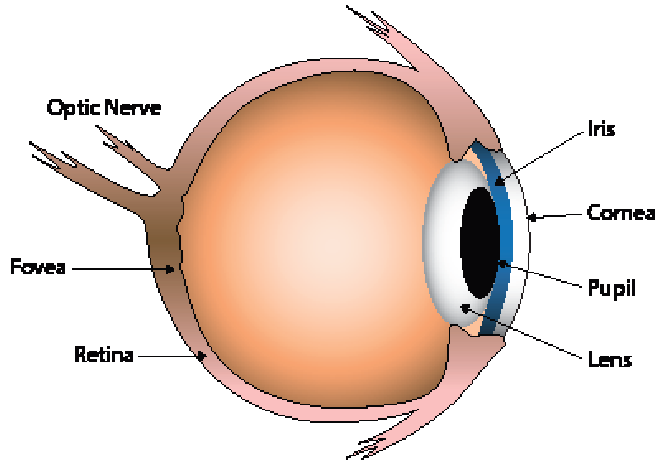
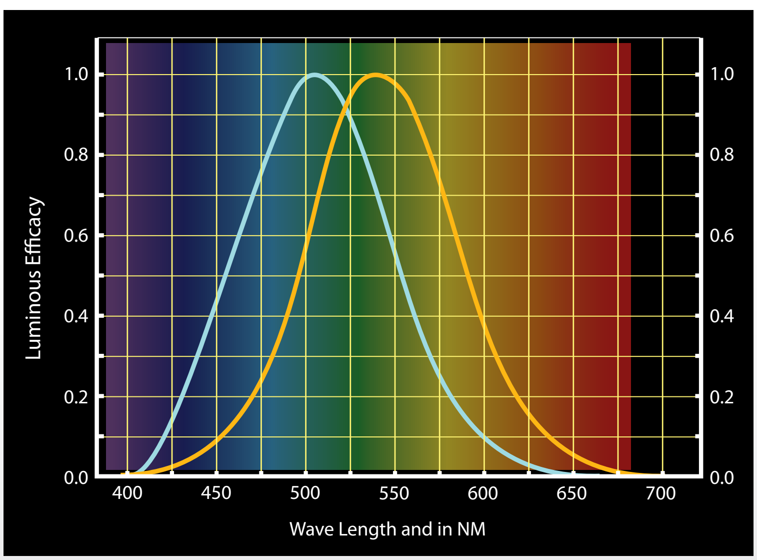
PHOTOPIC, MESOPIC & SCOTOPIC VISION

IN RELATION TO LIGHTING

Did You Know?



A human being's eye perception of brightness depends on color. It takes more energy in the blue and red spectrum to create the same appearance of brightness than in the yellow-green areas of the spectrum.



Light is sensed by the human eye by two main cells called rods and cones. There are approximately 6 million cones in the human eye. Cones are mainly located in the central part of the eye called the fovea. Cones have a peak response in the yellow-green region of the light spectrum at about 555 nanometers (Photopic). They operate at higher light levels and are responsible for color vision and the high visual acuity needed for reading and seeing small details. There are also approximately 125 million rods in the human eye. Rods and cones are clustered in the area of the eyes surrounding the fovea with rods outnumbering cones 10 to 1. Rods have a peak response in the bluish-green region of the light spectrum at about 505 nanometers (Scotopic). They operate at lower light levels and are responsible for peripheral vision and "night vision".

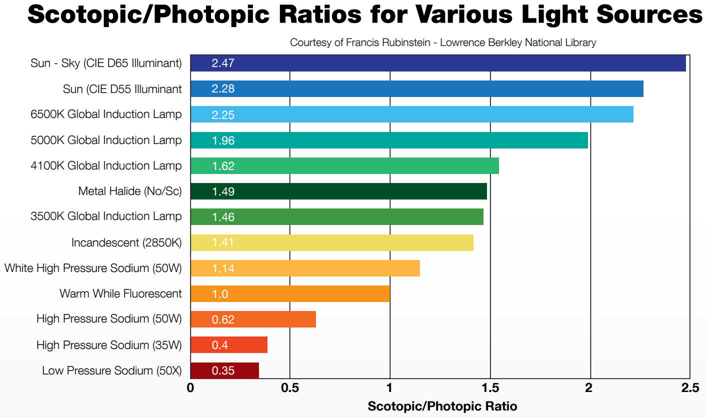
Until recent years, it was mainly considered that cones were responsible for daytime vision and when light levels fell low enough the cones switched off and the rods switched on. Because of the light meters used today foot-candles and photometrics are calibrated using 1951 CIE (International Commission on Illumination) Color Space Standards such as CSS; which only measures based on a photopic curve and ignores the scotopic curve. A study conducted by Dr. Sam Berman and Dr. Jon Jewett (sponsored by the U.S. Department of Energy) shows that rod and cone activation are not exclusive but share responsibility depending on the lighting conditions. More importantly, for the lighting industry, the study shows that rods do play a role in typical working conditions which is known as “mesopic vision”.

Since light meters are based on a 1951 CSS light meter using photopic curves, readings match vision very well in areas lit by sunlight and incandescent sources because these types of lighting are “full spectrum”.

Conversely, issues occur when areas are lit by some fluorescent and gas discharged lamps as human eyes are built to respond to full spectrum sunlight, not partial spectrum lighting. For example, High Pressure Sodium lighting releases light in the red-orange spectrum and produce very little output in the blue-green spectrum. This forces our eyes to rely almost entirely on photopic vision giving us less of a “quality” light. Because HPS lamps release light in the red-orange spectrum they will provide a high reading on a standard light meter while not appearing as bright to the average person. LED and induction lighting systems release light in a blue-red spectrum which allows the eyes to use both photopic and scotopic vision. This explains why an induction or LED light can appear brighter than a high pressure sodium lamp to a person while having a much smaller photometric footprint. By utilizing both photopic and scoptopic vision Induction and LED lights can provide more visible light at significantly lower wattages.

The ratio of Scotopic vs Photopic light in a lamp is called the S/P ratio. This determines the apparent visual brightness of a lamp. The S/P ratio of a lamp provides the lighting community with a number that can be used to multiply the reading of a lamp using a 1951 CSS conventional light meter. This also determines how much light the lamp will produce which is visible to the human eye. This new number is known as the Visually Effective Lumens (VEL). This is put into use by operating a conventional light meter used to measure the photopic curve, and then the same light source is measured with a meter calibrated to the scotopic curve. The resulting number is expressed as a single number.

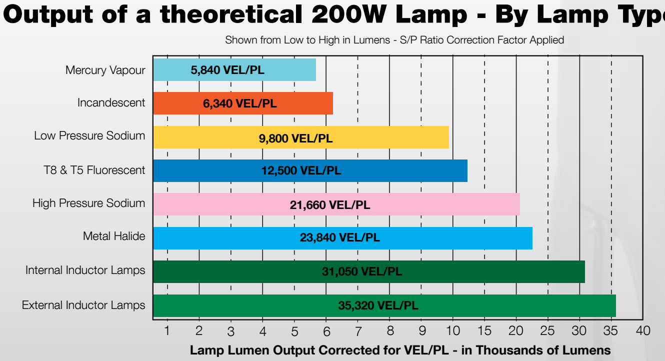
Scotopic/Photopic Ratios for Various Light Sources



Example: A 400 watt pulse start metal halide lamp has a listed 27000 mean lumens. To establish the VEL we would take the 27000 lumens and multiply it by the 1.49 S/P ratio like so 27000x1.49=40230. This gives you 40230 VEL. In contrast a high pressure sodium lamp has a listed 45000 mean lumens. However, it only has a 0.62 S/P ratio which would give 45000x0.62=27900 VEL.

This table shows the theoretical output of a 200w lamp in several types of sources allowing you to see a visual representation of how much useful and visible light will be given by each source.

Output of a theoretical 200W Lamp - By Lamp Type



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