SSL

Bruce Kinzey

Light at Night A collaborative approach helps balance dark-sky considerations with safe and responsible design

The use of electric light at night is increasing around the world, a trend guaranteed to continue as populations and economies grow. Coupled with widespread conversion of street lighting to energy-efficient LED–which has more short-wavelength content than some of the incumbent technology it's replacing—this increase has triggered a myriad of concerns worldwide about corresponding growth in the obscurity of the night sky, energy use and possible health impacts. These are absolutely valid concerns, yet the information at hand is often incomplete and misunderstood, with the discourse often based more on emotion than on objective science.

That's why the U.S. Department of Energy (DOE) is pitching in on several fronts to fill in the information gaps and come to a better collective understanding of issues related to such things as overlighting; improper installation; and the causes of, and remedies for, the intrusion of "artificial" light in the night sky. (A variety of resources on the topic can be found at *www.energy.gov/eere/ssl/street-lighting-blue-light-and-light-night*.) Given the wide range of benefits that lighting brings, the formidable reality is that we must find the best balance among frequently competing objectives: not only to be able to see the stars and incoming asteroids, but also to ensure safety, maximize health, protect the environment and save energy—all while demonstrating fiscal responsibility.

Achieving that balance is made easier by the advent of LED lighting, which offers an unprecedented degree of control in terms of output, optics and spectrum. A 2017 DOE study on LED street lighting's impacts on sky glow found that, typically, a light source's contributions to light entering the night sky follow this order of influence: uplight, lumen output (or "lumen package") and spectral content. This means that, generally speaking, this same order also applies to the most-effective ways of addressing light-at-night issues.

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Based on a data set developed during the 2017 study, last year some of my colleagues at Pacific Northwest National Laboratory (PNNL) created a simplified spreadsheet tool that allows the user to compare lighting products' contributions to sky glow, and to vary the traditional output characteristics (e.g., spectral content, output level, percent uplight) of each product being compared. A copy of the tool can be requested from *www.energy.gov/eere/ssl/potential-impacts-led-street-lighting-sky-glow*.

Work on this important topic continues. For example, the IES Sky Glow Calculations Committee (SGCC)—formed by the IES in 2017—is truly a "who's who" of astronomers and other experts from universities, national laboratories and similar organizations, including some from outside the U.S. I'm very honored to be a part of it. The

committee's goal is to develop recommended procedures and tools for estimating quantifiable contributions to sky glow from individual lighting applications, thereby helping to identify practical means of reducing sky glow for use by lighting designers, specifiers, owners and agencies responsible for outdoor lighting. The SGCC's inaugural project is a forthcoming Technical Memorandum to describe the state of the current science, identifying what's known about human-based sky glow and its causes, and providing guidance and recommendations while recognizing other aspects of the underlying science that are still under investigation.

Determining the appropriate output of LED replacement products for matching illumination levels of legacy street lighting systems is an ongoing source of confusion for many. Municipalities and utilities often simplify the process by using lookup tables that specify the conventional high-intensity discharge (HID) lamp type and wattage and suggest a corresponding lumen package for the LED replacement. However, these values can differ significantly, depending on the source. Our review has found more than 50% variation in recommended LED lumens for replacing a 100-W high-pressure sodium streetlight, for example. Such simplified approaches can significantly compromise the resulting performance when distribution, uniformity, and appropriate light-loss factors are not also incorporated into the analysis; unfortunately, information on how the lookup tables were developed is typically limited.

As noted earlier, excess lumens emitted by a streetlight fixture translate into more lumens in the night sky and result in energy waste and other undesirable effects. The DOE Solid-State Lighting Program has therefore embarked on the development of an improved methodology that will strive for a consensus approach to characterizing consistent lumen-output equivalencies. Producing a single value (such as is sought from a lookup table) that's able to adequately fit the great range of situations out there will be exceedingly difficult, if not impossible. But we believe that the current widely inconsistent approach can certainly be improved. If you're interested in learning more, an April 2 IES webinar (information at *www.ies.org/education/webinars*) has been scheduled to provide an overview of the draft methodology, along with a review of comparative light-loss factors and other considerations for HID and LED sources.

Although outdoor luminaires are typically photometered and designed to have their aperture planes parallel to the ground, in their actual application they're often installed on a tilt and aimed to project light farther away from the pole or the wall. When luminaires are tilted in this way, owners, contractors and designers may not realize the dramatic impact this has on light going into the night sky (effectively defeating a U0 rating, for starters). Tilting may also increase glare for drivers and pedestrians, as well as light spilled onto adjacent properties and wildlife habitats. To help raise awareness of these unintended side effects, DOE, together with Lightlab Allentown, is conducting a preliminary investigation into the impact of tilting roadway lights, floodlights, etc., on sky glow, distribution, and glare.

DOE also has several other related projects underway or slated to begin in the next few months, so stay tuned. Success in achieving the critical balance sought among the range of different objectives for outdoor lighting will require approaches that are not only science-based, but also *collaborative*—because we're truly all in this together. Pitting ourselves against imagined adversaries only serves to impede progress. Many of these problems have been growing for decades and won't be solved overnight, but the advent of LEDs brings possibilities for solutions that we've never had before. Together, we will reach the stars.

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