Eco Sol Energy

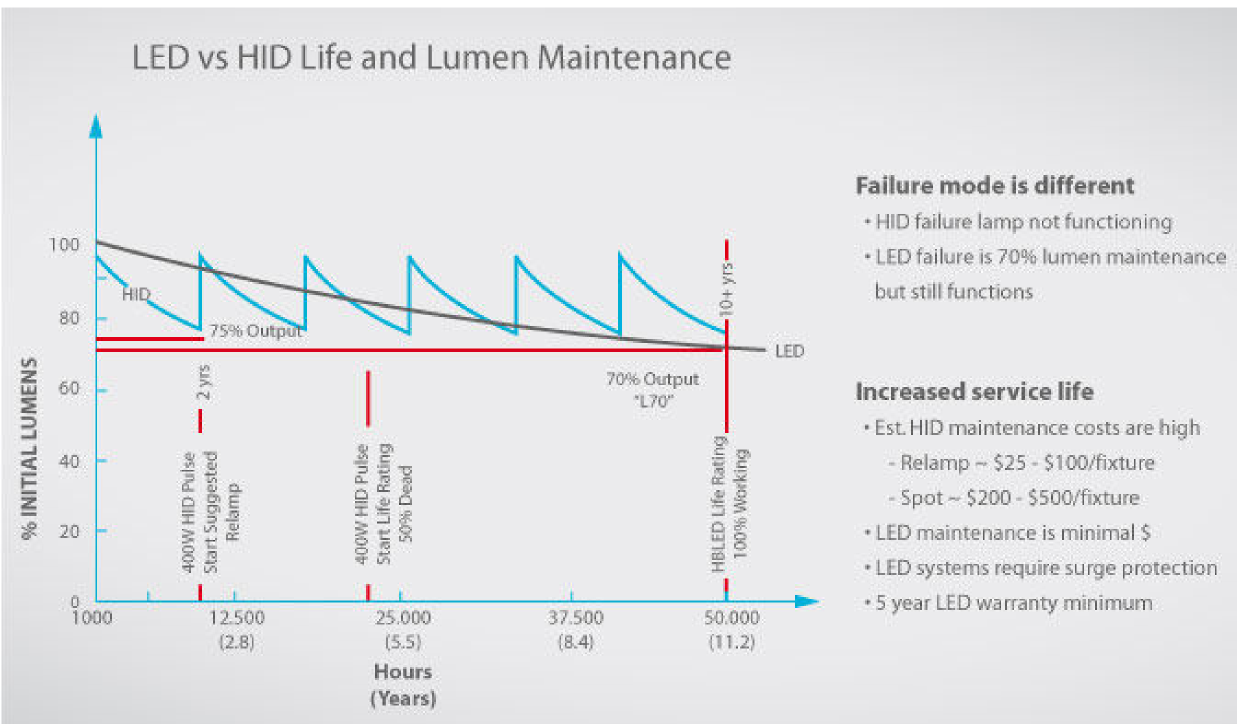
Street lighting technology comparison

Street lighting today

Today, street lighting commonly uses **high-intensity discharge lamps, often HPS high pressure sodium lamps**. Such lamps provide the greatest amount of photopic illumination for the least consumption of electricity. However when scotopic/photopic light calculations are used, it can been seen how inappropriate HPS lamps are for night lighting. White light sources have been shown to double driver peripheral vision and increase driver brake reaction time at least 25%. When S/P light calculations are used, HPS lamp performance needs to be reduced by a minimum value of 75%.

A study comparing metal halide and high-pressure sodium lamps showed that at equal photopic light levels, a street scene illuminated at night by a metal halide lighting system was reliably seen as brighter and safer than the same scene illuminated by a high pressure sodium system.

New street lighting technologies, such as induction or **LED lights, emit a white light that provides high levels of scotopic lumens allowing street lights with lower wattages and lower photopic lumens to replace existing street lights**. Formal specifications around Photopic/Scotopic adjustments for different types of light sources enables municipalities and street departments to test, implement and benefit from this new technologies.
Read more about Photopic and scotopic vision here.



Street lighting technology comparison

light technology	life time	lumens per watt	color temperature	CRI (color rendering index)	ignition time	considerations
incadescent light	1.000 - 5.000	11 - 15	2.800K	40	instant	very inefficient, short life time
mercury vapour light	12.000 - 24.000	13 - 48	4.000K	15 - 55	up to 15 min	very inefficient, ultraviolet radiation, contains mercury
metal halide light	10.000 - 15.000	60 - 100	3.000-4.300K	80	up to 15 min	high maintenance UV radiation, contains mercury and lead, risk of bursting at the end of life
high pressure sodium light	12.000 - 24.000	45 - 130	2.000K	25	up to 15 min	low CRI with yellow light, contains mercury and lead
low pressure sodium light	10.000 - 18.000	80 - 180	1.800K	0	up to 15 min	low CRI with yellow light, contains mercury and lead
fluorescent light	10.000 - 20.000	60 - 100	2.700-6.200K	70 - 90	up to 15 min	UV radiation, contains mercury, prone to glass breaking, diffused non-directional light
compact fluorescent light	12.000 - 20.000	50 - 72	2.700-6.200K	85	up to 15 min	low life / burnout, dimmer in cold weather (failure to start), contains mercury
induction light	60.000 - 100.000	70 - 90	2.700-6.500K	80	instant	higher initial cost, limited directionality, contains lead, negatively affected by heat
LED light	50.000 - 100.000	70 - 150	3.200-6.400K	85 - 90	instant	relatively higher initial cost

Incandescent lamps

Incandescent Lamps are "standard" electric light bulbs that were introduced more than 125 years ago by Thomas Edison. They have the **lowest initial cost, good color rendering and are notoriously inefficient**. They typically have short life spans and use significantly more watts than CFLs and halogen lamps do to produce the same lumens, or light output. Incandescent technology produces light by heating up a metal filament enclosed within the lamp's glass.

More than ninety percent of the energy used by an incandescent light bulb escapes as heat, with less than 10% producing light. Their use is most common in areas prone to frequent theft or vandalism of light fixtures. In these locations a very high rate of replacement may make a case for use of these cheap light bulbs. Anywhere else they are too wasteful to make sense. After all, 5 % efficiency and a few hundred hours lifespan are difficult to consider when replacement with LED systems use 7 times less energy.

High Intensity Discharge (HID) Lamps include:

- Mercury Vapor lamps (outdated and almost extinct)
- Metal Halide lamps
- High Pressure Sodium lamps (HPS)

Mercury Vapor Lamps

Mercury Vapor Lamps were introduced in 1948. It was deemed a major improvement over the incandescent light bulb, and shone much brighter than incandescent or fluorescent lights. Initially people disliked them because their bluish-green light. Other disadvantages are that a significant portion of their **light output is ultraviolet, and they "depreciate"**; that is, they get steadily dimmer and dimmer with age while using the same amount of energy.

Mercury lamps developed in the mid 1960s were coated with a special material made of phosphors inside the bulb to help correct the lack of orange/red light from mercury vapor lamps (increasing the color rendering index(CRI)). The UV light excites the phosphor, producing a more "white" light. These are known as "color corrected" lamps. Most go by the "DX" designation on the lamp and have a white appearance to the bulb. As of 2008, the sale of new mercury vapor streetlights and ballasts was banned in the United States by the Energy Policy Act of 2005, although the sale of new bulbs for existing fixtures do continue.

Metal Halide Lamps

In recent years, metal halide lamp (MH) streetlights have illuminated roadways, parking lots and also warehouses, schools, hospitals and office buildings. Unlike the old mercury lights, metal halide casts a true white light. It is not nearly as popular as its sodium counterparts, as it is newer and less efficient than sodium. MH lamps operate at high temperatures and pressures, **emit UV light and need special fixtures to minimize risk of injury or accidental fire in the event of a so called 'non passive failure'** – or when the lamp bursts at the end of the useful life. A small fire at the Harvard University greenhouse was started by one such lamp that was not properly contained. These cannot start up at full brightness as the gases in the lamp take time to heat up.

Additionally, every time the light is switched on a re-strike time of 5 to 10 minutes is needed before the lamp can be switched on. These lamps are thus not suited to situations when intelligent control systems are used to switch lights on and off. MH lamps suffer color shift as they age though this has been improving. Actual life expectancy is about 10,000 to 12,000 hours on average.The mercury and lead content of these lamps is also a serious issue. A single 1500 watt lamp may contain as much as 1000 mg of mercury. High cost and low life hours has kept them from becoming popular municipal lighting sources even though they have a much improved CRI around 85.

High Pressure Sodium (HPS) lamps

HPS lamps were introduced around 1970 and are one of the more popular street lighting options, the most efficient light source when compared to mercury vapor and metal halide lamps (on a 'lumen/ watt' scale). The disadvantage is that they produce narrow spectrum light mostly a sickly yellow in color. These lights have a very **low color rendering Index and do not reproduce colors faithfully**. These lights do not find favor with police departments as it is difficult to determine the color of clothes and vehicles of suspects from eye witness accounts in the event of a crime. Color-corrected sodium vapor lamps exist but are expensive. These "color corrected" HPS lamps have lower life and are less efficient.

There are two types of sodium vapor streetlights: high-pressure (HPS) and low-pressure (LPS). Of the two, HPS is the more-commonly used type. **Low Pressure Sodium** lights are even more efficient than HPS, but produce only a single wavelength of yellow light, resulting in a Color Rendering Index of zero, meaning colors cannot be differentiated. LPS lamp tubes are also significantly longer with a less intense light output than HPS tubes, so they are suited for low mounting height applications, such as under bridge decks and inside tunnels, where the limited light control is less of a liability and the glare of an intense HPS lamp could be objectionable.

Another issue of HPS lights is that they contain 1 to 22 mg of **mercury** for a 100 watt bulb with an average of 16 mg per bulb. They also contain **lead**. Unsafe disposal of these bulbs can lead to significant exposure of human beings and wild life to mercury contaminated water and food. Issues with mercury contamination and customer preference for full spectrum light has been fuelling the replacement of these lights particularly in areas like self managed residential complexes where people can directly pay for the quality of light.

Fluorescent lamps

The fluorescent lamp first became common in the late 1930s. These lamps are a form of discharge lamp where a small current causes a gas in the tube to glow. The typical glow is strong in ultraviolet but weak in visible light. However, the glass envelope is coated in a mixture of phosphors that are excited by the ultraviolet light and emit visible light. Fluorescent lamps are much more efficient than incandescent lamps, but less efficient than High Pressure Sodium.

The major problems with standard fluorescent lamps for street lighting is that they are large, and produce a diffused non-directional light. They are also susceptible to **low voltage failure, prone to breakage of glass parts and contain harmful mercury**. Therefore the fixtures needed to be large, and could not be mounted more than 20–30 feet above the pavement if they were to produce an acceptable light level. Fluorescent lamps quickly fell out of favor for main street lighting, but remained very popular for parking lot and outside building illumination for roadside establishments.

Compact fluorescent lamp

Compact fluorescent lamps (CFL) have been used more frequently as time has improved the quality of these lamps. These lamps have been used on municipal walkways and street lighting though they are still rare at this time. Improvements in reliability still need to be made. Some issues with them are **limited lumen output, high heat build up** in the self contained ballast, **low life/burnout due to frequent cycling (on/off) of the lamp**, and the problem where most fluorescent sources become **dimmer in cold weather (or fail to start at all)**. They also contain harmful mercury. CFL efficiency is high and CRI is excellent around 85. CFL produces a color temperature around 3000 K with its light being "soft white" around that color temperature. Higher color temperatures are available.

Induction lights

Induction based fixtures are relatively new to the market. Induction lamps use radio frequency or microwaves to create induced electrical fields, which in turn excite gases to produce light. Induction lights have a **rapid start-up** and work at peak efficiency with minimal warm-up time, much like LED technology. This technology has some advantages versus HPS technology in the areas of efficiency and life cycle, however, initial cost barriers and the rapidly evolving nature of LED technology have led to limited adoption of induction based roadway lighting systems. Another limitation of Induction Lighting is that it has **limited directionality** when compared to LEDs. The life of induction light is negatively affected by heat and they also contain lead.

LED lights

Light emitting diodes are rapidly developing in light output, color rendering, efficiency, and reliability.
Achieving good maintenance-free thermal management in an often hostile environment while keeping product competitive is the largest challenge, which only few manufacturers managed to achieve. This **latest high quality LED technologies are already exceeding all other available technologies by all technical parameters**. According to its numerous advantages, even higher initial cost quickly pays for itself due to vastly reduced cost of electricity and maintenance. But **to fully benefit from outstanding advantages it is important to educate and recognize the difference between low quality and latest state of the art LED technologies, since low quality LED alternatives have quickly spread all over the world**.

Difference between low and high quality LED street lights

LED technology has developed dramatically over the last few years. **The production of LED lighting luminaire is an extremely difficult process** that requires a combination of advanced production lines, top quality materials and high-precision manufacturing processes.

Not many companies in the world meet the qualitative standards in the production of LED lamps. Because LED technology is increasing, there are a lot of inexperienced producers of LED street lights with very poor quality on the market.

Poor quality LED street lights can be worse than other types of existing energy-saving lamps on the market, while high-quality LED street lights exceed other types of street lighting in all technical parameters.

There is currently less **than 100 experienced manufacturers of LED street lights** in the world, of which **less than 10 are able to produce high-quality LED street lamp with the highest quality standards**. **Those manufacturers are optimally exploiting full benefits of LED technology**.

General benefits of high quality LED street lights

Below listed benefits of LED street lighting are related only to latest, high quality LED street lights:

Less energy consumption

LED street lights use **40-80% less electricity** and have at least **5 times the life expectancy than regular High Pressure Sodium (HPS) fixtures**. LED lamps are **7 times more energy efficient than incandescent and twice as efficient as fluorescent lamps.**

Higher efficiency and low light pollution due to directional light

LED street lights with a lower lumen output can replace conventional lamps with a higher output. For example, a 30W LED street light can often replace an 80W High Pressure Sodium lamp. The reason for this is directionality. LED street lamps are very directional and the **light output is much more even then by other street lamps**. Also there is little or **no hot spot under the LED lamp**. The light emitted from the LED lamp is directed downwards, spread throughout the entire area it covers. This means that a **lower amount of light is needed to properly illuminate the area**. This also **dramatically reduces light pollution**, which affects the mood of human beings, navigation in birds and insects, mating behavior in animals and flowering in plants.

Long life – up to 100.000 hours

LED street lights last **much longer than conventional lamps (3 to 8 times longer)**. This results in less expense in replacing the lights themselves but also the labor to replace the lamp is needed less often. This provides a great cost savings by itself.
Also the loss of brightness or lumen depreciation is slower over the life of an LED lamp than that of a sodium or other lamp. So not only does the LED have a longer life span than the conventional lamp, but **it stays brighter longer than other lamps**. The long life span reduces maintenance expenses and makes these bulbs particularly suitable for difficult to reach locations and for streetlights where maintenance costs can be significant.

Great operating characteristics

LED operate at lower temperatures, are not sensitive to low temperature and unaffected by on off cycling. This makes **them safer, more efficient in cold environments** (outdoor lights, refrigerator lights and cold room lights) and better for applications requiring frequent switching on and off lights. These bulbs are **shocks and vibrations resistant** making them the best choice for places like bridges.

Reducing carbon footprint

The carbon footprint of LED street lights is smaller than other lights due to lower energy usage. Moreover LEDs last 4 to 10 times longer than any other bulbs, further reducing the carbon footprint of manufacture over the life time.

Darksky friendly

Because of the **directional light**, light is carefully distributed exactly where it is meant to go and therefore there is no or little light which is wasted by illuminating the night sky. This is a considerable plus especially if the local community has a Darksky Initiative.

Natural light specter – Color Rendering Index

LED street lamps with color temperature 3.500-4.200 K are rendering more natural light than the yellow of sodium lamps or green of flourescent streetlights. Also **no UV or IR radiation** is emitted from the LED street lamps. Color rendering index **(CRI) is high (80-90)** and displays natural colors of illuminated objects.

Free of harmful substances and lower environmental impact when used up

LED luminaires contain no harmful substances, like mercury, lead or other hazardous chemical and gasses. Spent LED lamps can be thrown away without any special handling or disposal requirement,since **they are recyclable and environmentally friendly**. Other light often have hazardous materials such as lead and mercury which require special handling and waste management procedures which have both economic and environmental costs.

Easily controllable

The light is easily controllable with intelligent systems. The light can be turned on and off instantly and can be dimmed for added energy savings at dawn, dusk, and also during hours of low traffic. **Switching on-off and dimming does not affect the life-time** of the luminaire as in the case of CFL lights.

Complete the financial analysis

A preliminary analysis of the financial payback can be done pretty quickly. The formula for Simple Financial Payback is ,

Example:

Replacing (1,000) 250W HPS Cobra-head Style Street Lights with Rs.6 kWh energy rate. Initial Cost:

•Cost of new LED luminaries = Rs.18,000 X 1,000 = Rs.1,80,00,000

•Cost of installation = (4 luminaries per hour installed at Rs.12000 per hour for two person crew) Rs.3000 X 1,000 = Rs.30,00,000

•Total Initial Cost = Rs.2,10,00,000

•Annual Energy Savings = 1,000 street lights X 4,000 hours per year X 175W per luminary savings X Rs.6 kWh rate = Rs.42,00,000

•Annual Maintenance Savings = 1,000 street lights X Rs.1800 per fixture per year savings (assuming 4 year cycle of HID spot relamping, cleaning, changing igniters, ballasts, photocells, etc. vs. LED 10 year cleaning cycle and occasional photocell and driver replacements) = Rs.18,00,000.

Total Annual Savings = Rs.42,00,000 + Rs.18,00,000 = Rs.60,00,000

Simple Payback = Rs.210,00,000/Rs.60,00,000 = 3.5 years.

Typically programs with paybacks under 5 years should certainly be done and paybacks over 10 years are usually deferred. However, because of the urgency of global climate change, many communities (especially where the electrical energy source is fossil fuel based) are even proceeding with energy saving programs that have very long financial payback periods. Also if the funding source is a state grant, it will normally make sense for the city to proceed with the project regardless of the payback. If the payback seems favorable it will probably be desirable to complete a more rigorous financial analysis to determine Return On Investment (ROI) and the Net Present Value (NPV) of the project.

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Project Solution Supplier

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