National Electrical Manufacturers Association

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Outdoor Lighting and Human/Animal Factors: An Industry Evaluation

Prepared by:

NEMA Lighting Systems Division
National Electrical Manufacturers Association
1300 North 17th Street, Suite 900
Rosslyn, Virginia 22209

The opinions expressed in this statement represent the consensus views of the member companies of the Lighting Systems Division of the National Electrical Manufacturers Association. The members of the Lighting Systems Division manufacture indoor and outdoor lamps, which include incandescent, fluorescent, light-emitting diode, and solid-state lamps, lighting fixtures, and lamp ballasts.

technology producing the light can change from fluorescent to high-pressure sodium, to metal halide, or to LED, the light energy is all the same, regardless of the source. There is no difference between the short wavelength blue light energy produced by a fluorescent lamp, or a metal halide lamp or an LED source; it is all radiated short wavelength blue light.

The lighting industry characterizes the color of white light using the term CCT. Color temperatures of common light sources used outdoors can range from approximately 2000K to 7000K. Lamps that have a 2000K color temperature, such as high-pressure sodium, look very yellow. Lamps that have color temperature of 7000K look very blue. Lamps that have CCT between 3000K and 4000K have a balanced color spectrum and tend to look white. 3000K lamps have a slightly warmer (yellow) appearance than 4000K lamps.

A single color temperature is not appropriate for all applications. Each application must be evaluated on a case by case basis to select the most appropriate color temperature for that application. Proposals for outdoor lighting that suggest that limiting the CCT to a maximum of 3000K in all cases are not supportable and are focused on resolving issues for specific applications to the detriment of other applications.

The Case for Only Using Higher Color Temperature Lamps

Some groups have made the case to only use higher color temperature sources when outside, e.g., 4000K, 5000K, or higher. Their point is that light sources with higher CCT have more energy in the short wavelength (i.e., blue) part of the spectrum which is better seen by the human eye at the very low light levels typical of outdoor applications. The argument is that use of high color temperature sources, therefore, can improve human reaction time, and improve energy efficiency, safety and security. Following this logic, they argue that using such sources may also allow designers to reduce light levels, rather than using lower color temperature sources to achieve the same visual lighting effect.

The Case for only using Lower Color Temperature Lamps

The American Medical Association Community Guidance issued on June 14, 2016, suggested only using lower color temperature sources of 3000K or less over concerns about circadian rhythm effects. They argue that the short wavelength radiation, (i.e., blue light) found in higher color temperature sources can potentially suppress melatonin and negatively affect sleep cycles. However, it has been documented in several studies that such effects can only occur with a high exposure level and a long exposure time to blue light. The required exposure to blue light for the retina is extremely unlikely to be achieved under outdoor lighting conditions where outdoor light levels are very low, and users are generally exposed to outdoor lighting for a very short period. In contrast, people with seasonal affective disorders (SAD) who try to suppress melatonin levels in the morning are often told to sit next to a lighting fixture containing high-intensity, high CCT light sources for 30 to 60 minutes.

The Lighting Research Center (LRC) has indicated that CCT is not the correct metric to predict blue light content. Rather, it is recommended that the appropriate metric must consider spectral power distribution (SPD) along with light level expressed in photopic lux.[1]

[1] LRC Response to the 2016 AMA Report on LED Lighting,
http://www.lrc.rpi.edu/resources/newsroom/AMA.pdf
LRC Webinar on Blue Light - Response to AMA,
https://www.youtube.com/watch?v=2BcfcONrm58&feature=youtu.be
LRC Releases Free, Open Access Circadian Stimulus Calculator,

An LED lighting system has the capability to link all street lighting assets, remotely control luminaires and communicate over the network in real-time that enables on-demand dimming and expand control capabilities. It is one of the most efficient options compared to traditional lighting technologies.

In summary, there are several well-respected organizations (see Appendix A) attempting to address the above issues. Much of the current research compares 2000K to 6000K and does not represent the 3000K or 4000K that is being installed in the outdoor space today. Also lacking is definitive research on exposure time. Research thus far has been largely focused on shift workers and their exposure to artificial light in the interior space. This in no way represents the possible exposure that individuals typically experience under street lighting. The IES has organized numerous forums for the presentation and discussion of information and collected data from a wide range of researchers and laboratories. There is still not consensus within IES on these matters. This demonstrates the need for additional research and more scientific study. More studies must be conducted, and scientific data must be collected for the industry to establish agreed upon corresponding actions. NEMA welcomes the opportunity to work with various organizations to prioritize and drive projects to research this area further. We are committed to improving outdoor lighting based on factual data and scientific conclusions.

APPENDIX A

NEMA encourages a thorough review of statements issued by government and academic experts on this topic:

U.S. Department of Energy Posting, June 21, 2016
Jim Brodrick, Solid-State Lighting Technology Manager at the U.S. Department of Energy (DOE), explains that there is nothing different about the blue light emitted by LEDs as compared to other sources with blue, rich content. He also indicates that there is nothing inherently dangerous about LED lighting and that it should be used with the same prudence with which we use any other technology. It is commonly agreed that light should be directed only where it is needed at the minimal levels required to support visibility, safety, and security, and to use a spectral content that supports the needs of the application. DOE also indicates that lighting products with low CCTs may result in light that no longer appears white and colors can be substantially distorted, reducing visibility. In this case, higher lighting levels may be required, which may completely negate the effects of reducing the relative amount of short wavelength 'blue' emission.

DOE related documents include:

True Colors, LEDs and the relationship between CCT, CRI, optical safety, material degradation, and photobiological stimulation, October 2014, https://www.osti.gov/scitech/biblio/1165332

Street Lighting and Blue Light Frequently Asked Questions, February 2017, https://energy.gov/sites/prod/files/2017/03/f34/Street%20Lighting%20and%20Blue%20Light%20FAQs.pdf

View all DOE documents and presentations relating to Street Lighting and Blue Light at https://energy.gov/eere/ssl/street-lighting-and-blue-light

Illuminating Engineering Society Updates, June 2016
IES expresses concern with the varying degrees of information and misinformation about claims and recommendations in the AMA report specific to the use of blue-rich lighting. IES also questions if the references in the 2016 AMA are sufficient to justify the expanded recommendations from the 2012 AMA report. IES continues to work with researchers and experts on this subject.

Lighting Research Center Response, June 30, 2016
The LRC suggests that CCT ignores nearly all important factors associated with light exposure and is only relevant to the perceived color of illumination. The LRC concludes that CCT should never be used to characterize light as a stimulus for blue light hazard. The LRC also provides an example illustrating that, given equal illuminance; a 3500K source may produce greater melatonin suppression than a 5000K source. The LRC believes that there is not enough research available yet to reach firm conclusions about blue light and circadian disruption.

Lam Partners Statement: Is LED Street Lighting Bad For Your Health?
Glenn Heinmiller, June 29, 2016
Glenn Heinmiller, a lighting designer in Boston, indicates that the AMA report cites no evidence that the intensity and duration of exposure typically experienced from street lighting are sufficient to have any

melatonin-suppressing effect. He also cites a report from the Northwest Energy Efficiency Alliance concluding that 4100K LED street lighting resulted in significantly better ability of drivers to detect pedestrians at greater distances, compared to the other higher and lower color temperatures tested. Mr. Heinmiller suggests that this might make 4100K the best choice from a safety standpoint on streets with pedestrians and cyclists.

U.S. Department of Energy Municipal Solid State Street Lighting Consortium
The Light Post, July 2016
The Municipal Solid State Street Lighting Consortium states that new LED luminaires with improved optical distribution emit only half (or less) of the light output of luminaires using conventional light sources. Therefore, the reduction in light levels may reduce the overall melanopic output for the application even if there is an increase in blue spectral content of the source compared to traditional technologies. This report furthermore lists the melanopic content of several different light sources, with the conclusion that LED lighting with a CCT as high as 4500K can have the same melanopic content as an incandescent lamp at 2700K. It is important to note that two highly regarded researchers in this specific field of light and health, Bud Brainard, Ph.D. and Robert Lucas, Ph.D., provided a review of this report for accuracy and that Bud Brainard was also listed as a contributor to the AMA report.

U.S. Department of Energy "Get the Facts on LED Streetlighting" Solid State Lighting webcast, October 2016
A presentation on key issues underlying concerns raised by the American Medical Association community guidance on street lighting, and their applicability to LED street lighting. This presentation highlights the facts as we know them today and points out that there is no single solution for all applications. Users need to understand all key factors prior to making a decision on their lighting solution. The DOE discusses their investigations into items such as sky glow, light source comparisons, proper measurement of total blue light exposure, and research on how much light is actually coming into homes. DOE highlights the fact that by using LED luminaires with lower lumens, and the ability to dim for a portion of the night, the experience may be less blue light exposure compared to traditional light sources.
https://energy.gov/eere/ssl/downloads/webinar-get-facts-led-street-lighting

National Institute of Health (NIH) "Lighting and its Impact on Circadian Disruption and Health: What We Know, What We Don't Know and What We Need to Know" webcast, Dr. Mariana G. Figueiro, February 2017

Webcast provides an overview of light as it affects the circadian system, discusses tools to measure and specifies circadian effective light. It also proposes gaps in besides no underscore, what is Webcast? Is that the name of something? our knowledge of the health effects of light. Also discussed are potential research studies to minimize these gaps.

APPENDIX B
Industry References

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