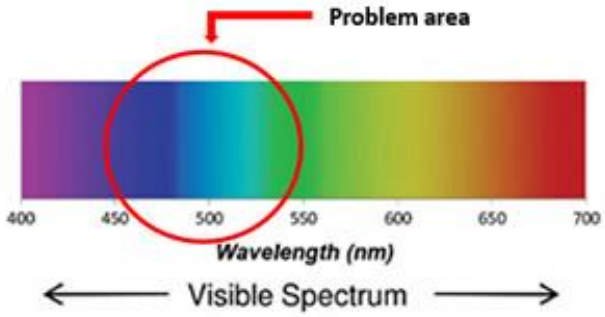
Ivins Night Sky Initiative
improve, preserve, and protect the night sky over Ivins Utah

SHEDDING LIGHT ON OUTDOOR LED CHOICES

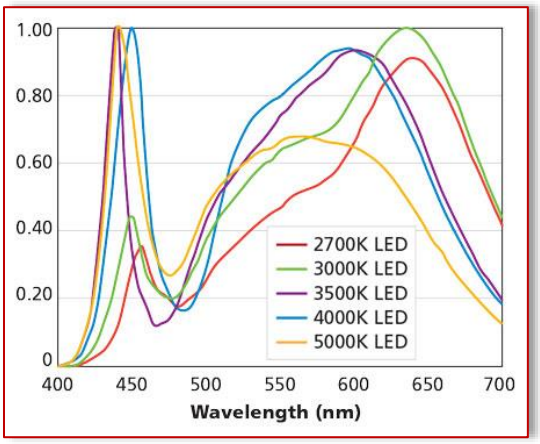
January 2019

New technologies come with unanticipated challenges. With outdoor LED lighting, that turns out to be significant levels of blue light. As a result, most current outdoor LED lighting is far more damaging to us and our nighttime environment than the old technologies they replace. This article appears to be a bit technical, but please continue reading. It will all make sense.



FEELING BLUE

LEDs with coordinated color temperatures (CCTs) over 3500K emit a lot of blue light (wavelengths below 550nm). That, mixed with the other emitted colors results in the bright, glaring white light we see with most LED street lights and parking lot lights.



The amount of blue light emitted falls significantly when CCTs are at or below 3000K, but they still emit more blue light than the older technologies they are replacing.

Because of the amount of blue light emitted, even relatively low (CCT) LEDs at 3,000K have lumen-for-lumen sky glow impacts six times greater than low pressure sodium (LPS) and more than double the sky glow from high pressure sodium (HPS).

Even 2200K LEDs generate almost four times more sky glow than LPS and 50% more than HPS. LEDs can't currently match LPS or HPS lighting until narrowband amber (NBA) LEDs, phosphor converted amber (PCA) LEDs, or filtered warm-while LEDs (FLED) become more commonly available.

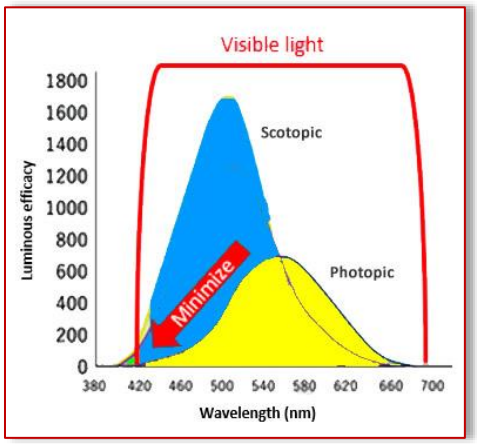
LIMITING BLUE

LEDs with higher CCTs create more light pollution because they emit more blue light. Blue light is a short wavelength light, so it is scattered by everything it hits, even air molecules. Even when the light is fully shielded and directed downward, the scattering sends it everywhere. Warm white light sources are preferred because they emit less blue light which means less scattering which creates less sky glow.

The solution is to minimize the amount of blue light generated. This isn't a problem for LPS lights because they don't emit blue light. Except for NBA LEDs, all other LEDs emit blue light. But the lower the correlated color temperature, the less blue light emitted. LEDs with a CCT of 3000K or less typically won't emit more than 25% of their total spectral power below 550 nanometers (where blue light resides), limiting the amount of blue light emitted. That should be the minimum goal. When it comes to blue, less is more.

THE SCOTOPIC-TO-PHOTOPIC RATIO

But it's not that simple. Our eyes sensitivity to blue light is significant. That's one of the reasons we react negatively to so much of the outdoor LED lighting common today, those lights are rich in blue light, much too rich.



The scotopic/photopic ratio (S/P ratio) measures how much emitted light is useful to the human eye. Higher S/P ratios provide more visually effective lumens for our eyes to process and translate into more energy efficiency. But higher S/P ratios mean more blue light is emitted.

"WARMER" LEDS ARE LESS EFFICIENT

LEDs are a lot more energy efficient than older technologies they are replacing. But warmer LEDs are less efficient than LEDs with CCTs at 3000K or more because they emit less blue light. A 2200K LED is only about two-thirds as efficient as a 3000K LED, meaning it will consume more watts to create the same amount of useful light. But a 2700K LED almost matches the efficiency of 3000K LEDs.

Scotopic/photopic (S/P) ratio versus CCT

	← Warmer Colder →				
CCT (K)	2200	2700	3000	3500	4000
S/P ratio range	0.8 – 0.9	1.1-1.4	1.2-1.5	1.3-1.6	1.4-1.8

DO THE LEAST HARM

The use of warmer instead of colder LEDs increases energy use, but they meet a goal that cities should adopt, namely "do the least harm." Because of the blue light they emit, "colder" LEDs simply can't be justified unless they are coupled to a significant reduction in illumination. Even so, no more than 2,700K CCT should ever be considered. But, except for increased sky glow from colder LEDs, where is the harm?

GLARE

Better visual acuity and apparent brightness is achieved with colder CCTs. But their blue-rich white light is known to increase glare and compromise human vision, especially in the aging eye. These lights create potential road safety problems for motorists and pedestrians alike.

Using innovative fixtures that employ frosted lenses or reflectors will help reduce glare, but at the cost of some efficiency. That minimized the operating cost differences between warmer and colder LEDs.

MEDICAL PROBLEMS KEEP PILING UP

A June 2016 American Medical Association (AMA) report, “Human and Environmental Effects of Light Emitting Diode Community Lighting,” concluded that “white LED street lighting patterns [may] contribute to the risk of chronic disease in the populations of cities in which they have been installed.”

The AMA recommends “minimizing and controlling blue-rich environmental lighting by using the lowest emission of blue light possible” to reduce potential negative effects on human health. And, although there is less light output per watt of electricity in the lower Kelvin temperature rated lights, the AMA considers that a good thing, as they affirm outdoor public lighting is not just too blue, it is too bright.

A Harvard medical study states that "…blue light has been identified for years as the most dangerous light for the retina. After chronic exposure, one can expect to see long range growth in the number of macular degenerations, glaucoma’s, and retinal degenerative diseases."

A paper published by the American Macular Degeneration Foundation (AMDF) reports, "the blue rays of the spectrum seem to accelerate age-related macular degeneration (AMD) more than any other rays in the spectrum".

Blue light also disrupts the circadian rhythms of humans, animals, and plants; and it has even been implicated in the global obesity epidemic. Light pollution may be making us fat. Blue light also disrupts nocturnal animal behavior; both wild and domesticated animals.

DON’T FORGET ABOUT PREFERENCES

In addition to all these health risks, it cannot be assumed that light sources that produce a perception of greater brightness and greater clarity will be preferred for functional lighting. Preference is based not just on the perception of a light’s brightness but also on the context of the space and people’s expectations for lighting of such a space.

Many people prefer low CCT outdoor lighting, especially in residential areas. The city of Davis, California, for example, was obliged to replace newly-installed 4800K street lighting with 2700K luminaires at a cost of $350,000 following residents' complaints about "prison-white" lighting.

WHAT SHOULD WE DO RIGHT NOW?

1. Limit outdoor lighting CCTs to no more than 2700K, and ideally 2200K, with less than 25% of its total spectral power at wavelengths < 550 nanometers to keep blue emissions to a minimum.
2. Look for ways to reduce the number of outdoor lighting installations and reduce the total lumens per installation to minimize blue light impacts on citizens and sky glow as much as possible.
3. Use timers, motion sensors, adaptive controls, and curfews to limit lighting to when it is needed.
4. Consider using NBA LED or PCA LED when available and practical.

Special thanks: *While we take full responsibility for the statements in this article, we appreciate the information from Christian Luginbuhl, U.S. Naval Observatory, Flagstaff (Retired), and founder of the Flagstaff Dark Skies Coalition.*

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Two recently published studies (Luginbuhl et al., 2014; Aubé et al., 2013) have evaluated the visible sky glow brightness caused by the following lamp types:

Type	Description	S/P Ratio	Sky Glow[1] (relative to LPS)	Sky Glow[1] (relative to HPS)
			FDSC Grade[2]	
LPS	Low-pressure sodium – a nearly monochromatic yellow-orange light source used mostly in areas near astronomical observatories and sea turtle nesting beaches. 	0.23	1.0	0.4
			AAA	
NBA LED[3]	Narrow-band amber LED – a narrow-spectrum yellow-orange LED nearly equivalent to LPS in light pollution impacts. 	0.23-0.30	1.0	0.4
			AAA	
HPS	High-pressure sodium – A golden-yellow light source, widely used throughout the world. 	0.64	2.4	1.0
			A	
PCA LED[4]	Phosphor-converted amber LED – Similar to HPS though products vary. 	0.45-1.0	1.8-4.1	0.7-1.6
			AA-B	
FLED[5]	Filtered warm-white light-emitting diode – a straw-yellow LED lamp with a filter that removes most emission with wavelength shorter than 500 nanometers. 	0.9	3.6	1.5
			B	
LED 2200K	Light-emitting diode with "correlated color temperature" (CCT) of 2200K – a "warm-white" LED. This type of LED has not seen wide use. 	0.84-0.90[6]	3.6-3.8	1.4-1.5
			C	
LED 3000K	Light-emitting diode with "correlated color temperature" (CCT) of 3000K – a "warm-white" LED. 	1.3[6]	5.4	2.1
			C	
LED 4100K	Light-emitting diode with CCT of 4100K – a "cool-white" LED. This is a common LED type in recent LED area lighting installations. 	1.6[6]	6.4	2.7
			D	