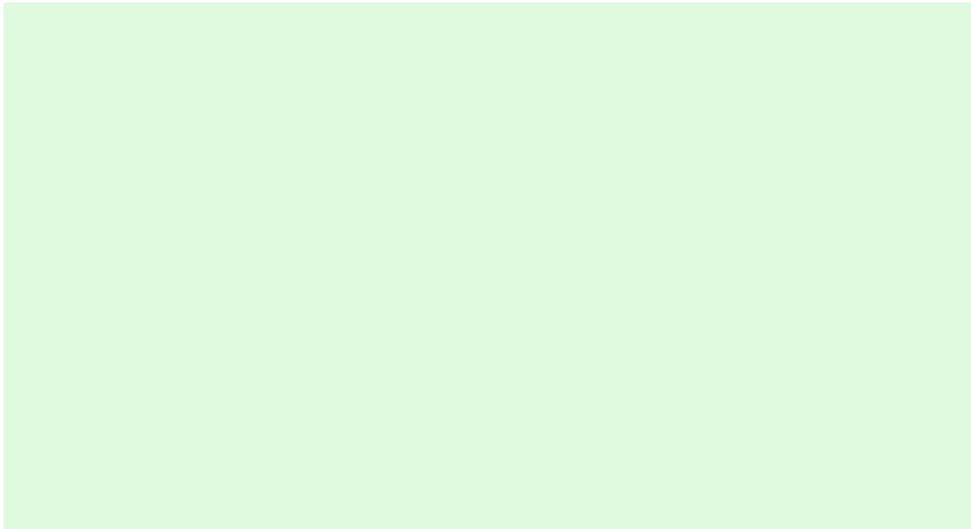# Photopic Lumens vs. Scotopic Lumens & Usable Light

In lighting design there are two distinct kinds of lumen output produced by lamps. The first is called **photopic** lumens, which represent the relative sensitivity of the eye under intense lighting such as full outdoor sun. **Photopic** lumen output is the amount of light registered by the cones in the human eye and is measured by standard lumen and foot candle meters.

The second type of lumens is called **scotopic**, which represent the sensitivity of the eye under typical interior lighting conditions and cannot be measured directly with a standard light meter. **Scotopic** lumen output is the amount of light registered by the rods of the human eye and also controls pupil size directly effecting visual acuity for tasks.

For lighting interior spaces a correction factor may be applied to **photopic** lumen readings to find the usable light produced by a given light source, also called **scotopic** lumens. As shown below, two different light sources having similar **photopic** lumen readings taken by a standard light meter can have drastically different **usable light outputs** and apparent brightness.

The factor **S/P** is the ratio of **scotopic** luminous quantity to **photopic** luminous quantity for the lamp spectral power distribution. From a given **photopic** quantity, the analogous **scotopic** quantity can be found by multiplying the **photopic** quantity by the value of the S/P ratio. Natural daylight has an **S/P** ratio of close to **2.5** which means that it is highly **scotopically** enriched.

Light Source	Photopic Lumens /Watt	S/P Ratio	Scotopic Lumens/Watt
5000k Ultra LED White Lite	**90**	**2.00**	**180**
4100k T5 Fluorescent	**90**	**1.80**	**162**
Clear Metal Halide	85	1.49	126
5000k Triphosphor Fluorescent	70	1.58	111
4000k Multi-Vapor Metal Halide	85	1.26	107
6500k Daylight Fluorescent	55	1.72	95
3500k Triphosphor Fluorescent	69	1.24	85
Vitalite Fluorescent	46	1.71	79
5000k 90 CRI Fluorescent	46	1.70	78
2900k Warm White Fluorescent	65	0.98	64
Low-Pressure Sodium	165	0.38	63
50watt High-Pressure Sodium	65	0.76	49
Deluxe Mercury Vapor	40	0.86	34
35watt High-Pressure Sodium	55	0.57	31
Tungsten Halogen	22	1.32	29
Standard Incandescent	15	1.26	19
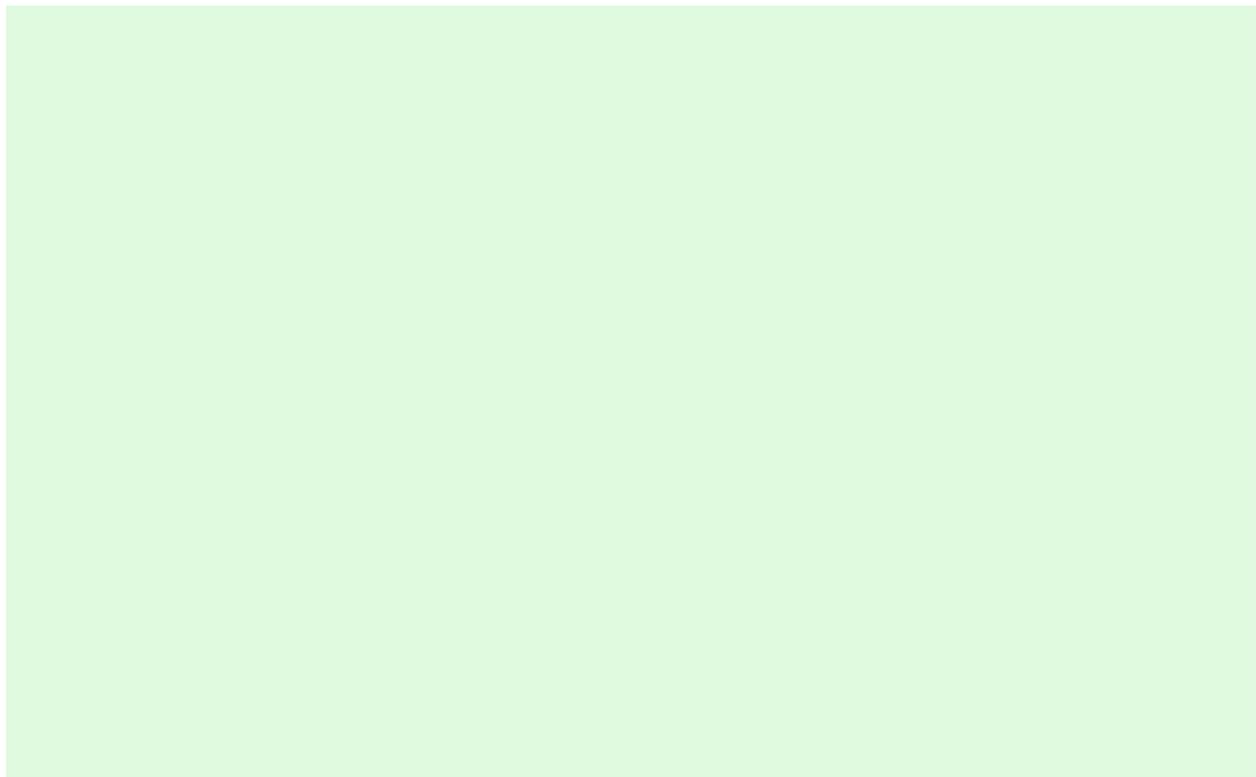
What is Photopic and Scotopic Vision?

The retina, a light sensitive membrane at the back of the eye, contains millions of very tiny light receptors that convert light into electrified signals sent to the vision centers of the brain. The two major categories of light receptors (photoreceptors) are called cones and rods because of their shapes. The very central part of the retina, the fovea, contains only cones. The rest of the retina contains both rods and cones, with the number of rods dominating the cones by about ten to one.

Up until now, it's been widely accepted that cones handle day vision and rods are designed for night vision. Consequently, lighting manufacturers have utilized light meters to measure a lamp's lumen output that are calibrated by examining the eye's sensitivity to only cone activated vision in the very central part of the retina **(photopic)**, completely ignoring the effect of rod activated vision **(scotopic).**

But, according to a study by [Dr. Sam Berman and Dr. Don Jewett](#), the roles of rods and cones are not that exclusive - they actually share responsibility depending on lighting conditions. Dr.'s Berman and Jewett's experiments, sponsored by the U.S. Department of Energy, have shown that rods (scotopic) do indeed play a role in typical workplace lighting conditions. Thus, human perception of lighting conditions is not consistent with the devices we generally use to measure light output.

This and other studies lead us to the conclusion that both **photopic** and **scotopic** responses to lighting need to be evaluated when measuring light effectiveness. Ideally, this would require light meters with a calibration for conventional **(photopic)** illuminance as well as an addition calibration for **scotopic** illuminance.

Source: Platts Research & Consulting