled material, use less energy to make, ship and use, do not contain dangerous mercury or rare metals, last longer, and feature packaging that is reusable and biodegradable.

Some LED's application samples: