International Dark-Sky Association

Blue-White Light and the Night Environment

Background: The rapid growth in the use of "white" light sources for outdoor lighting is changing the night environment with potentially damaging effects. Metal halide lamps, induction lamps and white-light LED light sources all have strong emissions in the blue region of the spectrum unlike the familiar and widely-used high pressure sodium lamps which emit mainly in the yellow-orange part of the spectrum.

Incorrect and misleading information by some manufacturers, especially those promoting LED outdoor lighting, suggests that blue-white light may improve vision. The research in this area is ongoing; but no application-oriented outdoor lighting recommendations from either the Illuminating Engineering Society or the International Commission on Illumination currently exist that provide guidance about how such benefits can be realized in practical lighting installations [1] [2]. The research, in fact, indicates that only under very special circumstances can the purported gains in outdoor lighting efficiency or improved visibility be realized. Therefore, widespread replacement of existing outdoor light sources (primarily high pressure sodium) with sources emitting bluish-white light is not prudent due to the negative environmental and human visual impacts that would result.

Outdoor lighting efficiency for visual tasks involving cognitive and foveal vision (primarily driving) is not increased using bluish-white light sources. Far more substantial gains in overall energy efficiency and visual acuity can be attained through designing for proper illumination levels and lighting distributions, using available controls, removing unnecessary lights, and by utilizing luminaires with better directional and glare control.

Position: The IDA recognizes that blue-rich artificial light at night is potentially harmful to human and environmental health and compromises human vision with respect to glare and visual performance – especially where older eyes are involved. Unless and until further research can be done to show how these detrimental effects might be beneficially balanced for users of practical lighting systems, the IDA recommends that blue-rich light sources not be used or, if used, the light sources be filtered to eliminate the light emissions in the 400-500 nanometer region. The IDA strongly supports research in this area to better understand the visual and environmental effects of outdoor lighting, not just its potential for energy savings.

Recommendations:

- Use light sources that strongly curtail emissions at light wavelengths shorter than 500 nanometers over the complete life of the product.
- Utilize control options such as motion sensing, time-of-night dimming, and stepped switching, including complete shutoff.

- Specify luminaire shielding to curtail uplight, glare and light trespass.
- Limit illumination to the specific task area.
- Design for minimum lighting levels necessary for the task.
- Minimize use of light sources with a Correlated Color Temperature (CCT) above 3000 Kelvins. (Note: CCT only roughly correlates with the emission of blue light wavelengths. The specification of light source spectral output is preferred.)

Concerns:

- The addition of *any* artificial light into the nocturnal environment has negative consequences.
- Environmental problems related to artificial light are primarily caused by wavelengths shorter than 500nm (violet and blue light).
- Use of bluish-white light disrupts the natural behavior of wildlife and contributes to a decline in population health.[3]
- Bluish-white light because of greater atmospheric scattering of short-wavelength light disproportionately increases sky glow. Aggregation of short wavelength outdoor light sources will irreparably degrade night sky quality. [6]
- The glare response in humans is color dependent. Any increase in bluish-white light sources has detrimental effects in situations where glare impacts visibility. Eyes become more sensitive to glare with age.

Discussion:

Vision

Scotopic vision (dark-adapted vision at moonlight levels and below) does not occur in most circumstances involving electric lighting. By definition, the lumen applies to daytime vision where color vision and the photopic response curve are active to the exclusion of other types of vision. The "mesopic" adaptation range is between the photopic and scotopic ranges, but there is no defined "mesopic lumen" since there is no agreed-upon way to characterize and measure the visual adaptation and phenomena involved. At this point, however, substitution of "mesopic" or "scotopic lumens" for photopic lumens has no scientific basis.

The Scotopic/Photopic ratio is being misused by lighting manufacturers and misunderstood by users. For all cognitive visual functions, the action spectrum is photopic. Wavelengths in the blue region of the spectrum below 500nm contribute less than 7% of photopic response (see chart below). Even though bluish-white light appears to be brighter to most observers, there is no evidence that it provides better visibility at photopic light levels [1].

Efficient Outdoor Lighting Systems

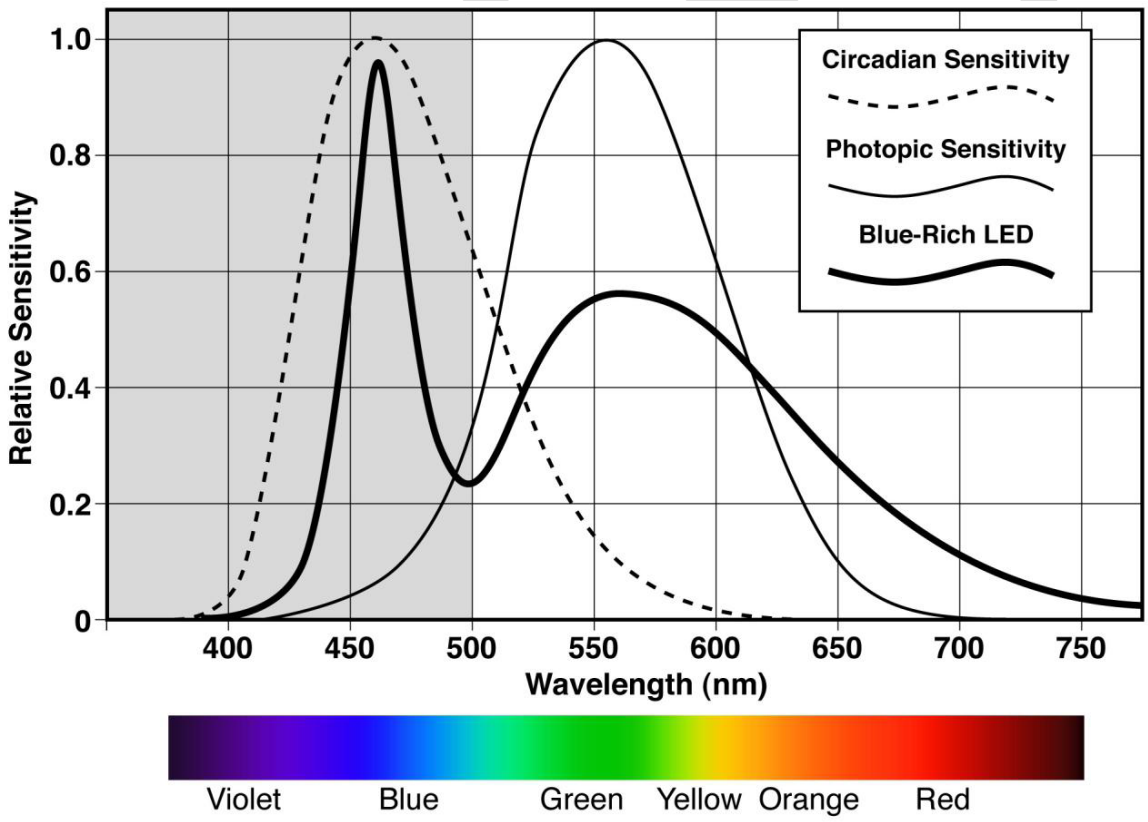
The efficacy of a lighting system (lumens/watt) measures how well the lighting system transforms electricity into visible light. Typical high pressure sodium and metal halide lighting systems have efficacies that range from 80 to over 100 lumens/watt. The efficacy of white-light LEDs is improving rapidly and even considering luminaire and system losses is expected to

match and exceed older light sources over the next few years. Accordingly, LEDs have the potential to meet many outdoor lighting requirements, including those utilizing advanced lighting controls, variable brightness levels, precisely tailored light colors, shifting light colors and life cycle cost. However, most LED installations so far ignore these potential features and instead focus on a single metric – lumens per watt.

LEDs which emit in narrow spectral bands such as in the yellow (around 590 nanometers), for example, have great potential to replace legacy LPS lighting systems long recommend for protected zones around astronomical observatories if lighting is those areas is essential. Such LED systems could also address concerns about protecting astronomical research, public stargazing, and wildlife habitat.

Circadian Response

Artificial light sources have been shown to affect all living organisms through disruption of their natural cycles that rely upon rhythms of daylight and night darkness. In humans, the peak sensitivity of this response is in the range of 459-484 nanometers (blue).[4] [5]



The graph shows the visible spectrum, the human photopic sensitivity which defines the lumen, the human circadian sensitivity and the typical output of a blue-rich white-light LED light source.

A large portion of light emitted by bluish-white LED source falls outside of the human photopic vision range, but falls within the circadian sensitivity curve, where it does not aid photopic vision but

may disrupt normal day/night cycles.

References

1. "Spectral Effects of Lighting on Visual Performance at Mesopic Light Levels". Illuminating Engineering Society. New York. IESNA TM-12-06. http://www.iesna.org

2. "IESNA Lighting Handbook", Ninth Edition, 2000. Illuminating Engineering Society. New York. http://www.iesna.org

3. Rich, C and Longcore, T. "Ecological Consequences of Artificial Night Lighting" Island Press, 2006. ISBN 1-55963-128-7.

4. "Light and Human Health: An Overview of the Impact of Optical Radiation on Visual, Circadian, Neuroendocrine and Neurobehavioral Responses." Illuminating Engineering Society. New York. Publication TM-18-08. 2008. http://www.iesna.org

5. Stevens, RG; Blask, DE; Brainard. GC; Hansen, J; Lockley, SW; Provencio, I. Meeting Report: The Role of Environmental Lighting and Circadian Disruption in Cancer and Other Diseases. *Environmental Health Perspectives*, 115:1357-1362, 2007.

6. Wainscoat, Richard J. Meeting Report: Protection of Hawaii's Observatories from Light Pollution. Proceedings of the International Conference in Defence of the Quality of the Night Sky and the Right to Observe the Stars. Canary Islands, Spain, 2007.

7. Sleep, sleep disorders and circadian rhythms – general information: http://science.education.nih.gov/supplements/nih3/sleep/guide/info-sleep.htm and http://www.cdc.gov/Features/Sleep/

10-13-09

FORM FOR COMMENT ON IDA POSITION STATEMENT: BLUE-RICH WHITE LIGHT

All Comments Must Be Received by 5:00 pm MST on 29 October 2009.

Name_____ Date_____ Tel_____

Company/Affiliation_____Email_____

Comment Recommends (check one) _____Additional Text _____Revised Text

Comment (Include proposed additional or revised wording, or identification of wording to be deleted) [Note: Please use underscore to denote wording to be inserted [inserted wording] and strike-through to denote wording to be deleted [~~deleted wording~~].)

Statement of Corroboration and Substantiation for Comment (Please offer corroboration of points presented, elaborate on a proposed idea, or define the problem that would be resolved by your recommendation. Give the specific reason for your comment, including citations or copies of tests, research papers, etc.)

Copyright Assignment (for added text)

_____ I am the author of the text or other material proposed in the comment.

_____ Some or all of the text or other material proposed in this comment was not authored by me. Its source is as follows: _____.

Thank you for your valuable feedback. IDA does not guarantee incorporation of comments or suggestions.