1. HID Mercury lamps produce visible light mainly in the:

a) Blue-white colour region

b) Blue-green colour region

c) Blue-red colour region

d) Blue-yellow colour region

Clear mercury lamps produce white light with a bluish-green tint

Sodium vapor process (occasionally referred to as yellowscreen) is a film technique that relies on narrowband characteristics of LPS lamp. Color negative film is typically not sensitive to the **yellow** light from an LPS lamp, but special black-and-white film is able to record it.

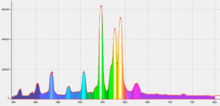
**Metal-halide lamp**

From Wikipedia, the free encyclopedia

[Jump to navigation](https://en.wikipedia.org/wiki/Metal-halide_lamp#mw-head)[Jump to search](https://en.wikipedia.org/wiki/Metal-halide_lamp#p-search)

[](https://en.wikipedia.org/wiki/File:Metaalhalidelamp.JPG)

Metal halide lamp bulb (type /O with arc tube shield)

[](https://en.wikipedia.org/wiki/File:Metal_Halide_Rainbow.png)

[Spectrum](https://en.wikipedia.org/wiki/Spectrum) of a 175 watt metal halide lamp

[](https://en.wikipedia.org/wiki/File:Mhlightsbaseball.JPG)

Metal halide floodlights at a baseball field

[](https://en.wikipedia.org/wiki/File:Picture_of_Charles_Proteus_Steinmetz.jpg)

Invented by [Charles Proteus Steinmetz](https://en.wikipedia.org/wiki/Charles_Proteus_Steinmetz) in 1912 and used in almost every city in the world.

A **metal-halide lamp** is an electrical lamp that produces light by an [electric arc](https://en.wikipedia.org/wiki/Electric_arc) through a gaseous mixture of vaporized [mercury](https://en.wikipedia.org/wiki/Mercury_(element)) and [metal halides](https://en.wikipedia.org/wiki/Metal_halides)[[1]](https://en.wikipedia.org/wiki/Metal-halide_lamp#cite_note-Hordeski-1)[[2]](https://en.wikipedia.org/wiki/Metal-halide_lamp#cite_note-Grondzik-2) (compounds of metals with [bromine](https://en.wikipedia.org/wiki/Bromine) or [iodine](https://en.wikipedia.org/wiki/Iodine)). It is a type of [high-intensity discharge](https://en.wikipedia.org/wiki/High-intensity_discharge) (HID) [gas discharge lamp](https://en.wikipedia.org/wiki/Gas_discharge_lamp).[[1]](https://en.wikipedia.org/wiki/Metal-halide_lamp#cite_note-Hordeski-1) Developed in the 1960s, they are similar to [mercury vapor lamps](https://en.wikipedia.org/wiki/Mercury_vapor_lamp),[[1]](https://en.wikipedia.org/wiki/Metal-halide_lamp#cite_note-Hordeski-1) but contain additional metal halide compounds in the [quartz](https://en.wikipedia.org/wiki/Quartz) arc tube, which improve the efficiency and [color rendition](https://en.wikipedia.org/wiki/Color_rendering_index) of the light. The most common metal halide compound used is [sodium iodide](https://en.wikipedia.org/wiki/Sodium_iodide). Once the arc tube reaches its running temperature, the sodium dissociates from the iodine, adding orange and reds to the lamp's spectrum from the sodium D line as the metal ionizes. As a result, metal-halide lamps have high [luminous efficacy](https://en.wikipedia.org/wiki/Luminous_efficacy) of around 75–100 lumens per watt,[[2]](https://en.wikipedia.org/wiki/Metal-halide_lamp#cite_note-Grondzik-2) which is about twice that of mercury vapor lights and 3 to 5 times that of [incandescent lights](https://en.wikipedia.org/wiki/Incandescent_light)[[1]](https://en.wikipedia.org/wiki/Metal-halide_lamp#cite_note-Hordeski-1) and produce an intense white light. Lamp life is 6,000 to 15,000 hours.[[2]](https://en.wikipedia.org/wiki/Metal-halide_lamp#cite_note-Grondzik-2)[[3]](https://en.wikipedia.org/wiki/Metal-halide_lamp#cite_note-TERI-3) As one of the most efficient sources of high [CRI](https://en.wikipedia.org/wiki/Color_rendering_index) white light, metal halides as of 2005[[update]](https://en.wikipedia.org/w/index.php?title=Metal-halide_lamp&action=edit) were the fastest growing segment of the lighting industry.[[1]](https://en.wikipedia.org/wiki/Metal-halide_lamp#cite_note-Hordeski-1) They are used for wide area overhead lighting[[2]](https://en.wikipedia.org/wiki/Metal-halide_lamp#cite_note-Grondzik-2) of commercial, industrial, and public spaces, such as parking lots, sports arenas, factories, and retail stores,[[1]](https://en.wikipedia.org/wiki/Metal-halide_lamp#cite_note-Hordeski-1) as well as residential [security lighting](https://en.wikipedia.org/wiki/Security_lighting) and [automotive headlamps](https://en.wikipedia.org/wiki/Automotive_headlamp) ([xenon headlights](https://en.wikipedia.org/wiki/Xenon_HID_headlamp)).

The lamps consist of a small [fused quartz](https://en.wikipedia.org/wiki/Fused_quartz) or [ceramic](https://en.wikipedia.org/wiki/Ceramic) [arc tube](https://en.wikipedia.org/wiki/Arc_tube) which contains the gases and the arc, enclosed inside a larger glass bulb which has a coating to filter out the [ultraviolet light](https://en.wikipedia.org/wiki/Ultraviolet_light) produced.[[1]](https://en.wikipedia.org/wiki/Metal-halide_lamp#cite_note-Hordeski-1)[[3]](https://en.wikipedia.org/wiki/Metal-halide_lamp#cite_note-TERI-3) They operate at a pressure between 4 and 20 atmospheres, and require special fixtures to operate safely, as well as an electrical [ballast](https://en.wikipedia.org/wiki/Ballast_(electrical)). Metal atoms produce most of the light output.[[1]](https://en.wikipedia.org/wiki/Metal-halide_lamp#cite_note-Hordeski-1) They require a warm-up period of several minutes to reach full light output.[[2]](https://en.wikipedia.org/wiki/Metal-halide_lamp#cite_note-Grondzik-2)

3. The metal halide HID lamp includes metal halides inside the arc tube:

a) To give a longer lamp life

b) To reduce the overall size of the bulb

c) To reduce the re-strike time

d) To improve the colour rendition

Electronic ballasts usually supply power to the lamp at a frequency of 20,000 Hz or higher, rather than the [mains frequency](https://en.wikipedia.org/wiki/Utility_frequency) of 50 – 60 Hz; this substantially eliminates the [stroboscopic effect](https://en.wikipedia.org/wiki/Stroboscopic_effect) of flicker, a product of the line frequency associated with fluorescent lighting (see [photosensitive epilepsy](https://en.wikipedia.org/wiki/Photosensitive_epilepsy)). The high output frequency of an electronic ballast refreshes the phosphors in a fluorescent lamp so rapidly that there is no perceptible flicker. The flicker index, used for measuring perceptible light modulation, has a range from 0.00 to 1.00, with 0 indicating the lowest possibility of flickering and 1 indicating the highest. Lamps operated on magnetic ballasts have a flicker index between 0.04–0.07 while digital ballasts have a flicker index of below 0.01.[[6]](https://en.wikipedia.org/wiki/Electrical_ballast#cite_note-nlpip-6)

Because more gas remains ionized in the arc stream, the lamp operates at about 9% higher [efficacy](https://en.wikipedia.org/wiki/Luminous_efficacy) above approximately 10 kHz. Lamp efficiency increases sharply at about 10 kHz and continues to improve until approximately 20 kHz.[[7]](https://en.wikipedia.org/wiki/Electrical_ballast#cite_note-7) Electronic ballast retrofits to existing street lights had been tested in some Canadian provinces circa 2012[[8]](https://en.wikipedia.org/wiki/Electrical_ballast#cite_note-8); since then LED retrofits have become more common.

With the higher efficiency of the ballast itself and the higher lamp efficacy at higher frequency, electronic ballasts offer higher system efficacy for low pressure lamps like the [fluorescent lamp](https://en.wikipedia.org/wiki/Fluorescent_lamp). For [HID lamps](https://en.wikipedia.org/wiki/HID_lamp), there is no improvement of the lamp efficacy in using higher frequency, but for these lamps the ballast losses are lower at higher frequencies and also the light depreciation is lower, meaning the lamp produces more light over its entire lifespan.[[*citation needed*](https://en.wikipedia.org/wiki/Wikipedia:Citation_needed)] Some HID lamp types like the [ceramic discharge metal halide lamp](https://en.wikipedia.org/wiki/Ceramic_discharge_metal_halide_lamp) have reduced reliability when operated at high frequencies in the range of 20 – 200 kHz; for these lamps a square wave low frequency current drive is mostly used with frequency in the range of 100 – 400 Hz, with the same advantage of lower light depreciation.[[*citation needed*](https://en.wikipedia.org/wiki/Wikipedia:Citation_needed)]

Application of electronic ballasts to HID lighting is growing in popularity. Most newer generation electronic ballasts can operate both [high pressure sodium (HPS) lamps](https://en.wikipedia.org/wiki/Sodium-vapor_lamp#High-pressure_sodium) as well as [metal-halide lamps](https://en.wikipedia.org/wiki/Metal-halide_lamp), reducing costs for building managers who use both types of lamps. The ballast initially works as a starter for the arc, supplying a high-voltage impulse and, later, it works as a limiter/regulator of the electric flow inside the circuit. Electronic ballasts also run much cooler and are lighter than their magnetic counterparts.[[6]](https://en.wikipedia.org/wiki/Electrical_ballast#cite_note-nlpip-6)

Electronic ballasts typically work in the frequency range of:

a) 1000 to 5000 Hz

b) 2000 to 10000 Hz

c) 25000 to 40000 Hz

d) 10000 to 20000 Hz

**Voltage Variations And Arc Discharge Lamps**

Mar 1, 1999 12:00 PM, By Joseph R. Knisley, Senior Editorial Consultant

*How do line voltage excursions affect HID and fluorescent ballast regulation and lamp operation? Are the effects different for the two lamp/ballast systems?*

Sure, manufacturers design their arc discharge lamps to perform best when operated on a line voltage within the range of ballast design (indicated on the ballast nameplate). But what about line voltage excursions? How do they affect HID and fluorescent lamps/ballast systems? Will the effects differ for each type of lamp and/or ballast? Can you troubleshoot problems based on behavioral symptoms? Read on and find out.

**Fluorescent ballast behavior during voltage excursions.** If your supply voltage is too low for a fluorescent lamp, it will have difficulty starting, especially if the humidity is high. This condition can cause the lamp to flash off and on without starting, which may slowly deteriorate the lamp's electrodes. Also, because of the reduced energy level in the

mercury arc, you'll get less visible light.

What about too high a voltage? With a preheat or rapid start lamp, it will sometimes operate as an instant start lamp. As a result, the lamp's cathode coating will deteriorate because of the high-voltage pulses delivered to the cathode. Lumen maintenance will also suffer. At the same time, higher than normal lamp operating currents can cause premature lamp failure and overheating of ballasts.

A temporary voltage drop (sag) on the power system, even for a few cycles, will cause a fluorescent lamp to "drop out." If the voltage drops below 80% of the rated level of a rapid-start ballast (and most other ballasts), the arc stream within the lamp becomes unstable and extinguishes. Fortunately, the lamp will restrike almost immediately upon restoration of full voltage.

**New versus old fluorescent ballast systems.** Older electronic fluorescent ballasts can be more sensitive than their magnetic counterparts to a surge or a swell. These surges (and poor heat sinking of transistors) were main causes of electronic ballast failures in the early '80s. Designs now employ filters and voltage limiters at their input to protect internal transistors and rectifiers from electrical line surges.

Manufacturers design today's units with tight regulation, so there's virtually no change in light output over the entire 610% voltage input range to the ballast. This regulation assures the ballast maintains specified lighting levels.

**HID ballast behavior during voltage excursions.** With reactor ballasts, a +/- 5% change in line volts causes a variation of +/- 10 % change in lamps watts. You can use this type of ballast only on specified line voltages-usually 240V or 277V for 100W through 400W lamps; and 480V for 700W and 1000W lamps. Make sure you use this ballast only on circuits where you're certain to maintain +/- 5% of line volts. With regulator ballasts, +/- 13% change in line voltage results in 2% or 3% change in lamp watts. You can install it on any circuit without concern for voltage variations or sags. With auto-regulator ballasts, regulation is high: Line voltage changes of +/- 10% can result in changes in lamp watts of about 5%.

With lag reactor or high-reactance autotransformer ballasts, lamp wattage regulation is poor: A 5% change in line voltage can result in a 12% change in lamp wattage.

**HID system options for voltage interruptions.** Any interruption in the power supply, or even a serious voltage dip for a few cycles, causes any HID lamp to go out. It takes minutes before the lamp will restart, because the arc tube has to cool, and the internal vapor pressure has to decrease to the point when the arc can restrike. This restrike time, together with the warm-up period, means an 8 min to 15 min waiting period before full light returns.

To address this problem, the NEC requires some form of a backup lighting system immediately available in case you experience power interruptions with HID lighting systems.

*Auxiliary tungsten halogen lamp option.* You can order an industrial HID luminaire with an integral tungsten halogen lamp. Here, you provide a separate power source for the halogen lamp (which usually operates at 120VAC), such as an emergency power source. Whenever the light fixture ballast senses a loss of lamp current, the halogen source turns on. A time-delay following return of normal power maintains the tungsten lamp illumination until the HID lamp returns to full output.

*Hot restrike option.* A ballast component called a hot restrike device, which provides a higher-than-normal ignition pulse can be specified for some single- and double-ended MH lamps. The hot restrike feature delivers a high-voltage pulse to one of the electrodes, similar to the starting method for the HPS lamp. Thus, a hot restrike accessory can restart the MH lamp's arc almost immediately following a momentary voltage dip. You can find this feature on the high wattage (generally 1000W or 1500W) MH lamps at sports arenas and other high occupancy facilities.

*Double arc-tube HPS lamp.* To provide almost immediate light output following a voltage dip or momentary outage on a HPS lighting system, you could use a special lamp with a double arc-tube. When you energize this lamp, only one of its arc tubes ignites, and the parallel arc tube stays in a standby mode. When a loss of power of sufficient duration extinguishes the first arc tube, the second arc tube immediately ignites at partial output as soon as the power is reestablished. It will quickly come up to full brightness. With about a 50% cost premium over a standard HPS lamp, the double arc tube lamp has applications at prisons and related facilities.

**Sidebar: HID Lamp and Ballast System Basics**

There are three high intensity discharge (HID) lamps: mercury vapor (MV), metal halide (MH), and high-pressure sodium (HPS). Their starting method is completely different from the low intensity discharge (fluorescent) lamp.

**Lamps.** MV and MH lamps have a separate staring electrode, along with the two operating electrodes of the arc tube.

When you energize an HID ballast, it applies voltage between the starting electrode and the adjacent operating electrode, creating an emission of electrons that sets up a local glow. This causes the mercury within the lamp to slowly vaporize, allowing the arc to strike between the two operating electrodes.

HPS lamps use a small diameter arc tube that doesn't have room for a separate starting electrode. Instead, the ballast creates a high pulse of voltage every half-cycle with its integral special starting circuit. Peaking at 2500V and lasting one microsecond, these high-voltage pulses ionize the xenon gas, allowing the arc to strike between electrodes. Once it strikes, the starting pulses cease.

Even though an MH lamp is similar to an MV lamp, there are two differences: An MH lamp needs a higher ballast open-circuit voltage to start the arc as well as a higher re-ignition voltage. During warm-up, low conduction of the arc occurs. This means the re-ignition needed to establish/reestablish an arc after each half cycle is greater than what the voltage standard mercury ballast normally supplies.

**Ballasts.** The reactor ballast is the simplest magnetic ballast, consisting of a choke coil wound on an iron core (to limit the current).

A lag ballast combines a reactor and an autotransformer on a single winding. It's generally used on 120V circuits. The lag ballast doesn't have a capacitor added to correct the 50% power factor. However, it does have the same features as the reactor ballast. You can use it when the line voltage is lower or higher than the required starting voltage.

A regulator ballast (for both MV and MH lamps) consists of a capacitor in series with a lamp and either in series or parallel with two separate windings.

An auto-regulator, or constant wattage autotransformer ballast, combines a regulator circuit with an autotransformer. Part of the primary winding couples with the secondary winding, reducing ballast size. This is the most popular because it offers the best compromise between cost and performance.

The MH ballast has a peak-lead or lead peaked design. It's essentially the same as a MV auto-regulator type, the difference being the peak-lead ballast has one or more core slots on the secondary winding.

The HPS ballast has an auxiliary starting circuit to begin arc conduction. The circuit provides a high-voltage pulse between 2500V to 3000 V. HPS ballast types are: reactor, regulator, and auto-regulator.

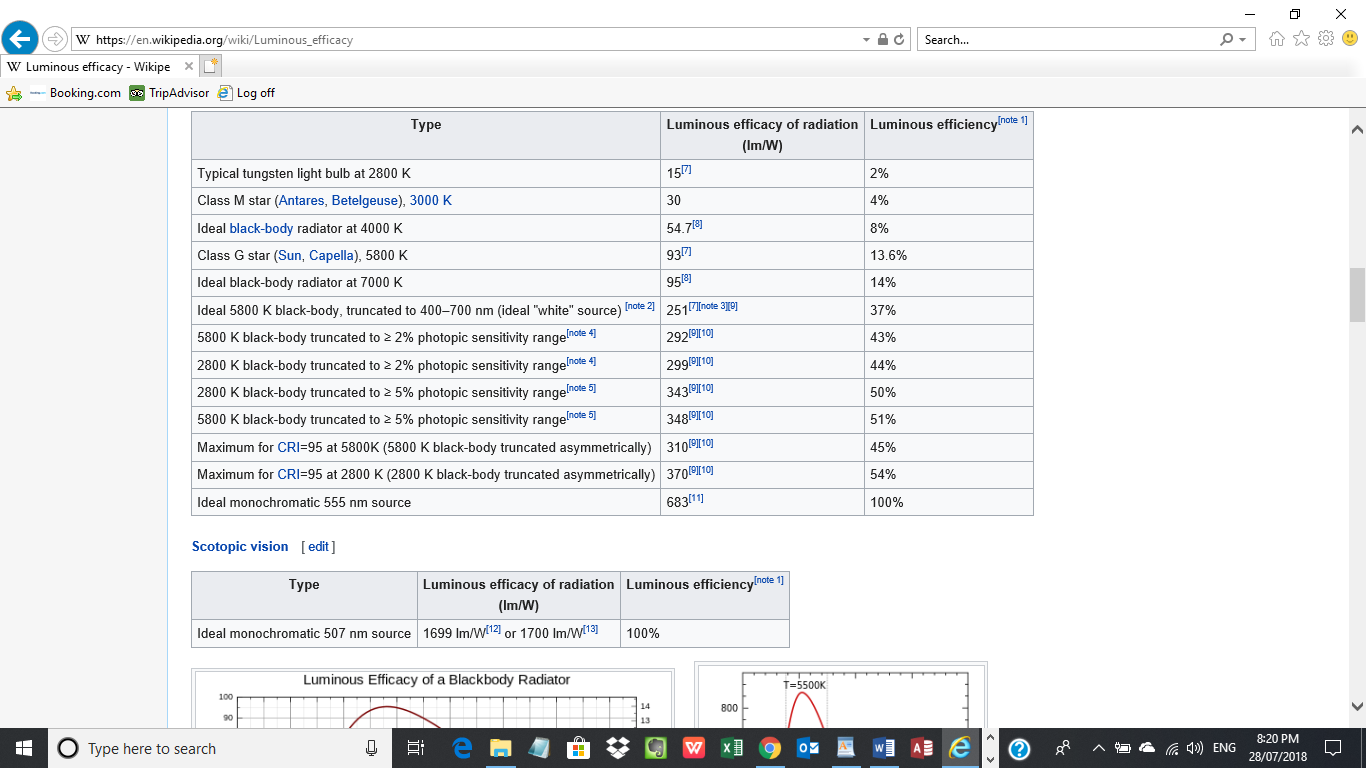
The supply voltage and frequency for a metal halide should be within:

a) 3% and 5% respectively of the nominal values

b) 5% and 5% respectively of the nominal values

c) 5% and 3% respectively of the nominal values

d) 3% and 3% respectively of the nominal values



More energy-efficient **lighting** - which right now often means fluorescent **lighting** - will be required, as will dimmers and occupancy sensors. ... **High**-**efficacy lighting** is defined as: 15 watts or less: Minimum of 40 lumens/watt. 15 to 40 watts: Minimum of 50 lumens/watt. More than 40 watts: Minimum of 60 lumens/watt.

# Quick Quiz: What is the Most Efficient Artificial Light Source?

[Team Treehugger](https://www.treehugger.com/author/team-treehugger/)

[Team Treehugger](https://www.treehugger.com/author/team-treehugger/)

December 19, 2006

The efficiency of a light source is measured in lumens per watt- simplified, the luminous power measured in lumens divided by the electrical power measured in watts. The more lumens per watt, the better the light source in terms of energy efficiency. A lot has changed in the last few years; what do you think is the most efficient light source? Answers after the fold, but no peeking! We can tell.   
  
After spending hours making my own list, of course there was this neat table from [Wikipedia](http://en.wikipedia.org/wiki/Luminous_efficacy) which agrees with our other sources. I was surprised by the results.





1) Low pressure sodium lamps were far and away the most efficient, at 200 lumens/watt, but they give out a single orangy -yellow frequency of light and have been used mainly as roadway lighting. While I always found them easy on the eyes when driving, evidently the police didn't like them because it is impossible to tell the colour of a car, everything is grey or orange. They are being replaced by less efficient high pressure sodiums.



2) Next best are the high intensity discharge lamps like the metal halides (seen in big box stores and gymnasiums) and high pressure sodium (exterior and roadway lighting). at 150 they are every efficient but always big and bright, not suitable for home use.

3) Conventional fluorescent tubes are currently in third place, but that really depends on the colour temperature (cool white is more efficient than warm white)



4) [Compact Fluorescents](https://www.treehugger.com/files/2006/03/evangelizing_co.php) are slightly less efficient than long tubes at this time, but obviously far more efficient than the incandescents they replace.



Tied for 3 or 4) LED's, at 26 to 70, are not yet more efficient than flourescents, but are catching up; in the lab there are prototypes up to 131. They are also coming out in MR16 sizes to replace existing halogen fixtures, although they are still expensive.



5) Quartz Halogen fixtures are better than conventional incandescent at 24 but are evil little things. They are in fact, a very small incandescent that would melt if not made from quartz. 10 years ago they were all the rage, and I have a ceiling with 18 of them. They are extremely hot, they require transformers that burn out, and you can't just change the bulbs to CFL,s but have to wait until the LED replacements are bright, affordable and a decent colour temperature, which they are not yet. There have been many recalls of cheap quartz halogen lamps causing fires. They should be put out to pasture as quickly as incandescents. IKEA has lots of lovely quartz halogen designs that look so modern, but keep away.

6) Way down there at the bottom:



The incandescent lightbulb, all of which belong a museum with this one.

Be sure to read [How to Green your Lighting](https://www.treehugger.com/files/2006/11/how_to_green_yo_5.php) again!

The most efficious (*efficient*) artificial lamp is:

a) The Low Pressure Mercury Lamp

b) The Low Pressure Sodium Lamp

c) The High Pressure Mercury Lamp

d) The High Pressure Sodium Lamp

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| |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | |  | | --- | | **NLPIP Home** | |  |  |  | | --- | | **MH Lamps Q & A** | | **Appendix** |  |  | | --- | | **Resources** | | **Sponsors and Credits** |  |  | | --- | | **Glossary** | | **Legal Notices** |  |  | | --- | | **Site Map** | | | |  | | --- | | **Technologies** | | **Search** |  |  | | --- | | **FAQ** | | **Publications** | |  |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | |  | | --- | | **Introduction** | | **How do metal halide lamps work?** |  |  | | --- | | **What is the difference between quartz and ceramic arc tubes?** | | **What is the difference between probe-start and pulse-start?** |  |  | | --- | | **Why do MH lamps require a ballast?** | | **What types of ballasts are available for MH lamps?** |  |  | | --- | | **What effect does burning postion have?** | | **What are warm-up and restrike times?** |  |  | | --- | | **What are some important characteristics of MH lamps?** | | **Are mid-wattage MH lamps cost effective?** |  |  | | --- | | **How well do MH lamps work in retrofitting?** | | **What safety issues should specifiers consider?** | | | What are warm-up and restrike times for metal halide lamps? Metal halide (MH) lamps do not achieve their full light output immediately after starting. Rather, they require a period of time-1 to 15 minutes-to reach 90% of their full light output. This period is called the [**warm-up**](http://www.lrc.rpi.edu/programs/nlpip/lightinganswers/mwmhl/restrikeTimes.asp) (or run-up) time. After a lamp has been on for a period of time and then extinguished, it cannot be immediately turned back on. Before the lamp can be turned back on, the [**arc tube**](http://www.lrc.rpi.edu/programs/nlpip/lightinganswers/mwmhl/restrikeTimes.asp) must have a chance to cool down or the lamp will not restart. This period of time is called the [**restrike time**](http://www.lrc.rpi.edu/programs/nlpip/lightinganswers/mwmhl/restrikeTimes.asp). Restrike times for traditional probe-start MH lamps can take 15 minutes or longer, but restrike times for pulse-start MH lamps are generally much shorter (see Figure 4). According to manufacturers' literature, restrike times for pulse-start MH lamps can be more than twice as fast as for probe-start MH lamps. |

1. Why do HID lamps take time to initially light?

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2. Why do HID lamps, under standard conditions, take time to restrike after being turned

off?

**Advantages of HID Lamps**

The advantages of having HID lamps are plentiful. Xenon headlights offer a larger spectrum of visibility while driving. This specific style of headlights was first developed in 1991 and has since gained in popularity due to the benefits. During that time the headlights were more expensive than individuals were willing to pay for lamps. However, in the recent days the cost has plummeted making them far more affordable.

One of the main benefits of having Xenon headlights is the fact they offer a longer lasting life than typical lamps. They last three times longer that the halogen bulbs. This will save the driver money.  
Another wonderful advantage is they offer lower energy usage. The Xenon headlights use 25-30 percent less energy than halogen bulbs. It is much easier on the electrical system and the battery, which will also save money for the driver.

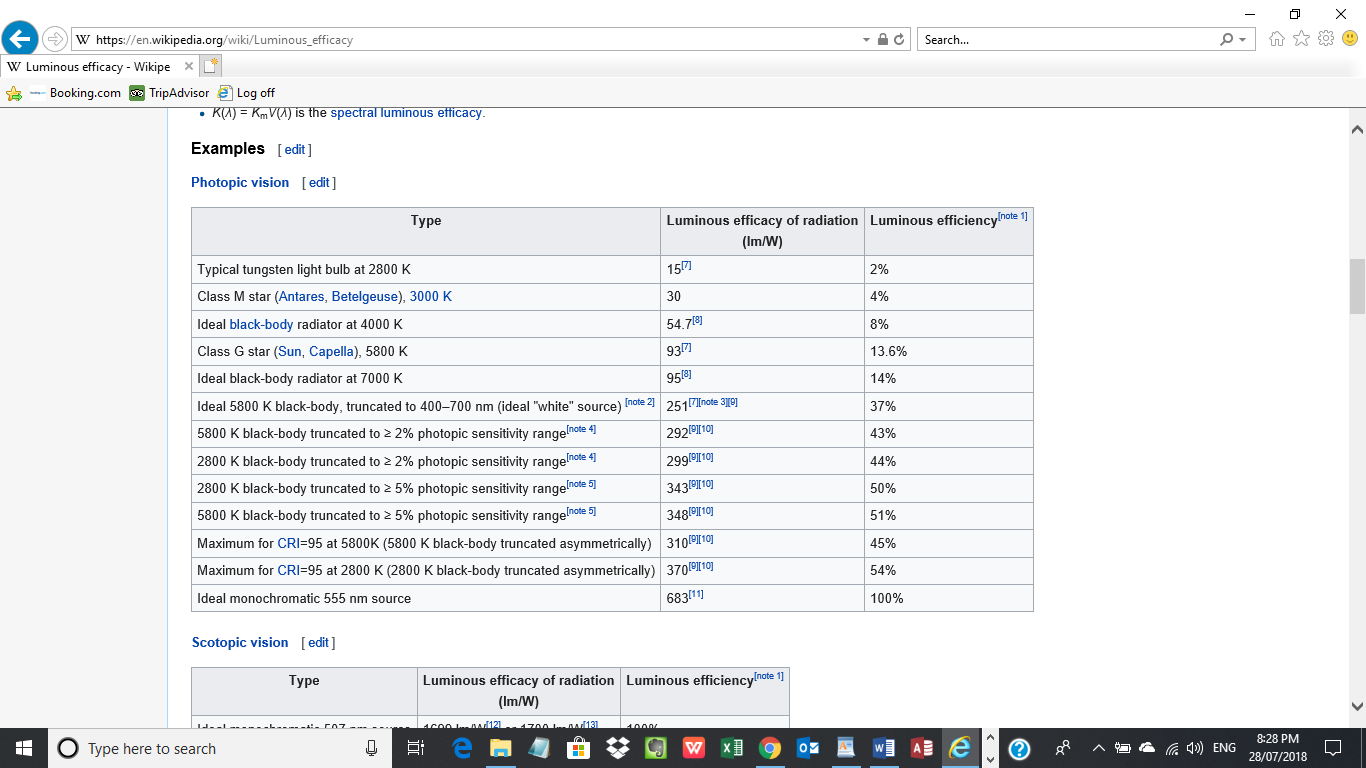
Of course the fact Xenon headlights are extremely more attractive than typical headlights it one of the benefits. The light given off by these types of headlights are cleaner and provide a classy look to any luxury vehicle. It is considered to be cost efficient and an aesthetic upgrade for your vehicle. Xenon headlights are functional and elegant.

**Disadvantages of HID Lamps**

With every wonderful product, there are always drawbacks. One of the disadvantages to the HID headlights is the brightness of the lights in the rear view mirrors. This causes a problem for drivers in front of your vehicle. It is so widely known that USA Today did an investigation and report on the headlights. They found although they prove to be troublesome, using halogen bright lights are debilitating, where as the HID lamps do not offer impairment for the drivers in front of the beams. They are still overall better than traditional lamps.

There have been reports of drivers having issues while driving in foggy weather conditions. The blue light of the HID headlights prove to scatter more with water droplets than typical headlights.

In conclusion, the HID headlights are more cost effective, provide a more natural light while driving, extends the life of the headlights, battery, and electrical system; this offers the solution to the problem on confusion to purchasing Xenon headlights.



### Examples[[edit](https://en.wikipedia.org/w/index.php?title=Luminous_efficacy&action=edit&section=9)]

The following table lists luminous efficacy of a source and efficiency for various light sources. Note that all lamps requiring [electrical/electronic ballast](https://en.wikipedia.org/wiki/Electrical_ballast) are unless noted (see also voltage) listed without [losses](https://en.wikipedia.org/wiki/Electrical_efficiency) for that, reducing total efficiency.

| **Category** | **Type** | **Overall luminous efficacy (lm/W)** | **Overall luminous efficiency**[[note 1]](https://en.wikipedia.org/wiki/Luminous_efficacy#cite_note-max-7) |
| --- | --- | --- | --- |
| Combustion | [candle](https://en.wikipedia.org/wiki/Candle) | 0.3[[note 6]](https://en.wikipedia.org/wiki/Luminous_efficacy#cite_note-19) | 0.04% |
| [gas mantle](https://en.wikipedia.org/wiki/Gas_mantle) | 1–2[[14]](https://en.wikipedia.org/wiki/Luminous_efficacy#cite_note-20) | 0.15–0.3% |
| [Incandescent](https://en.wikipedia.org/wiki/Incandescent_light_bulb) | 15–40–100 W tungsten incandescent (230 V) | 8.0–10.4–13.8[[15]](https://en.wikipedia.org/wiki/Luminous_efficacy#cite_note-21)[[16]](https://en.wikipedia.org/wiki/Luminous_efficacy#cite_note-22)[[17]](https://en.wikipedia.org/wiki/Luminous_efficacy#cite_note-23)[[18]](https://en.wikipedia.org/wiki/Luminous_efficacy#cite_note-philc-24) | 1.2–1.5–2.0% |
| 5–40–100 W tungsten incandescent (120 V) | 5–12.6–17.5[[19]](https://en.wikipedia.org/wiki/Luminous_efficacy#cite_note-incandescent-25) | 0.7–1.8–2.6% |
| [Halogen incandescent](https://en.wikipedia.org/wiki/Halogen_lamp) | 100–200–500 W tungsten halogen (230 V) | 16.7–17.6–19.8[[20]](https://en.wikipedia.org/wiki/Luminous_efficacy#cite_note-26)[[18]](https://en.wikipedia.org/wiki/Luminous_efficacy#cite_note-philc-24) | 2.4–2.6–2.9% |
| 2.6 W tungsten halogen (5.2 V) | 19.2[[21]](https://en.wikipedia.org/wiki/Luminous_efficacy#cite_note-27) | 2.8% |
| halogen-IR (120 V) | 17.7–24.5%[[22]](https://en.wikipedia.org/wiki/Luminous_efficacy#cite_note-28) | 2.6–3.5% |
| tungsten quartz halogen (12–24 V) | 24 | 3.5% |
| photographic and projection lamps | 35[[23]](https://en.wikipedia.org/wiki/Luminous_efficacy#cite_note-bulbguide-29) | 5.1% |
| [Light-emitting diode](https://en.wikipedia.org/wiki/Light-emitting_diode) | LED [screw base](https://en.wikipedia.org/wiki/Edison_screw) lamp (120 V) | up to 102[[24]](https://en.wikipedia.org/wiki/Luminous_efficacy#cite_note-Toshiba-LED-30)[[25]](https://en.wikipedia.org/wiki/Luminous_efficacy#cite_note-Toshiba-LED_LDA5N-E17-31)[[26]](https://en.wikipedia.org/wiki/Luminous_efficacy#cite_note-32) | up to 14.9% |
| 11 W LED screw base lamp (230 V) | 138[[27]](https://en.wikipedia.org/wiki/Luminous_efficacy#cite_note-:0-33) | 20.3% |
| 21.5W LED retrofit for T8 fluorescent tube (230 V) | 172[[28]](https://en.wikipedia.org/wiki/Luminous_efficacy#cite_note-34) | 25% |
| Theoretical limit for a white LED with phosphorescence color mixing | 260–300[[29]](https://en.wikipedia.org/wiki/Luminous_efficacy#cite_note-physorg.com-35) | 38.1–43.9% |
| [Arc lamp](https://en.wikipedia.org/wiki/Arc_lamp) | [carbon arc lamp](https://en.wikipedia.org/wiki/Carbon_arc_lamp) | 2-7[[30]](https://en.wikipedia.org/wiki/Luminous_efficacy#cite_note-carbon-36) | 0.29-1.0% |
| [xenon arc lamp](https://en.wikipedia.org/wiki/Xenon_arc_lamp) | 30–50[[31]](https://en.wikipedia.org/wiki/Luminous_efficacy#cite_note-xenon-37)[[32]](https://en.wikipedia.org/wiki/Luminous_efficacy#cite_note-38) | 4.4–7.3% |
| [mercury](https://en.wikipedia.org/wiki/Mercury_(element))-[xenon](https://en.wikipedia.org/wiki/Xenon) arc lamp | 50–55[[31]](https://en.wikipedia.org/wiki/Luminous_efficacy#cite_note-xenon-37) | 7.3–8% |
| [UHP](https://en.wikipedia.org/wiki/Ultra-high-performance_lamp) – ultra-high-pressure [mercury-vapor](https://en.wikipedia.org/wiki/Mercury-vapor_lamp) arc lamp, free mounted | 58–78[[33]](https://en.wikipedia.org/wiki/Luminous_efficacy#cite_note-39) | 8.5–11.4% |
| UHP – ultra-high-pressure mercury-vapor arc lamp, with reflector for [projectors](https://en.wikipedia.org/wiki/Digital_Light_Processing) | 30–50[[34]](https://en.wikipedia.org/wiki/Luminous_efficacy#cite_note-40) | 4.4–7.3% |
| [Fluorescent](https://en.wikipedia.org/wiki/Fluorescent_lamp) | 32 W T12 tube with magnetic ballast | 60[[35]](https://en.wikipedia.org/wiki/Luminous_efficacy#cite_note-FEMP-41) | 9% |
| 9–32 W [compact fluorescent](https://en.wikipedia.org/wiki/Compact_fluorescent_lamp) (with ballast) | 46–75[[18]](https://en.wikipedia.org/wiki/Luminous_efficacy#cite_note-philc-24)[[36]](https://en.wikipedia.org/wiki/Luminous_efficacy#cite_note-cf-42)[[37]](https://en.wikipedia.org/wiki/Luminous_efficacy#cite_note-43) | 8–11.45%[[38]](https://en.wikipedia.org/wiki/Luminous_efficacy#cite_note-CF_efficiency-44) |
| T8 tube with electronic ballast | 80–100[[35]](https://en.wikipedia.org/wiki/Luminous_efficacy#cite_note-FEMP-41) | 12–15% |
| PL-S 11 W U-tube, excluding ballast loss | 82[[39]](https://en.wikipedia.org/wiki/Luminous_efficacy#cite_note-U-tubes-45) | 12% |
| T5 tube | 70–104.2[[40]](https://en.wikipedia.org/wiki/Luminous_efficacy#cite_note-energyrating-46)[[41]](https://en.wikipedia.org/wiki/Luminous_efficacy#cite_note-Plusrite-47) | 10–15.63% |
| 70-150 W Inductively Coupled Electrodeless Lighting System | 71-84[[42]](https://en.wikipedia.org/wiki/Luminous_efficacy#cite_note-ICETRON®-48) | 10-12% |
| [Gas discharge](https://en.wikipedia.org/wiki/Gas-discharge_lamp) | 1400 W [sulfur lamp](https://en.wikipedia.org/wiki/Sulfur_lamp) | 100[[43]](https://en.wikipedia.org/wiki/Luminous_efficacy#cite_note-49) | 15% |
| [metal halide lamp](https://en.wikipedia.org/wiki/Metal_halide_lamp) | 65–115[[44]](https://en.wikipedia.org/wiki/Luminous_efficacy#cite_note-50) | 9.5–17% |
| [high pressure sodium lamp](https://en.wikipedia.org/wiki/Sodium_vapor_lamp#High_pressure_/_HPS_/_SON) | 85–150[[18]](https://en.wikipedia.org/wiki/Luminous_efficacy#cite_note-philc-24) | 12–22% |
| [low pressure sodium lamp](https://en.wikipedia.org/wiki/Sodium_vapor_lamp#Low_pressure_/_LPS_/_SOX) | 100–200[[18]](https://en.wikipedia.org/wiki/Luminous_efficacy#cite_note-philc-24)[[45]](https://en.wikipedia.org/wiki/Luminous_efficacy#cite_note-sodium-51)[[46]](https://en.wikipedia.org/wiki/Luminous_efficacy#cite_note-lightning-52) | 15–29% |
| [Plasma display panel](https://en.wikipedia.org/wiki/Plasma_display_panel) | 2-10[[47]](https://en.wikipedia.org/wiki/Luminous_efficacy#cite_note-53) | 0.3–1.5% |
| [Cathodoluminescence](https://en.wikipedia.org/wiki/Electron_stimulated_luminescence) | [electron stimulated luminescence](https://en.wikipedia.org/wiki/Electron_stimulated_luminescence) | 30[[*citation needed*](https://en.wikipedia.org/wiki/Wikipedia:Citation_needed)] | 5% |
| Ideal sources | Truncated 5800 K blackbody[[note 3]](https://en.wikipedia.org/wiki/Luminous_efficacy#cite_note-ideal_white-11) | 251[[7]](https://en.wikipedia.org/wiki/Luminous_efficacy#cite_note-ideal-white-8) | 37% |
| Green light at 555 nm (maximum possible luminous efficacy) | 683.002[[11]](https://en.wikipedia.org/wiki/Luminous_efficacy#cite_note-luminosity-16) | 100% |

5. What is a precaution that must be taken when connecting LED’s? Polarity

**Argon** is a commonly used gas used to fill incandescent light bulbs. It increases bulb life by preventing the **tungsten filaments** from deteriorating too quickly. Other gases such as **helium**, **neon**, **nitrogen** and **krypton** are also used in lighting. The gases used in light bulbs are known as **inert** gases.

Used **in** light **bulbs**. The very thin metal filament inside the **bulb** would react with oxygen **and** burn away if the **bulb** were **filled** with air instead of **argon**. **Argon** stops the filament burning away because it is unreactive.

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2 Ways to Excite Electrons Into High Energy States

By Michael E Carpenter; Updated April 24, 2017



Electrons are the negatively charged particles of the atom. Electrons circle the nucleus, which contains the protons and neutrons, at various distances called shells. Each element has a certain number of electrons and shells. Under certain circumstances, an electron may move from one shell to another, or even be expelled from the element. There are two ways in which an electron can be excited enough to move to a higher shell and higher energy state.

Absorption of Photons

An element's electron can absorb a light photon to enter a higher energy state. However, the wavelength of the photon must be a specific wavelength from each atom. Each atom when placed in spectroscope produces different combinations of colors. The elements only accept and emit light of certain wavelengths. If the wavelength has too much or too little energy for the element, it will not be accepted. Once the electron is in the excited state, for it to come down to the lower state, it emits the same color frequency photon to release energy.

Collisions

When elements collide electrons can be taken from low states of energy to higher states. This occurs because some of the kinetic energy between the two colliding atoms is transferred into the electron. In come very fast collisions an electron may be knocked free from its parent atom. This is called collision ionization. The electron is then able to be absorbed by other atoms. Ionic bonds, which form when electrons are transferred from one element to another, occur in the fashion.

Collisions Variables

Not all collisions will result in the excitation of electrons. The kinetic energy, or the energy of motion, must be able to overcome a certain threshold to excite the electron. Temperature is a way of providing more energy and more collisions to excite atoms. At low temperatures elements move slowly and do not contain sufficient energy to excite electrons or result in chemical reactions. Higher temperatures impart more energy to the atom and increases the kinetic energy of the atom and resulting collisions.

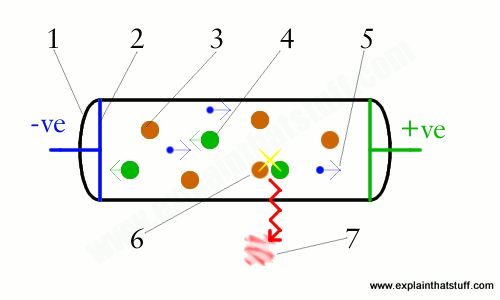
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A **cold cathode** is a cathode that is not electrically heated by a filament. A cathode may be ... **The** other **type** of cathode is a **hot cathode**, which is heated by electric current ... These lamps are commonly used for **neon signs**. ... Nixie **tubes** too are **cold**-**cathode neon** displays that are in-line, but not in-plane, display devices

## How neon lamps work



1. A neon lamp is a sealed glass tube filled with neon gas, which is one of the so-called "noble" (inert or unreactive) gases on the far right of the Periodic Table. (There are minute quantities of neon in the air around us: take a deep breath and you'll breathe in a volume of neon as big as an orange pip!)
2. There are electrical terminals at either end of a neon tube. At one end, there's a negative terminal ("-ve", shown blue); at the other end there's a positive terminal ("+ve", shown green).
3. When the tube is switched off, it contains ordinary atoms of neon gas (brown circles).
4. Rig the terminals up to a high-voltage power supply (about 15,000 volts—because you need a lot of "electrical force" to make things happen) and switch on, and you'll literally start pulling the neon atoms apart. Some of the atoms will lose electrons to become positively charged ions (big green dots). Being positively charged, these neon ions will tend to move toward the negative electrical terminal.
5. The electrons the neon atoms lose (small blue dots) are negatively charged, so they hurtle the opposite way toward the positive terminal at the other end of the tube.
6. In all this rushing about, atoms, ions, and electrons are constantly colliding with one another. Those collisions generate a sudden smash of energy that excites the atoms and ions and makes them give off photons of red light.
7. So many collisions happen with such rapidity that you get a constant buzzing of red light from the tube. You also get quite a lot of energy given off as [heat](https://www.explainthatstuff.com/heat.html). If you've ever stood near a neon light, you'll know they can get very hot. That's because the atoms are giving off quite a bit of invisible [infrared radiation](https://www.explainthatstuff.com/electromagnetic-spectrum.html) (in other words, heat) as well as visible radiation (better known as red light).

## Why is neon light red?

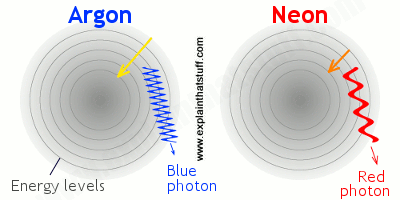


Photo: When electrons in neon atoms return from their "excited" state to their "ground" (unexcited) state, they give out packets of energy called quanta that our eyes see as red light. In argon atoms, the quanta are bigger and our eyes see them as higher-frequency blue light.

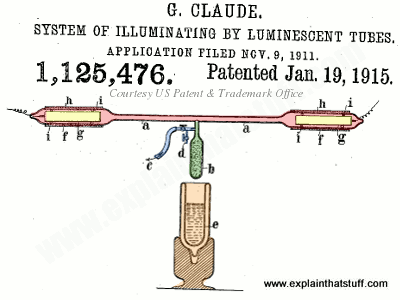
The energy levels inside atoms are a bit like rungs on a ladder or steps on a staircase. Electrons can only be on the rungs or steps, not on the gaps in between. That means atoms can absorb or release energy only in fixed-sized packets (called quanta, which is the plural of quantum) and atoms of different chemical elements will give out quanta that are bigger or smaller, depending on their precise inner structure. Atoms that give out bigger quanta of energy make higher-frequency (bluer) light than atoms that give out smaller quanta. In neon, the quanta of energy that are given out correspond exactly with light that we see as red. Other noble gases make light of different colors. Argon, for example, makes blue light—so when you see "neon" lamps shining blue, you're actually looking at tubes filled with argon, not neon. There are two ways to make other colors. You can put more than one gas in the same "neon" tube. To make green tubes, you need neon and argon together. For purple, you'd use argon and xenon. You can also change the color that a tube makes by painting its walls with phosphors of different colors. So you can use a blue phosphor painted on a red neon tube to make pink light, or a green phosphor with red neon to make orange light.

## Why "cold cathode"?

You'll sometimes see neon signs referred to as an example of cold-cathode lighting. That doesn't make sense unless you understand that various other electrical devices use a hot cathode. But what is a cathode anyway...?

In a lamp with two electrical terms, the positive terminal is called the anode (the green terminal in the artwork up above) and the negative one is called the cathode (the blue terminal on the left). In a hot-cathode device, the cathode has to be heated with a filament (a small [heating element](https://www.explainthatstuff.com/heating-elements.html)) so electrons "boil off" its surface—and then do something useful. Hot cathodes were used in vacuum tubes, which were used as computer switches before [transistors](https://www.explainthatstuff.com/howtransistorswork.html) were invented. They're also used in [cathode-ray tubes](https://www.explainthatstuff.com/television.html), such as the ones that make the picture in an old-fashioned TV (one of those really old ones that sticks out at the back) and the graph-traces on [oscilloscopes](https://www.explainthatstuff.com/howoscilloscopeswork.html). The light you see on this kind of TV screen comes from energy released when the cathode is heated up so it gives off electrons. The electrons (which were historically known as "cathode rays") make your TV picture when they fly down the tube and smash into the phosphor-coated screen at the front. In a neon lamp, light is made by exciting gas atoms in the space between two electrodes and there's no need for a hot cathode. But just because the cathode isn't heated, it doesn't follow that a neon lamp is cold; indeed, you'll find neon lamps surprisingly hot if you stand anywhere near them!

## Who invented neon lamps?



Artwork: From [*US Patent 1,125,476: System of illuminating by luminescent tubes*](https://patents.google.com/patent/US1125476) by Georges Claude. Jan 19, 1915, courtesy of US Patent and Trademark Office.

French chemical engineer **Georges Claude** (1870–1960) invented the neon lamp, filing his original French patent on March 7, 1910. The same year, he made his first, spectacular public demonstration of neon lighting at the Paris Motor Show, using two gigantic 12m (39ft) lamps. By 1913, neon lighting was being used in French advertising signs, though it didn't find its way to the United States until the 1920s.

Here's a fascinating illustration from Claude's US patent, filed in 1915. You can see the main neon tube at the top (which I've colored red), with its two electrodes (yellow) at either end. Claude had discovered that impurities in neon gas could seriously affect how well his lamps worked, so the bits of apparatus in the middle were designed to purify the neon before the tube was electrically lit, then removed. The blue line is a link to a vacuum pump; the green flask contains wood or charcoal to absorb impurities; and the larger orange vessel underneath contains liquid air. Together, these things carried out what Claude described as "an exceedingly efficacious purification process on the spot in order to obtain a high degree of purity of the neon."

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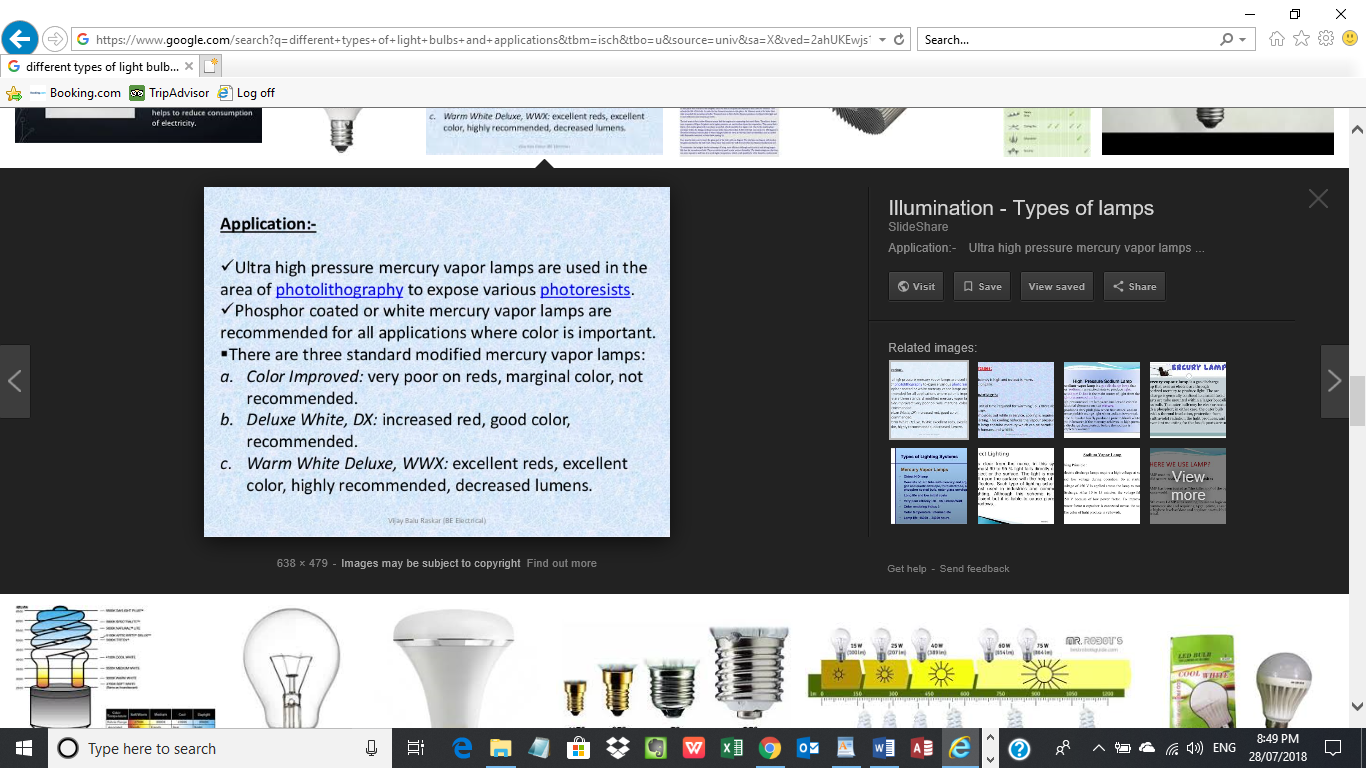
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| --- | --- | --- |
| Types of Light Bulbs and Their Uses By: [Jonathan Z. Kremer](http://www.yoni.kremer.co.il/)    There are many different types of light bulbs around, and they were all designed with a certain use in mind. What follows is a short description of each major type of bulb commonly found in the home, office and factory, how they work, and their uses.  **Incandescent**  These are the standard bulbs that most people are familiar with. Incandescent bulbs work by using electricity to heat a tungsten filament in the bulb until it glows. The filament is either in a vacuum or in a mixture of argon/nitrogen gas. Most of the energy consumed by the bulb is given off as heat, causing its Lumens per Watt performance to be low. Because of the filament's high temperature, the tungsten tends to evaporate and collect on the sides of the bulb. The inherent imperfections in the filament causes it to become thinner unevenly. When a bulb is turned on, the sudden surge of energy can cause the thin areas to heat up much faster than the rest of the filament, which in turn causes the filament to break and the bulb to burn out.   |  | | --- | | Traditional Incandescent Bulbs |   Incandescent bulbs produce a steady warm, light that is good for most household applications. A standard incandescent bulb can last for 700-1000 hours, and can be used with a dimmer. Soft white bulbs use a special coating inside the glass bulb to better diffuse the light; but the light color is not changed.  ﻿  **Halogen**  Halogen bulbs are a variation of incandescent bulb technology. These bulbs work by passing electricity through a tungsten filament, which is enclosed in a tube containing halogen gas. This halogen gas causes a chemical reaction to take place which removes the tungsten from the wall of the glass and deposits it back onto the filament. This extends the life of the bulb. In order for the chemical reaction to take place, the filament needs to be hotter than what is needed for incandescent bulbs. The good news is that a hotter filament produces a brilliant white light and is more efficient (more lumens per watt).   |  | | --- | | Various types of halogen bulbs |   The bad news is that a hotter filament means that the tungsten is evaporating that much faster. Therefore a denser, more expensive fill gas (krypton), and a higher pressure, are used to slow down the evaporation. This means that a thicker, but smaller glass bulb (envelope) is needed, which translates to a higher cost. Due to the smaller glass envelope (bulb), the halogen bulb gets much hotter than other bulbs. A 300 watt bulb can reach over 300 degrees C. Therefore attention must be paid to where halogen bulbs are used, so that they don't accidentally come in contact with flammable materials, or burn those passing by.  Care must be taken not to touch the glass part of the bulb with our fingers. The oils from our fingers will weaken the glass and shorten the bulb’s life. Many times this causes the bulb to burst when the filament finally burns out.  To summarize, the halogen has the advantage of being more efficient (although not by much) and having longer life than the incandescent bulb. They are relatively small in size and are dimmable. The disadvantages are that they are more expensive, and burn at a much higher temperature, which could possibly be a fire hazard in certain areas. |

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| **Fluorescent**  These bulbs work by passing a current through a tube filled with argon gas and mercury. This produces ultraviolet radiation that bombards the phosphorous coating causing it to emit light (see: “How Fluorescents Work”). Bulb life is very long - 10,000 to 20,000 hours. Fluorescent bulbs are also very efficient, producing very little heat. A common misconception is that all fluorescent lamps are neutral or cool in color appearance and do not have very good color-rendering ability. This is largely due to the fact that historically the "cool white" fluorescent lamp was the industry standard. It had a very cool color appearance (4200K) and poor CRI rating (62). This is simply no longer the case. Regarding color, a wide variety of fluorescent lamps (T12, T8, T5, etc.), using rare-earth tri-phosphor technology, offer superior color rendition (as high as 95) and a wide range of color temperature choices (from 2700K to 5000K and higher). Fluorescent bulbs are ideal for lighting large areas where little detail work will be done (e.g. basements, storage lockers, etc.). With the new type bulbs, and style of fixtures coming out, fluorescents can be used in most places around the home. Most fluorescent bulb cannot be used with dimmers.   |  | | --- | | Fluorescent tube bulbs | | Compact Fluorescent (CFL) | | PL type bulb (CFL) |   Note that fluorescent bulbs need components called ballasts to provide the right amount of voltage. There are primarily two types - magnetic and electronic. Electronic ballasts solve some of the flickering and humming problems associated with magnetic ballast, and are more efficient, but cost more to purchase. Some ballasts need a “starter” to work along with it. Starters are sort of small mechanical timers, needed to cause a stream of electrons to flow across the tube and ionize the mercury vapor (see: “[How Fluorescents Work](http://www.megavolt.co.il/Tips_and_info/BasicFluorLamp.html)”).  On tube type fluorescent bulbs, the letter T designates that the bulb is tubular in shape. The number after it expresses the diameter of the bulb in eighths of an inch.  ﻿    **Compact Fluorescent Lamps**  Compact Fluorescent Lamps (CFLs) are a modern type of light bulbs, that work like fluorescent bulbs, but in a much smaller package. Similar to regular fluorescent bulbs, they produce little heat and are very efficient. They are available to fit screw type base fittings and pin type (snap-in). Most CFLs either consist of a number of short glass sticks, or two or three small tubular loops. Sometimes, they are enclosed in a glass bowl, made to look similar to a regular incandescent bulb. Most CFLs cannot be used with dimmers. They normally last up to 10,000 hours. (For more info on CFLs see: [CFL](http://www.megavolt.co.il/Tips_and_info/cfl.html))   |  |  | | --- | --- | | **Approximate Equivalents to Incandescent Bulbs** | | | CFL | Incandescent | | 7–10 Watts | 40 Watts | | 15-18 Watts | 60 Watts | | 20 Watts | 75 Watts | | 20-25 Watts | 100 Watts | | 32 Watts | 150 Watts |   **High-Intensity Discharge Lamps**  High Pressure Sodium (HPS), Metal Halide, Mercury Vapor and Self-Ballasted Mercury Lamps are all high intensity discharge lamps (HID). With the exception of self-ballasted lamps, auxiliary equipment such as ballasts and starters must be provided for proper starting and operation of each type bulb. Compared to fluorescent and incandescent lamps, HID lamps produce a large quantity of light from a relatively small bulb.  HID lamps produce light by striking an electrical arc across tungsten electrodes housed inside a specially designed inner glass tube. This tube is filled with both gas and metals. The gas aids in the starting of the lamps. Then, the metals produce the light once they are heated to a point of evaporation.   |  | | --- | | Mercury Bulb | | Metal Halide Bulb |   Standard high-pressure sodium lamps have the highest efficacy of all HID lamps, but they produce a yellowish light. High-pressure sodium lamps that produce a whiter light are now available, but efficiency is somewhat sacrificed. Metal halide lamps are less efficient but produce a whiter, more natural light. Colored metal halide lamps are also available. HID lamps are typically used not only when energy efficiency and/or long life are desired, but also when high levels of light are required over large areas. Such areas include gymnasiums, large public areas, outdoor activity areas, roadways, pathways, and parking lots. Lately, metal halide is successfully being used in residential environments.  **Low-Pressure Sodium Lamps**  Low-pressure sodium lamps have the highest efficacy of all commercially available lighting sources. Even though they emit a yellow light, a low-pressure sodium lamp shouldn't be confused with a standard high-pressure sodium lamp. Low-pressure sodium lamps operate much like a fluorescent lamp and require a ballast. There is a brief warm-up period for the lamp to reach full brightness.  With a CRI of 0, low-pressure sodium lamps are used where color rendition is not important but energy efficiency is. They're commonly used for outdoor, roadway, parking lot, and pathway lighting.  **LED (Light Emitting Diodes)**   |  | | --- | | Light Emitting Diodes |   Light Emitting Diodes (LED) are bulbs without a filament, that are low in power consumption and have a long life span. LEDs are just starting to rival conventional lighting, but unfortunately they just don't have the output (lumen) needed to completely replace incandescent, and other type, bulbs just yet. Never the less, technology is advancing everyday, and it will not be long until the LED bulb will be the bulb of choice for most applications in the home and work place. (For more info on LEDs see: [LED Lighting - the lighting of the future](http://www.megavolt.co.il/Tips_and_info/LED.html))    **Jonathan Z. Kremer** *(better known as Yoni) is the proprietor of* [*"Yoni - Electrical Design and Installations"*](http://www.yoni.kremer.co.il/)*, a Maale Adumim (Israel) based business that has been serving primarily Jerusalem, Maale Adumim, and surrounding areas since 1989. We undertake various forms of electrical work including renovations, maintenance, installations, and repairs - encompassing the domestic (home), industrial and commercial arenas. 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Name two applications for the following light sources:

a) High Pressure Mercury Vapour -\_\_ Mercury vapor lamps have been used as outdoor lighting for streets and parking lots and have also been used as indoor lighting in factories and gymansiums. They are much more energy efficient than incandescent lamps and have a much longer life. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

b) Metal Halide - \_\_\_\_\_ under-cabinet lighting, pendant lights and recessed cans. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

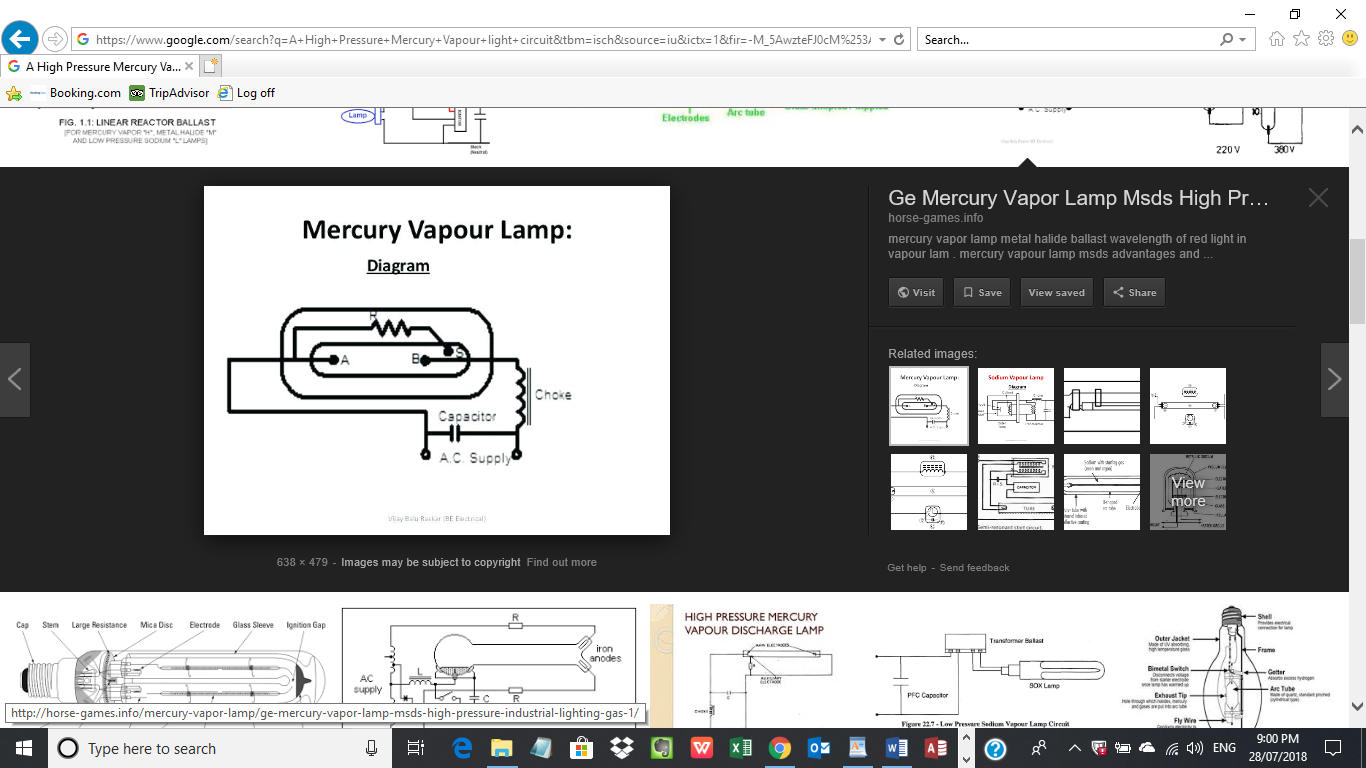
c) High Pressure Sodium -\_\_\_\_\_\_\_\_\_\_ High pressure sodium lamps are used in outdoor lighting of streets and parking lots and in indoor settings where color rendering is not critical. These indoor settings include warehouse and shipping areas and some manufacturing areas \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

d) Low Pressure Sodium -\_\_\_ street lighting as well as industrial **uses**. / Low pressure sodium lamps are used in outdoor lighting of some parking areas and bridge underpasses. The very yellow color does not attract insects but it distorts colors.

While these lamps are highly energy-efficient they are rarely used because all objects under their light appear to be yellow or yellow-gray.

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The HPS **lamp** consists of a narrow arc tube supported by a frame in a bulb. The arc tube has a high pressure inside for higher efficiency. ... There is an **ignitor** built into the ballast which sends a pulse of high voltage energy through the arc tube. This pulse starts an arc through the xenon gas.



A Metal Halide light circuit

