LED WATCH

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LED STREET LIGHTING'S IMPACT ON SKY GLOW

A DOE study looks at uplight, lumen output, spectral power distribution and other variables

Recently, there's been some concern as to whether LED street lighting is more likely to cause sky glow than conventional (typically, high-pressure sodium) street lighting. Compared to sodium light sources, LEDs do produce a larger portion of their output in shorter wavelengths, which scatter more readily in the atmosphere than do longer wavelengths. To further investigate this issue, the U.S. Department of Energy (DOE), together with experts in atmospheric scattering and astronomy, conducted a study of the expected contributions to sky glow from converting high-pressure sodium (HPS) street lighting to broader-spectrum (i.e., white light) sources, with specific focus on LEDs. The study's report, *An Investigation of LED Street Lighting's Impact on Sky Glow*, presents the contributions of LED conversions relative to HPS baseline conditions.

It's important to note that *all* white light sources—not just LEDs—produce a significant portion of their output in short wavelengths. What's more, street lighting is only one of many sources of light at night in urban areas. Other sources include interior light escaping through exterior windows, architectural and landscape lighting, signage, parking lots and garages, recreational lighting and vehicular lighting. The new study only considered contributions to sky glow from street lighting.

LEDs CAN HELP

When spectral content of the source is considered in isolation of all other factors, increasing the short-wavelength content of exterior lighting does increase the potential for sky glow, but this potential is, in actuality, typically reduced by

other common characteristics of LED street lighting conversions, including reductions in both total luminous output and percent uplight compared to the incumbent system. The amount of sky glow is also influenced by external factors, such as the observer's distance from the source of the light, the size of the source (i.e., city area) and atmospheric conditions. In the study, the influence of each of these factors was estimated using SkyGlow Simulator, a computer model developed by Dr. Miroslav Kocifaj at the Slovak Academy of Sciences.

Because the results of any modeling effort are only as valid as the underlying assumptions, considerable care was taken to select values for variables that are reasonable and representative of typical conditions and scenarios in the U.S. Four levels of uplight (0%, 2%, 5% and 10%) were compared, along with two levels of lumen output (100% and 50%). Ten different spectral power distributions (SPDs) from actual products of different light-source types were modeled, along with a hypothetical source whose radiant energy output is equal across the visible spectrum. Two observer positions were modeled: one at the perimeter of the city (the "near" observer) and one 40 km (25 miles) from the city center (the "distant" observer). The computer runs enabled each factor's effect to be examined individually, with other factors held constant. This isolated the influences of important variables, such as light distribution and SPD, and also allowed for more-comprehensive comparisons of sky glow resulting from representative streetlight conversions in the U.S. today—e.g., replacing a typical HPS glass refractor cobra-head streetlight (2% uplight) with an LED streetlight (0% uplight) that emits half the lumens. The latter characteristic is commonly enabled, in the U.S. at least, by the elimination of hot spots at nadir and most of the stray light that characterizes earlier lamp-based technologies.

STUDY FINDINGS

Focusing on the typical U.S. street lighting conversion, a key finding is that when the results are expressed as unweighted radiant power, all of the modeled LED product conversions reduce sky glow relative to an HPS baseline, for both the near and distant observers. Such unweighted results are most useful for astronomical observation instruments and the evaluation of impacts not specifically related to human vision. When the results are instead scotopically weighted to evaluate the effects on human vision (e.g., to determine the visibility of the night sky), some LED products reduce sky glow for the *near observer* compared to the baseline, and others increase it, depending on their relative content of shorter wavelengths. An important related finding, however, is that correlated color temperature (CCT) does not serve as a very reliable predictor of sky glow impacts, especially when scotopic weighting is not applied. Overall, the results for LED conversions in this study ranged from a low of 0.2 to a high of 1.6 times the baseline HPS sky glow, depending on the combination of variables and factors studied.

Another important finding has to do with uplight. For the *distant observer*, even at only 40 km from the city center, the elimination of uplight that occurs in typical conversions nearly removes (by 95% or more) the contribution to sky glow from the street lighting system for all SPDs under all atmospheric conditions, for both the unweighted and scotopically weighted results. Results indicate that for residents living near the city, the *visible* contribution to sky glow from a typical streetlight conversion is likely to be no worse than with the incumbent system and may even have improved.

It's important to keep in mind that all light that's added to a nighttime environment has the potential to contribute to sky glow. For electric light sources offering wide flexibility in terms of spectral content—such as LED streetlights—reducing the short-wavelength content reduces this potential but may also degrade visual performance and perception of brightness. The spectral content of sources affects both the luminance contrast and the color contrast of objects, and facilitates the ability to see and recognize the task and situation.

To enable an optimal and comprehensive balance in the results, cities that are undertaking a street lighting conversion should proceed through their design and selection process with as much knowledge as possible about the benefits and trade-offs.

For more details, see the full report at *https://energy.gov/eere/ssl/street-lighting-and-blue-light*.

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