

LED versus Traditional Lamps: A fight between unequals

LED lights are far superior to and can easily replace traditional lamps with far higher light output.

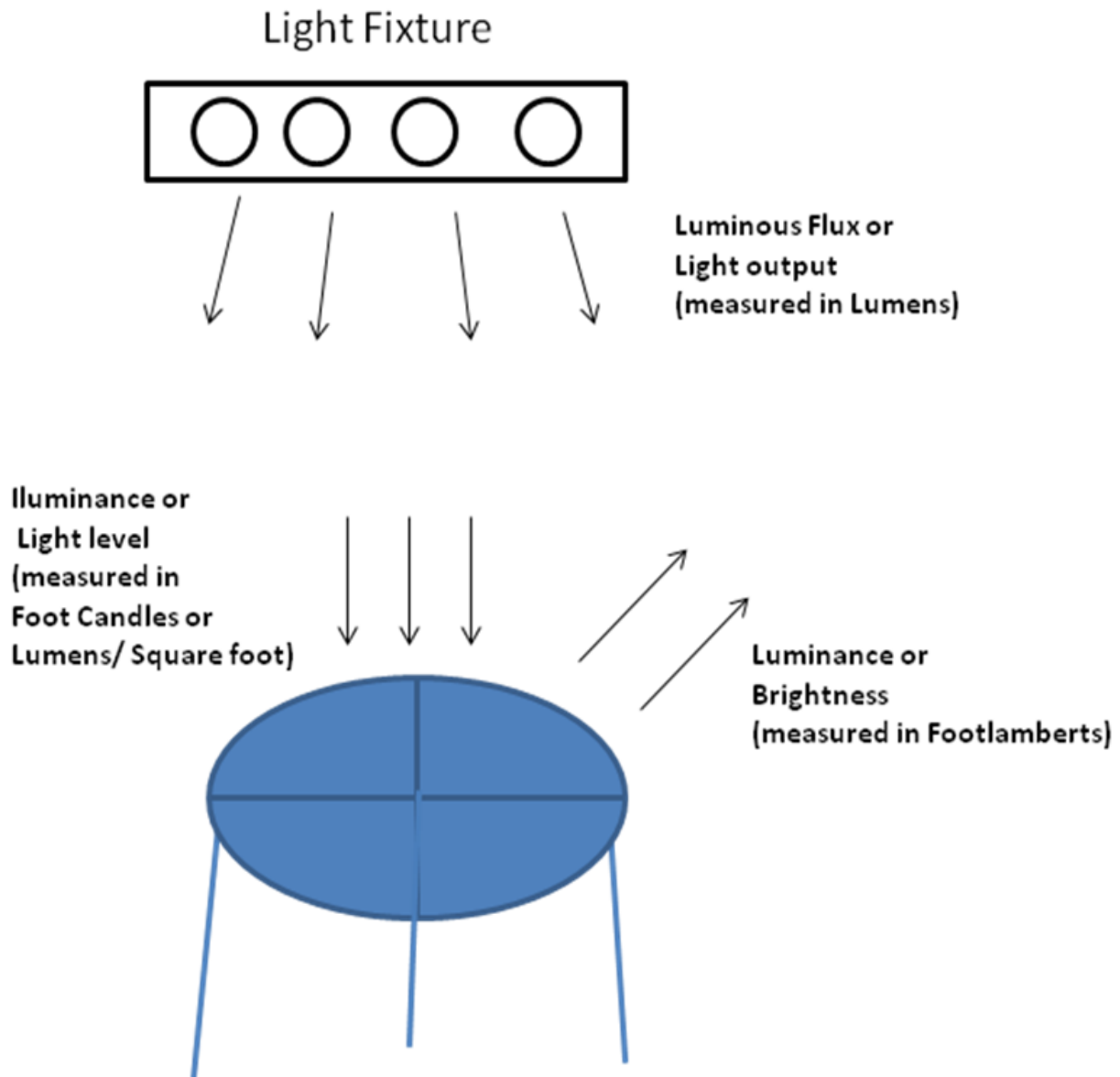
Two of the most important reasons for this are:

- Direct Light by a better Light Distribution Curve (the light is directed where it is needed)
- Scotopic advantage of LED street lights

There are several lumen traps that you must know about. Six of the most important lumen traps are

- 1) Luminary / System efficiency
- 2) Ballast and Driver efficiency
- 3) Scotopic superiority
- 4) Lumen Maintenance & depreciation
- 5) Uniformity of light distribution and light hot spots under traditional lights
- 6) Color reproduction

This article is focused on a holistic comparison of the luminous output of LEDs and other competing technologies.



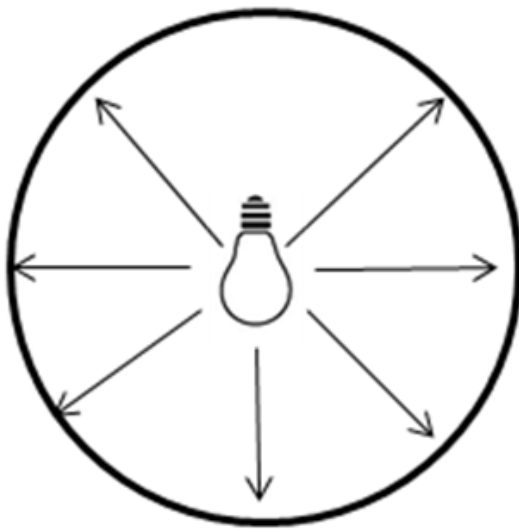
From Photon to Vision

The figure demonstrates why "Luminance" is important. Differences in installation height, air quality, electricity quality, reflectance of the surface mean that most lamps are rated for their Luminous flux or light output. Below is a systematic comparison of LED lights with competing technologies.

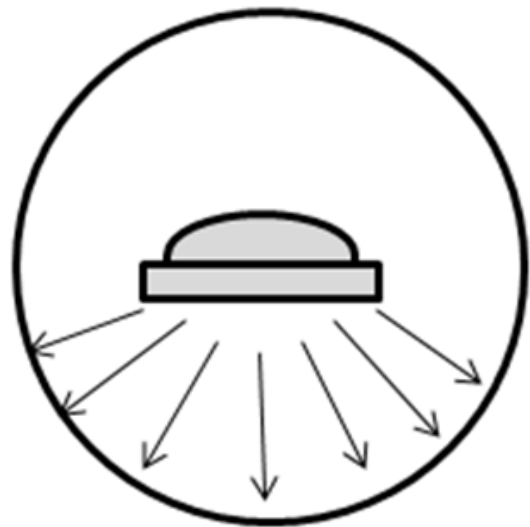
Luminous flux – Source efficiency versus System efficiency

Source efficiency is based on the amount of light produced by a lamp at room temperature. It is distinct from system efficiency that refers to the amount of usable light delivered to the target area. There are several causes why raw lumens produced by a light source are far higher than the actual light delivered on a surface.

Losses due to trapped light - Trapped light and reflection inefficiency are the first source of lower light output from traditional lamps. As long as LEDs had not entered the scene all bulbs produced lights in a 360 degree sphere and the comparison was easy. LEDs changed all that with the directional nature of their light.

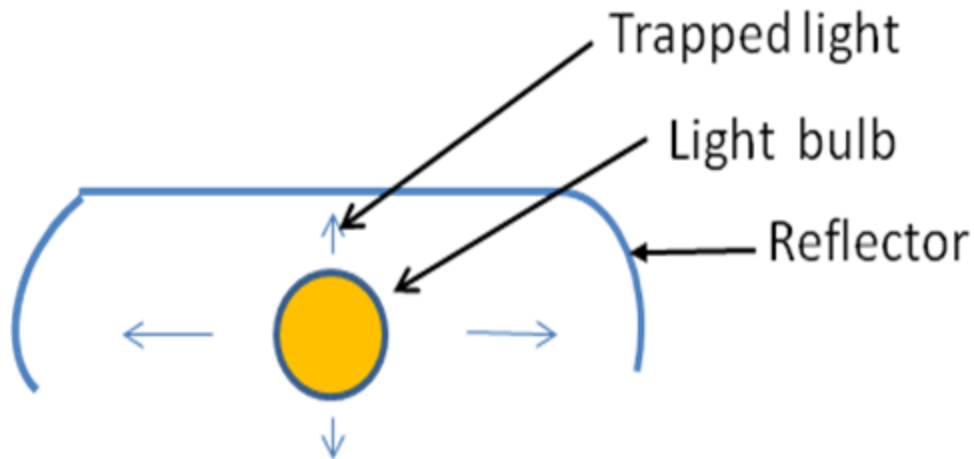


Traditional Light Bulb

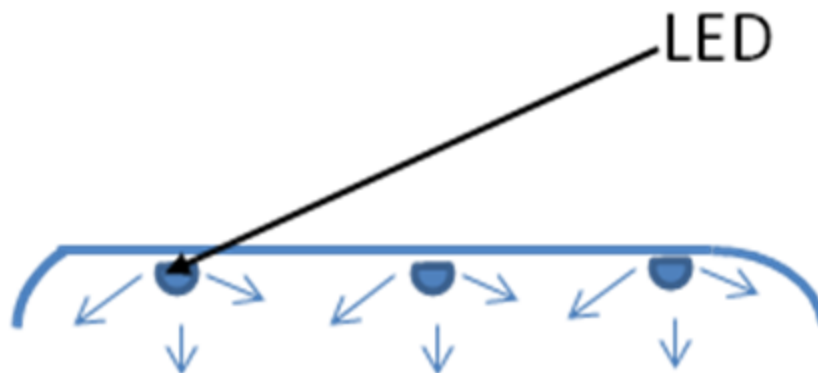


LED Light Bulb

In a traditional bulb (incandescent, metal halide, HPS etc.) a considerable portion of the light output is directed upwards. This light must then be reflected down. The efficacy of the reflector in turn is determined by the quality of finish, operating conditions and ambient temperature. The quality of the reflector and, therefore, the amount of light reflected degrades over time. The actual amount of light coming out of a fixture is, thus, considerably lower. With this fact alone, the fight of metal halide vs LED, LED vs HPS (or any type of HID light vs LED) is an obvious victory to LED, but lets continue.



An HPS lamp has a larger profile, a single source of light and a considerable amount of light trapped in the reflector.



An LED light by contrast has a small profile, several sources of light ensuring better light distribution. All the light is produced and directed downwards. There are no problems of reflector efficiency, aging of reflector coating and consequent loss in light output.

	HPS Lamps	LED Lamps
Light output in Lumens / Watt	101 Lumens / watt	150 Lumens / watt *
Trapped Light	Up to 40%	Nil
Available Lumens	60-80 Lumens / Watt	150 Lumens / Watt

* based on our 100W Retrofit (LED)

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Losses due to Cover and lenses – Lenses and glass covers are needed to direct light and to protect the bulb and reflectors from dust and other damage. Both LED light and traditional fixtures suffer from these losses.

	HPS Lamps	LED Lamps
Light output in Lumen / watt	101 Lumens / Watt	100 Lumens / Watt
Trapped Light	Up to 40%	Nil
Available Lumens 1	60-80 Lumens / Watt	100 Lumens / Watt
Loss Due to glass cover and lenses	20%	20%
Available Lumens 2	48-64 Lumens/ Watt	80 Lumens / Watt

Losses due to operating temperature – The lumen output of LEDs is measured at 25 degrees but the operating junction temperatures of LEDs can be high, resulting in a 10 % decrease in light output. For the same reason LEDs are an [excellent choice for outside lighting](#) in cold climatic conditions as the junction temperature is closer to the optimum operating temperature.

	HPS Lamps	LED Lamps
Available Lumens 3	43-57 Lumens / Watt	72 Lumens / Watt

Ballast and LED driver losses – Ballasts reduce efficiency by 20%. LED drivers are more efficient and reduce performance by 10% or less.

	HPS Lamps	LED Lamps
Available Lumens 3	43-57 Lumens / Watt	72 Lumens / Watt
Ballast / Driver Loss	20%	10%
System Efficiency	35-45 Lumens / Watt	65 Lumens / Watt

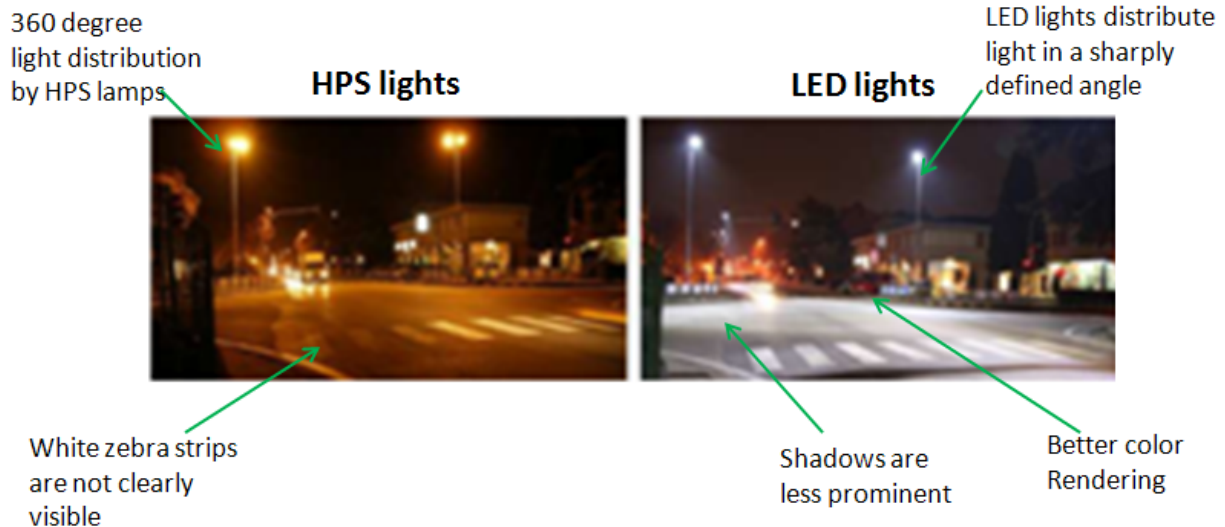
Thus, traditional HPS bulbs are as efficient at producing light as LEDs. When one considers the impact of systemic deficiencies, LEDs stand miles ahead of the competition.

Not all Lumens are equal

Human eye responds better to shorter wavelengths of 510 and 550 nm. These are conspicuous by their absence in HPS lights. Each LED photopic Lumen is equivalent to 2.4 Scotopic lumens (For a detailed analysis of the relationship between photopic and scotopic Lumens please refer to our article on Pupil

Lumens). When it comes to Scotopic equivalent lumens HPS lamps are no match for LED lights with richer light spectrum.

Visual evidence of the superiority of LED lights



A colleague sent the two pictures above. The image on the left shows illumination of a street with HPS lights while that on the right shows the impact of LED street lights. Several advantages of LED lighting systems are immediately visible. LED lights have significantly less glare when designed with a good light distribution curve (LDC), a more uniform light distribution, fewer shadows, and improved visibility. The best part is that this improvement is obtained with fewer lumens and 40 % or more savings in electricity and maintenance costs.

What Does The Office of Energy Efficiency and Renewable Energy Say?

1) Luminaire Efficiency - sample data from the EERE website LED lights reign supreme.

	HPS	Metal Halide	LED
System Watts	183	208	153

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Initial Lamp Lumens	16,000	11,700	N/A
Downward Efficiency	70%	81%	100%
Downward Lumens	11,200	9,477	10,200
Luminaire Efficiency	61 Lumens/Watt	46 Lumens/Watt	67 Lumens/Watt

2) Uniformity of light – LEDs win hands down

	HPS	LED
Power Consumption (Watts)	97 (lamp and ballast power)	72
Average Light Level (Foot candles)	3.5	3.6
Maximum Light Level (Foot candles)	7.5	5.1
Minimum Light Level (Foot candles)	1.3	2
Uniformity (ratio between maximum and minimum light levels)	6:1	2.7:1



LED outdoor light project – I-35W bridge, Minneapolis

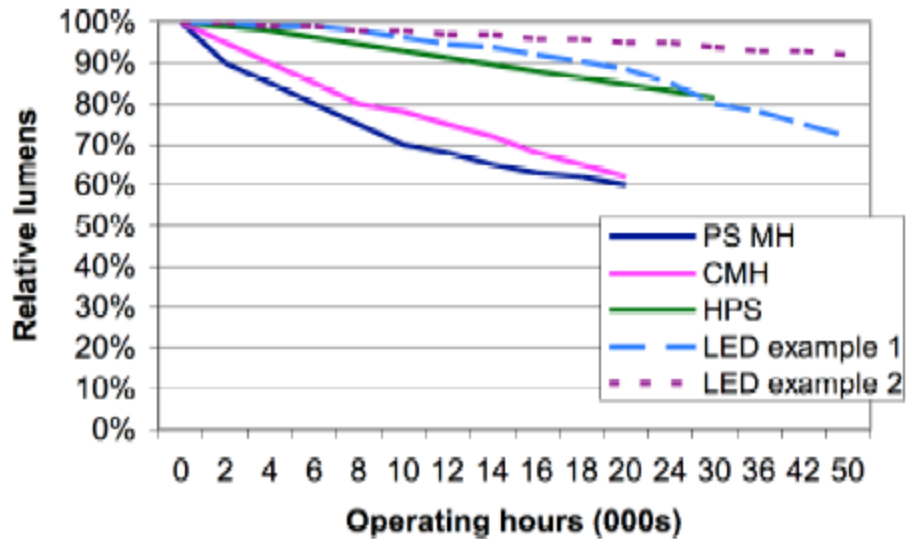
Photo credit -DOE's Office of Energy Efficiency and Renewable Energy.

The picture shows the advantage of uniform lumen distribution achieved by outdoor LED lights. What actually happens is that the upward directed light in a traditional luminaire is reflected straight down. This causes a 'hotspot' to form right below the luminaire while areas further away from the bulb have poor light intensity. These hotspots can be clearly seen in the picture of the I 35 W bridge. In this case, the improvement in lighting was accompanied with a 13 % savings in energy consumption, long maintenance free life span and the possibility of pairing the LED light fixture with smart energy saving technologies in the future.

Also, note the light intensity in different stretches of the road. The ends of the bridge (with several lanes of merging traffic) are lit by closely spaced 400 Watt HPS lights. The adjacent road on the left is lit by 20 Watt HPS lamps and the bridge itself is lit by 290 Watt LED lights. HPS lamps barely hold a candle to their modern challengers.

3) Lumen Maintenance

Lumen maintenance is another area that decision makers need to consider. The human eye can adapt well to up to 30% reduction in light levels. When light levels fall below the 30 % threshold reduction in light levels become evident and vision is compromised. Thus, lights need to be designed based on average lumens over the useful life of a light.



Credit -DOE's Office of Energy Efficiency and Renewable Energy

A comparison of the lumen maintenance data of different types of lights is shown in the graph above. A summary of the abbreviations, common name, and life till 70% of peak light output levels is given below.

PSMH – Pulse Start metal halide – 12,000 hours

CMH – Ceramic Metal Halide – 16,000 hours

HPS – High Power Sodium – 24,000 hours

LED – Light Emitting Diode – 50,000 hours and more.

A pulse start metal halide lamp with a peak light output of 10000 lumens will require that the fixtures be designed for 7000 lumens. This would require compromises in lamppost height, ground coverage and reduced spacing of light fixtures resulting in increased costs. A long life LED light on the other hand, with a similar peak output would, need fixture design for 9000 lumens.

Color Reproduction - The subtle trap

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In areas like car parking color discrimination is important to identify the right car and to instill a feeling of safety in the users of the facility. Parking facilities are increasingly opting for higher CRI lights to serve the needs of their clients. The comparative CRI of different lighting technologies are

	LPS	HPS	Metal Halide	LED
CRI	0	22	65	75 or higher



Uniform lighting with LED parking area lights, Light hot spots under HPS lights can be seen in the image above. The excellent color reproduction with LED lights can be evaluated by observing the color of the grass.

(Public domain image from– The Office of Energy Efficiency and Renewable Energy

http://apps1.eere.energy.gov/buildings/publications/pdfs/alliances/outdoor_area_lighting.pdf Photo credit - Beta Lighting)

Each LED fixtures in the picture above produces 8040 lumens while HPS lamps on the right produce 19,000 lumens each. The picture tells quite a different story. Comparing plain lumens can clearly be highly misleading. (please note - today we would use our 100W Retrofit rated at 15,500 lumens)

Perhaps, more important than the energy savings, reduction in carbon-dioxide emissions and the greener grass is the fact that users of [led parking lot lights](#) reported a 300% increase in the feeling of safety!

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With LED lighting products from MyLEDLightingGuide becoming increasingly popular we believe that not just the users but climate scientists and vast human populations dependent on rain fed agriculture will find the world to be a safer place.

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