**2. Light Pollution Information and Mitigation**

The resources below provide detailed information about the causes and primary sources of light pollution, as well as standards, code and practices for mitigating light pollution impacts. All links below are up-to-date as of January 2020.

American Medical Association. (2016). Human and Environmental Effects of Light Emitting Diode (LED) Community Lighting. Retrieved from <https://www.ama-assn.org/sites/ama-assn.org/files/corp/media-browser/public/about-ama/councils/Council%20Reports/council-on-science-public-health/a16-csaph2.pdf> Several concerns about the use of LED sources for public lighting are discussed; recommendations to shield outdoor lighting and to use low correlated color temperature (CCT) sources are given.

ASSIST. (2010). The potential of outdoor lighting for stimulating the human circadian system. Troy, NY: Lighting Research Center. Retrieved from <https://www.lrc.rpi.edu/programs/solidstate/assist/pdf/ASSIST-TechnicalPaper-OutdoorLightingCircadianAnalysis.pdf> The International Dark Sky Association has raised concerns about the health effects of outdoor lighting at night. The Lighting Research Center and ASSIST here provide a quantitative analysis of the effects of light at night of different spectral power distributions on the human circadian system. A specific recommendation is made for "a reasonable and conservative working threshold" for exposure to light at night.

Bierman, A. (2012). Will switching to LED outdoor lighting increase sky glow? Lighting Research and Technology, 44(4), 449–458. Retrieved from <https://doi.org/10.1177/1477153512437147> As more and more outdoor lighting systems are switching to LED light sources, concerns are growing regarding the potential for increased sky glow resulting in the subsequent increase in short wavelength radiation from these sources. Atmospheric light scatter from a 6500 K LED source and a 2050 K High Pressure Sodium lamp are compared and it was found that one can expect roughly 10 -20% more light scatter attributing to sky glow from the LED source.

Brons, J. A., John D. Bullough, & Rea, M. S. (2008). Outdoor site-lighting performance: a comprehensive and quantitative framework for assessing light pollution. Lighting Research & Technology, 40(3), 201–224. Retrieved from <https://doi.org/10.1177/1477153508094059> Three different issues regarding outdoor, night-time lighting and light pollution are discussed and evaluated: sky glow, light trespass and glare. The benefits and drawbacks of nighttime lighting are discussed and Outdoor Site-Lighting Performance (OSP) is introduced as a useful tool for measuring and quantifying these issues.

Brons, J., Bullough, J., & Rea, M. (2007). Light Pollution: Thinking Inside the Box. Lighting Journal, 72 No 5, 27–34. Retrieved from <http://www.lrc.rpi.edu/researchAreas/pdf/insidetheBox.pdf> The Outdoor Site-Lighting Performance (OSP) is a method of calculating light pollution including light trespass, glare, and sky glow. This paper describes the system and provides evaluation data from real-world outdoor lighting installations.

Bullough, J. D., Sweater Hickcox, K., & Narendran, N. (2011). ASSIST recommends: A Method for Estimating Discomfort Glare from Exterior Lighting Systems (Vol. 9, pp. 1–7). Retrieved from <http://www.lrc.rpi.edu/programs/solidstate/assist/pdf/AR-DiscomfortGlare.pdf> This report discusses existing mathematical models for predicting discomfort glare and an extension of those models based on new research. Example calculations are provided.

Chartered Institution of Building Services Engineers (CIBSE). (2012). Guide to Limiting Obtrusive Light 2012. CIBSE. Retrieved from <https://www.cibse.org/knowledge/knowledge-items/detail?id=a0q20000008I7kPAAS> According to the authors, this guide outlines the causes and consequences of obtrusive light, and what can be done to minimize obtrusive light generally and in some commonly occurring applications.

Chepesiuk, R. (2009). Missing the Dark: Health Effects of Light Pollution. Environmental Health Perspectives, 117(1), 20–27. Retrieved from <https://dx.doi.org/10.1289/ehp.117-a20> This article is a high-level review of issues related to light at night. Topics include the mechanisms of sky glow, ecological impacts, and human health impacts such as circadian rhythm disruption and cancer risks.

CIE. (2017). Technical Report: Guide on the Limitation of the Effects of Obtrusive Light from Outdoor Lighting Applications (CIE 150:2017). Vienna, Austria: CIE. Retrieved from <http://dx.doi.org/10.25039/TR.150.2017> This technical report provides a methodology for the mitigation of the obtrusive effects of outdoor lighting such as light trespass, daytime appearance and glare.

Illuminating Engineering Society. (2011). IES TM-15-11: Luminaire Classification System for Outdoor Luminaires. Retrieved from <http://www.techstreet.com/products/1800146> As the authors state, "This Technical Memorandum defines a classification system for outdoor luminaires that provides information to lighting professionals regarding the lumen distribution within solid angles of specific interest." TM-15 describes the backlight, uplight, glare, or BUG, classification system.

Illuminating Engineering Society. (2012). DG-22-12: Design Guide for Sustainable Lighting: An Introduction to the Environmental Impacts of Lighting. Retrieved from <https://www.techstreet.com/mss/standards/ies-dg-22-12?product_id=1831690> This Design Guide gives an in-depth look at the environmental impact of lighting in its many applications. The guide discusses sustainability and the challenges and opportunities facing the lighting designers and practitioners of today. A section of the guide discusses reducing light pollution.

Illuminating Engineering Society. (2017). IES Board Position on AMA CSAPH Report 2-A-16, Human and Environmental Effects of Light Emitting Diode (LED) Community Lighting. Retrieved from <https://www.ies.org/about-outreach/position-statements/ies-board-position-on-ama-csaph-report-2-a-16-human-and-environmental-effects-of-light-emitting-diode-led-community-lighting/> This position statement outlines several objections to the AMA report on LED public lighting.

International Dark-Sky Association & Illuminating Engineering Society. (2011). Model Lighting Ordinance (MLO) with User’s Guide. Retrieved from <https://www.darksky.org/wp-content/uploads/bsk-pdf-manager/16_MLO_FINAL_JUNE2011.PDF> The Model Lighting Ordinance aims to help communities reduce light pollution in the forms of sky glow, light trespass and discomfort glare through the use of better lighting practice and technologies. The suggested ordinance is the joint work of the IES of North America and the International Dark Sky Association.

Kinzey, B et al. (2017). An Investigation of LED Street Lighting’s Impact on Sky Glow. U.S. Department of Energy, Pacific Northwest National Laboratory. Retrieved from <https://www.energy.gov/sites/prod/files/2017/05/f34/2017_led-impact-sky-glow.pdf> This document describes research to quantify the impacts of LED roadway lighting on light pollution and sky glow. The authors conclude that typical LED retrofit installations have the potential to reduce sky glow compared to previous incumbent lighting technologies.

Klinkenborg, V. (2008) Light Pollution. National Geographic. Retrieved from <https://web.archive.org/web/20081021104417/http://ngm.nationalgeographic.com/2008/11/light-pollution/klinkenborg-text> This magazine article summarizes the impacts of light pollution. The effects on birds, bats, and amphibians are discussed.

Lighting Research Center. (2003). Implementation of Decision-Making Tools that Address Light Pollution for Localities Planning Street Lighting. Retrieved from <http://www.lrc.rpi.edu/programs/transportation/pdf/lightPollution/whitePaper.pdf> This white paper provides information regarding Connecticut outdoor lighting legislation, light pollution, and best practice for efficient, effective outdoor lighting. The white paper discusses lighting considerations that should be considered before embarking on a lighting project and summarizes good lighting practice and how municipalities can work with designers or planners to ensure that their lighting installation meets the lighting objectives in their community.

Lighting Research Center. (2016). Response to the 2016 AMA Report on LED Lighting. Retrieved from [www.lrc.rpi.edu/resources/newsroom/AMA.pdf](http://www.lrc.rpi.edu/resources/newsroom/AMA.pdf) This report discusses the AMA report on public lighting and describes the appropriate use of lighting metrics to characterize impacts of LED lighting on public health and safety. See also https://youtu.be/2BcfcONrm58 for an LRC webinar presentation summarizing the key issues.

National Institute of Environmental Health Sciences. (2016). Workshop: Shift Work at Night, Artificial Light at Night, and Circadian Disruption. Retrieved from <https://ntp.niehs.nih.gov/pubhealth/roc/candidates/meetings/workshop_alan.html> This workshop was convened to bring scientists together to analyze and discuss impacts of lighting at night and shift work on circadian rhythms in people.

Rea, M S; Brons, J; Figueiro, M. F. (2012). Measurement of light at night (LAN) for a sample of female school teachers. Chronbiology International, 28(8), 673–680. Retrieved from <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3342668/> Past studies have shown links between exposure to light at night (LAN) as well as rotating shift schedules to an increased risk in breast cancer. Some such past studies have used satellite-photometry as well as self-reported bedroom light levels to express this link and have claimed that data from these reports show an increased risk in breast cancer regardless of shiftwork history. The present article investigates the use of satellite-photometry as well as self-reported brightness as a useful way of characterizing light levels at the cornea by studying light levels of a sample of female school teachers working regular day shifts using Daysimeter measurement devices. It was found that there was no known connection between the satellite measured photometric data and the 24-hr light-level exposures of the female school teachers.

Royal Commission on Environmental Pollution. (2009). Artificial Light in the Environment. Retrieved from <https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/228832/9780108508547.pdf.pdf> An in-depth inquiry into the human-health and environmental effects of light pollution in Great Britain. Glare, light trespass, light clutter, light profligacy, sky glow and an absence of darkness are listed as the different kinds of light pollution and are further analyzed in this publication.