Memorandum
City of Lawrence
Public Works

TO: Thomas M. Markus, City Manager
FROM: Charles F. Soules, Director of Public Works
CC: Diane Stoddard, Casey Toomay, Brandon McGuire
DATE: November 7, 2017
RE: CMR – LED Lights

On October 10th the City Commission received public comment from Mr. Adrian Millot about concern of the installation of light-emitting diode (LED) lights.

Over the past few months, City staff and Commissioners have received communications from citizens with questions and concerns about the conversion to LED lights – both as part of the City's Facilities Conservation Improvement Program (FCIP) project, and the Westar-owned streetlight conversion. Here's an update on recent conversations:

- On September 1st, City staff involved in the FCIP program met with Westar Energy representatives and a group of concerned citizens (the Lawrence Alliance for Responsible Lighting).

- It was a productive meeting with good information shared. The citizen groups' main concern is that the color temperature (measured in Kelvins) for outdoor lights should be less than 3,000K. They cite studies that have found human health and wildlife impacts from lights higher on the spectrum.

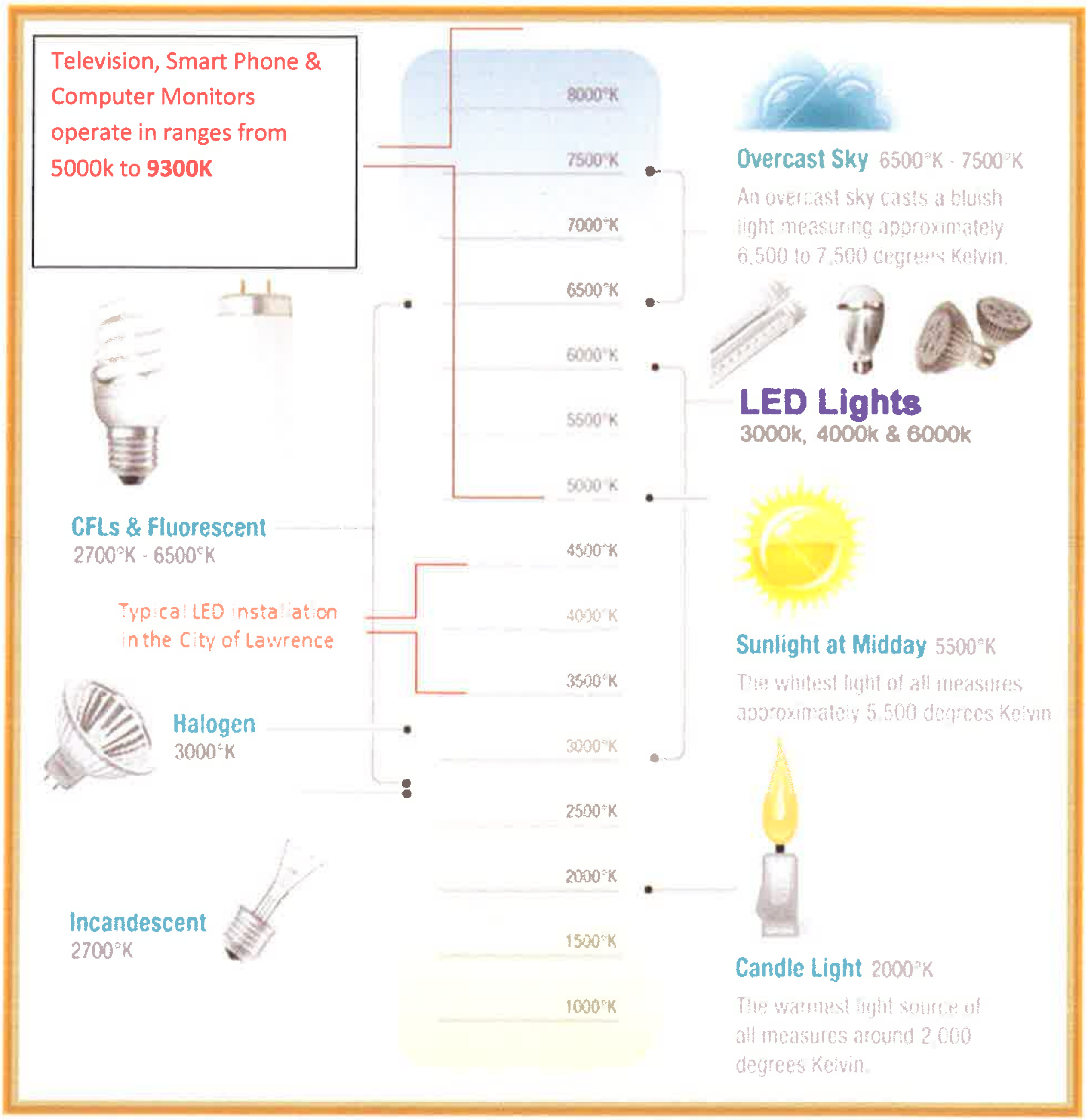
    - The City FCIP project lighting is about 90% installed at this point, so there is not an opportunity for the City to change course without incurring significant expense. We did create some FAQs and other resources on our website to keep citizens informed of our progress and some of the issues: https://lawrenceks.org/fcip/

    - The following illustration provides a comparison of the different light sources.

- The lights that the City and Westar are installing are 4,000K, a slightly bluer light.

    - The 4,000K light has been the industry standard for outdoor light retrofits as it tends to provide better safety and visibility.

- Televisions, computer monitors, and cell phones operate between 5,000K – 9,000K.



Television, Smart Phone & Computer Monitors operate in ranges from 5000k to 9300K
8000°K
7500°K
7000°K
6500°K
6000°K
5500°K
5000°K
4500°K
4000°K
3500°K
3000°K
2500°K
2000°K
1500°K
1000°K
Overcast Sky 6500°K - 7500°K
An overcast sky casts a bluish light measuring approximately 6,500 to 7,500 degrees Kelvin.
LED Lights
3000k, 4000k & 6000k
CFLs & Fluorescent
2700°K - 6500°K
Typical LED installation in the City of Lawrence
Sunlight at Midday 5500°K
The whitest light of all measures approximately 5,500 degrees Kelvin
Halogen
3000°K
Incandescent
2700°K
Candle Light 2000°K
The warmest light source of all measures around 2,000 degrees Kelvin.

- A complaint with the Kansas Corporation Commission (KCC) was filed objecting to Westar's LED retrofit project (attached).

- Westar has replaced approximately ½ of the 3,900 streetlights in the community.

- Westar has adopted the LED light color temperature of 4,000K as the industry standard.

- Westar's response to the KCC is attached.

- The City's lighting code has not been updated since the mid 90's, prior to the widespread adoption of LED technologies.

- The lighting code will not address Westar owned streetlights.

- On September 22nd, staff is Planning and Development Services met with the citizen group to talk about the information they have, and how it may be incorporated into future lighting codes. The Planning Department staff will continue to work to involve concerned citizens in the code re-write process.

At this point citizens are encouraged to participate with the Planning Department on the code revision.

Attachments: KCC Complaint Details LED Streetlights
Westar's Response
Lighting Research Center (LRC) Response to AMA
Illuminating Engineering Society (IES) Board Position on AMA
Prairie Village Lighting
Report of The Council on Science and Public Health
NEMA Comments on American Medical Association

Complaint Details:

I am a member of LARL Lawrence Alliance for Responsible Lighting . Many in Lawrence including members of LARL object to Westar s LED retrofit project because Westar is replacing traditional streetlights with LEDs of a color temperature CCT of 4 000K. As of a few weeks ago the project was half complete. The American Medical Association AMA recently stated that streetlights should be no more than 3 000K. Therefore Westar s continued retrofitting project using these nonconforming lights is a negligent business practice that may compromise our health. The adopted report can be found here https www.ama assn.org sites default files media browser public about ama councils Council 20Reports council on science public health a16 csaph2.pdf
We have met with Westar representatives where we requested and continue to request that they stop using nonconforming streetlights and immediately switch to the correct color temperature. We are requesting an immediate restraining order to halt the project until this matter is decided by KCC or a district court.
In its report the AMA stated that the 4 000K LEDs emit a large about of blue light that appears white to the naked eye but creates worse nighttime glare than conventional lighting. It states that discomfort and disability from the intense blue rich LED lighting can decrease visual acuity and safety resulting in road hazard.
The report states that the blue rich LED streetlights operate at a wavelength that most adversely suppresses melatonin during the night. The AMA also states that the unseen blue light can increase the risk of serious health conditions including cancer and cardiovascular disease. It states that studies show that bright LEDs reduce sleep time result in poor quality sleep and cause impaired daytime functioning.
In my recent consultation with an experienced neurologist he stressed that studies are showing that the blue rich content of LEDs may contribute to macular degeneration the leading cause of blindness in older people.
Numerous cities are following the AMA guidelines like Prairie Village KS and Knoxville TN. However Westar persists in giving our members and the media a variety of reasons for continuing with these unsafe streetlights claiming they are harmless. And yet those reasons are not supported by professionals who understand streetlight emissions. It is not only the AMA that considers these streetlights nonconforming but also the International Dark Sky Association the experts in streetlight emissions has specifically denounced them. Lighting manufacturers sold high CCT LEDs initially because it was the only option that was as efficient as existing HPS. That was then this is now. New 3000K CCT chips have similar efficacy to 4000K CCT. And there is no significant cost differential. No reason exists not to switch. And nothing will slow down the LED lighting industry or Westar s progress in this area like a national and local debate over glaring unsafe LED streetlights when the default should be a lower the CCT and to reduce the glaring lighting emissions.
Our position is that Westar is pursuing an unsafe business practice failing to engage in prudent risk management and intentionally avoiding a growing body of published health concerns. When these lights have to be replaced which is an avoidable cost at this time ratepayers should not be on the hook for Westar s failure to practice ordinary due diligence. Likewise if Westar is found liable for damages for customers health ratepayers should not be on the hook for those avoidable damages. Our request is for the immediate use of 3 000K lighting and for an immediate restraining order on the remaining lights until the KCC or a district court decides the matter.

Company Response:

Members of LARL Lawrence Alliance for Responsible Lighting met with four Westar representatives as well as engineers for the City of Lawrence at Lawrence City Hall. We explained our position that Westar s use of the 4 000k LED streetlights is in noncompliance with the American Medical Association s specific guidance on these lights that came out last year which recommends no higher a CCT level than 3 000k. We requested Westar to immediately start putting in 3 000k since they were only half done with the project. We handed out copies of the AMA report which itself cites to dozens of studies. We referenced a recent Harvard report reflecting similar health concerns and explained there are studies connecting these light emissions with macular degeneration and cancer and that the glare creates disability and road hazards for drivers. However Westar felt the emissions were harmless citing viewpoints at odds with the emerging studies on this. Further Westar has never indicated that cost is an issue. Therefore it is baffling to us that a responsible company presented with these concerns would not practice risk management at this point and simply change its default streetlight choice.

Suggested Resolution:

Westar should immediately stop retrofitting Lawrence streetlights with 4 000k CCT. It should continue replacing the old lights with 3 000k CCT. Without a cost penalty for doing this and in light of the specific AMA recommendation it is now an unreasonable and unsafe business practice not to act on the health evidence. The possible contribution of these lights to macular degeneration the leading cause of blindness in older people all by itself should decide the issue in favor of switching to the safe lights. The company should cease its project until the KCC or a district court decides whether this is an unsafe practice.

REID NELSON KCC REPLY (Sept. 2017)

Providing and maintaining streetlighting is an important role Westar Energy fills in many of the communities we serve. In 2015, we began a transition to energy-efficient LED lights for this purpose. Westar's approach to transitioning to LED streetlights has been to replace older lights when they fail with the new LED technology. At that time a color temperature of 4000K was the industry standard, as it remains.

Westar adopted the industry standard 4000K because it made sense. The light temperature is very close to that of the moon; studies show the light makes it easier to identify true colors, which aids law enforcement; and the better visibility it provides reduces accidents. As an industry standard, the lights were also readily available at a reasonable cost for our customers.

In summer 2016 the American Medical Association issued its report on LED lighting and we, like others, were interested in its conclusions and how they were reached. Within weeks of its issuance the Department of Energy, National Electrical Manufacturers Association, the Illuminating Engineering Society and others weighed in. These reputable experts said that more research was needed because the issue is more complex than presented in the AMA report.

The Illuminating Engineering Society, in its IES Board Position on the AMA report, said:

> The IES respectfully disagrees with the 2016 AMA Policy H-135.927 Statement 2 and the first sentence of Statement 3 specific to limitations on spectral content for outdoor area and roadway lighting. We want to emphasize, that while the principal motivators for the AMA report are understandable, the CSAPH 2-A-16 report filed as background for these statements does not provide sufficient evidence to substantiate these statements, and a more comprehensive analysis of the public health impacts of outdoor and roadway lighting should be considered prior to adopting policies that could have a negative effect on the safety of drivers and pedestrians. Given the state of current knowledge, it is not possible to weigh the probabilities of health care concerns regarding light-at-night and its effect on sleep disruption from outdoor and roadway lighting against the needs of nighttime driver and pedestrian safety, but such deliberations should precede any policy statement that affects both concerns.

In its report, the IES also stated that using only color temperature to understand potential health effects is inadequate. A study must also consider length of exposure and quantity of the light reaching the retina. This critique was echoed by the Lighting Research Center at Rensselaer Polytechnic Institute in its whitepaper responding to the AMA report.

IES, which helps establish American National Standards Institute (ANSI) Standards, invited the AMA to participate in technical committees to better understand the effects of occupational and environmental lighting on health and safety.

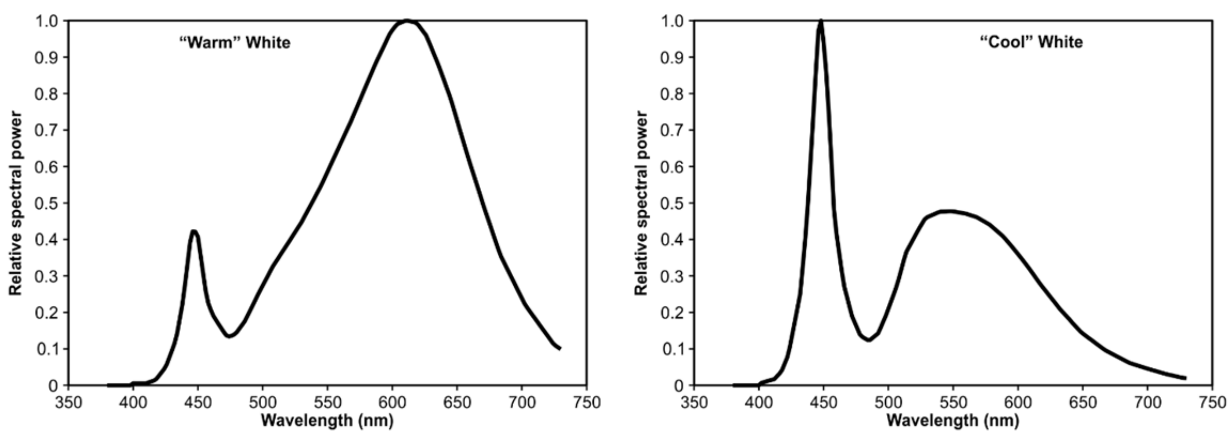
We agree that guidelines by organizations like the AMA merit close consideration, along with other reputable research. However, close examination of AMA's guidelines by experts in lighting and photometrics show that limiting decisions based on those guidelines would be premature. Clear evidence to support a change in color temperature has not been established. If collective research were to arrive at conclusory evidence Westar would, of course, consider that in the course of action it takes. Until such occurrence, Westar will continue to follow industry standards.

Response to the 2016 AMA Report on LED Lighting

June 30, 2016

In response to the American Medical Association (AMA) report "Human and Environmental Effects of Light Emitting Diode (LED) Community Lighting," Mark S. Rea, PhD and Mariana G. Figueiro, PhD of the Lighting Research Center at Rensselaer Polytechnic Institute have prepared the below, which is limited to the effects of indium gallium nitride (In-Ga-N) LED lighting on humans.

Recently the AMA has produced a document cautioning the public about In-Ga-N based LEDs used as sources of illumination both indoors and outdoors. These In-Ga-N LED sources generate short wavelength radiation from a solid state die. Some of that radiation is absorbed by a phosphor that, in turn, reemits long wavelength radiation. Together, the light emitted by the die and the light reemitted by the phosphor appear white to the human eye. Depending upon the relative emissions from the LED package, both the die and the phosphor, the white illumination can appear to have a "warm" tint (yellowish-white) or "cool" tint (bluish-white) or can appear neutral.



This solid state lighting technology has, or soon will, displace most other commercially available light sources used for general illumination because they are more energy efficient, have longer life and are more cost effective to own and operate than most other sources of illumination. The concern expressed by the AMA in their report is focused specifically on the short-wavelength emission from these In-Ga-N LED sources as that spectral region might negatively affect, through several modes, human health. Specifically, the following modes are of interest:

- Blue light hazard
- Glare, both disability and discomfort
- Melatonin suppression
- Circadian disruption

To understand the potential risk to human health through each of these modes it is first necessary to characterize the stimulus in terms of its physical properties and then second to relate those stimulus properties to specific, measureable biological outcomes.

Physical stimulus characteristics

Any light stimulus can be analyzed into the following physical characteristics.

- Spectrum
- Amount
- Duration
- Spatial distribution
- Timing
- Polarization

Biological response characteristics

Biological responses to light will mirror the physical stimulus conditions. Collectively, the spectral, temporal and absolute sensitivities of the biological system determine exposure. Hysteresis should also be considered due to non-linear changes in the biological system following exposure.

Exposure:

Spectral sensitivity

Temporal integration

Absolute threshold

Hysteresis

What must be known to make predictions

To meaningfully discuss the consequences of light exposure on human biology, and therefore, health, all of the physical characteristics of light as well as the specific biological response to light must be known. For example, the human retina will not respond to very short- (UV) and very long- (IR) wavelength optical radiation, so optical radiation emitted by sources in those regions will have no impact on visual and non-visual neural systems emanating from the retina. Light incident on the retina between the UV and IR bands can obviously evoke both visual and non-visual system responses by the retina, but each of these systems is tuned to different, relatively narrow wavelength bands. Meaningful discussion of the impact of light on human health as affected by optical radiation incident on the retina must therefore be framed in terms of the spectral emission of the light source and whether the spectral sensitivity of the visual or non-visual system is tuned to that emission. The amount and duration of light exposure must also be defined. The spectral emission from a light source might be perfectly tuned to the spectral sensitivity of the biological system, but if the amount and/or duration of light exposure are too low and/or too short, there will be no biological system responses. The timing of exposure is also important. For example, most biological responses to optical radiation, from humans to fungi, are dependent upon time of day. The same light stimulus may produce one effect at one time of day and a different response at another time. Finally, since biological systems are non-linear in their responses, the impact of a given light exposure can be different depending upon previous light exposure conditions. As a common example, melanin in the skin becomes darker with exposure to UV, thereby affecting the sensitivity of the system to subsequent radiation. Both sensitization and habituation are exhibited by the biological system. Finally, the spatial distribution of light is fundamentally important because all biological materials have optical properties that affect exposure. The cornea and the lens, for example, refract light to bring images to focus on the retina. Although polarization is another important physical characterization of light, it has, unlike insects, a very small effect on human biology.[1, 2]

Summary: Predictions of health consequences from light exposure depend upon an accurate characterization of the physical stimulus as well as the biological response to that stimulus. Without fully defining both the stimulus and the response, nothing meaningful can be stated about the health effects of any light source.

Biological Response Characteristics

Blue light hazard

High radiance, short-wavelength light focused on the retina by the optics of the eye for an extended duration has the *potential* to cause permanent damage to the retina.[3, 4] Diffuse short-wavelength light, as with the blue sky, does not cause damage nor do brief exposures to high radiance sources, as with incandescent filaments in a clear bulb. The American Conference of Governmental and Industrial Hygienists (ACGIH) provide specifications for exposure limits for blue light hazard.[5] To determine risk, the radiance of the light source (not the irradiance from the light source), the spectral distribution, and the duration of focused exposure on the retina must be known. Unless all of those terms are specified, it is not possible to assess blue light hazard.

Practically, however, the LED package (die + phosphor) can have high radiance in a spectral region that can cause damage. So, by calculation, focused, steady viewing of a 500 mW LED package (≈ 5 $W/cm^2/sr$) for approximately 10 seconds can cause damage. Humans' natural photophobic response to bright light would likely limit focused exposure to much less than a few seconds; however, some individuals may not have the capacity to avert gaze, such as premature infants.

Summary: Notwithstanding certain sub-populations that deserve special attention, blue light hazard from In-Ga-N LEDs is probably not a concern to the majority of the population in most lighting applications due to human's natural photophobic response.[3-11]

Disability and discomfort glare

There are two types of glare, one that can impair visual performance, disability glare, and one that causes an unpleasant sensation, discomfort glare. To determine the magnitudes of disability and discomfort glare, different formulations are necessary. Disability glare depends upon the amount of scattered light from small particles in the eye, but these particles are large enough that scatter is independent of wavelength. Therefore, short-wavelength and long-wavelength light produce the same amount of entopic scatter. Where visual performance (e.g., reading or judging speed and direction of a moving automobile) is important, the deleterious effects of scattered light can be weighted by the conventional photopic luminous efficiency function [$V(\lambda)$]. The well-established Fry (1954) disability glare formulation can be used to assess the impact of the light source in terms of conventional, photopic illuminance at the cornea and the angular distance between the line of sight and the light source.[12] Therefore, assessing the impact of In-Ga-N LED sources on disability glare would be the same as it would be for any other commercially available light source that might be used indoors or outdoors.

Discomfort glare is, however, much more complicated to assess. Like disability glare, discomfort glare increases with irradiance at the cornea and with reductions in the angular distance between the light source and the line of sight. Unlike disability glare, however, the spectral composition of the light source also influences discomfort glare; sources with relative greater short-wavelength content are seen as producing more discomfort for equal photopic illuminance at the cornea. All other factors being constant, sources dominated by short-wavelengths will produce relatively more discomfort glare than sources dominated by long-wavelengths. For white light sources, this effect is relatively small, relative to changes in corneal irradiance. The apparent size of the luminous element itself also impacts discomfort glare. Again, all other factors being constant, luminous elements larger than about 0.3 degrees of visual angle will produce more discomfort glare than smaller luminous elements. For light sources viewed from a short distance where the luminous element is 0.3 degrees of visual angle or larger, the discomfort-glare-specific spectrally weighted radiance of the light source must also be known to predict discomfort glare.[13]

Summary: In-Ga-N LED sources dominated by short wavelengths can cause relatively greater discomfort than sources dominated by long wavelengths, including "warm" In-Ga-N LED sources, at the same photopic illuminance at the cornea. As with disability glare, however, discomfort glare is mostly determined by the amount and distribution of light entering the eye, not its spectral content.[12-14]

Melatonin suppression

Melatonin is a hormone that signals "darkness" to the body; it is produced at night and in darkness. Retinal exposure to light during the nighttime can suppress melatonin synthesis by the pineal gland in the brain, potentially disrupting physiological processes timed to occur at night. "Darkness" is a relative term, however. Humans have a high threshold to retinal light exposure for suppressing melatonin at night.[15, 16] Well below this threshold (approximately 30 lux at the cornea from white light for 30 minutes), both rods and cones in the retina provide adequate visual information to humans for navigation, social interactions and even reading printed materials.[17] Nevertheless, the spectral sensitivity of melatonin suppression is dominated by short wavelengths,[18-24] so conventional means of measuring light exposure based upon the photopic luminous efficiency function (i.e., for visual performance) can underestimate the potential impact of In-Ga-N LED sources for suppressing melatonin at night. Light sources used for domestic and roadway lighting have traditionally been sources dominated by long-wavelengths, so the impact of In-Ga-N LED sources on melatonin suppression could, in principle, be of concern. New photometric instruments along with insights into the mechanisms underlying phototransduction by the retina as it affects melatonin suppression have been developed.[20, 25] Thus, it is now possible to measure and to quantify the impact of light exposure from any spectral irradiance distribution on nocturnal melatonin suppression in humans. These developments have, for example, provided insight into the impact of self-luminous displays on nocturnal melatonin suppression.[26-28]

It should be noted that melatonin appears to have an oncostatic effect on cancer proliferation. Blask and colleagues have shown that melatonin limits tumor progression in nocturnal rodents.[29, 30] The amount and the spectrum of light as they affect nocturnal rodents are quite different than they are for humans, however. Mice are between 3000 to 10000 times more sensitive to light as it affects melatonin synthesis at night.[31] Therefore, care must be given to any extrapolations from studies of melatonin suppression in nocturnal rodents to those in humans, particularly with regard to both visual and circadian phototransduction.

Summary: In-Ga-N LED sources dominated by short wavelengths have greater potential for suppressing the hormone melatonin at night than sodium-based sources commonly used outdoors. However, the amount and the duration of exposure need to be specified before it can be stated that In-Ga-N LED sources affect melatonin suppression at night.

Circadian disruption

Physiology and behavior of all vertebrates on Earth, including humans, are regulated by the 24-hour light-dark cycle incident on the retina. Disruption of that natural rhythm, either by rapid travel across time zones, or by aperiodic or highly variable exposures to light and dark at the wrong time, can cause disruption of physiology and behavior.[32-38] Epidemiological evidence suggests that humans performing rotating shift work are subject to a wide range of serious maladies from breast cancer to cardiovascular disease.[39-45] Melatonin suppression at night is undoubtedly an important part of circadian disruption, but it is not synonymous with circadian disruption. Staying awake in dim light at night or limited exposure to light during the day can also be disruptive to physiology and behavior, even though there is no effect of the light on melatonin concentrations. These disruptive social-behavioral effects may or may not be associated with nocturnal melatonin suppression.[46-49]

Much less is known about the spectral and absolute sensitivities to light as they affect circadian disruption. However, limited studies with red light exposures, which cannot suppress nocturnal melatonin synthesis, have shown that circadian-regulated physiology and behavior are affected.[50, 51] Again, therefore, it is quite possible that the negative impacts on human health by performing rotating shift work may only have a limited relationship to nocturnal melatonin suppression.

Summary: Until more is known about the effects of long-wavelength light exposure (amount, spectrum, duration) on circadian disruption, it is inappropriate to single out short-wavelength radiation from In-Ga-N LED sources as a causative factor in modern maladies.

The use and misuse of metrics

Lighting metrics have been developed and commonly used to predict biological responses to physical characteristics. Metrics are intended to be short-hand simplifications for characterizing *a particular* stimulus-response relationship. Correlated color temperature (CCT) for example is a simplification of the light source spectral power distribution (SPD) to represent how people will see the tint of illumination from that source (i.e., “warm” or “cool”). The CCT metric ignores nearly all of the important factors associated with light exposure (amount, duration, timing) and is only relevant to a single biological response (perceived tint of illumination). Therefore, CCT should never be used to characterize light as a stimulus for, say, blue light hazard. As a further example, the non-linear response of the human circadian system to white light indicates that for the same corneal photopic illuminance and depending on the SPD of the source, a 3500 K source can produce greater melatonin suppression than a 5000 K source.[52, 53] In general then, it is erroneous and misleading to use a metric developed for one purpose and then apply it to another purpose, particularly with regard to the impact of light on human health.

Overall summary

The public is becoming more aware of the role that light can play in our lives and has become sensitized to the impact that light may have on health. The development of In-Ga-N based LED light source technology has increased the social benefits of lighting by lowering its environmental and financial costs. It is nevertheless natural and appropriate for the AMA to question these advances in LED technology as they might negatively affect human health. Raising awareness is not enough, however. Professional responsibility must include rational and balanced discourse, whereby scientific and technical understanding lends insight into the social benefits as well as the social costs of In-Ga-N technology. The foundations for this discourse must rely upon a complete characterization of the physical stimulus as it affects a specific biological response. Misapplication of metrics, such as CCT, combining just one aspect of the physical stimulus with just one type of biological response, must be strenuously avoided. The present document attempts to draw attention to this problem of misapplying short-hand metrics to the topic of light and health and to provide the reader with published information that should inform rational discourse.

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IES Board Position on AMA CSAPH Report 2-A-16, Human and Environmental Effects of Light Emitting Diode (LED) Community Lighting

The American Medical Association (AMA) Council on Science and Public Health (CSAPH) has issued two reports related to nighttime lighting since 2012. The 2012 AMA Report CSAPH 4-A-12 report, Light Pollution: Adverse Effects of Nighttime Lighting, resulted in AMA Policy H-135.932, noting in particular the “need for further multidisciplinary research of occupational and environmental exposure to light-at-night”, the recognition of how interior lighting and the use of electronic media affect sleep disruption especially in children and adolescents, and the need for work environments operating in 24/7 fashion to have employee fatigue risk management plans in place. The IES supports the 2012 AMA Policy H-135.932.

In June 2016, the CSAPH issued Report 2-A-16, *Human and Environmental Effects of Light Emitting Diode (LED) Community Lighting*, which was accepted by the AMA House of Delegates (HOD) and resulted in the adoption of Policy H-135.927, which consists of these three statements:

- *Our AMA supports the proper conversion to community-based Light Emitting Diode (LED) lighting, which reduces energy consumption and decreases the use of fossil fuels.*
- *Our AMA encourages minimizing and controlling blue-rich environmental lighting by using the lowest emission of blue light possible to reduce glare.*
- *Our AMA encourages the use of 3000K or lower lighting for outdoor installations such as roadways. All LED lighting should be properly shielded to minimize glare and detrimental human and environmental effects, and consideration should be given to utilize the ability of LED lighting to be dimmed for off-peak time periods.*

The IES is aligned with the AMA in support of the proper conversion of outdoor area and roadway lighting to LED light sources to reduce energy consumption, with proper optics and shielding to reduce glare and light trespass. The IES further supports the AMA recommendation to consider the ability to reduce light levels during off-peak periods.

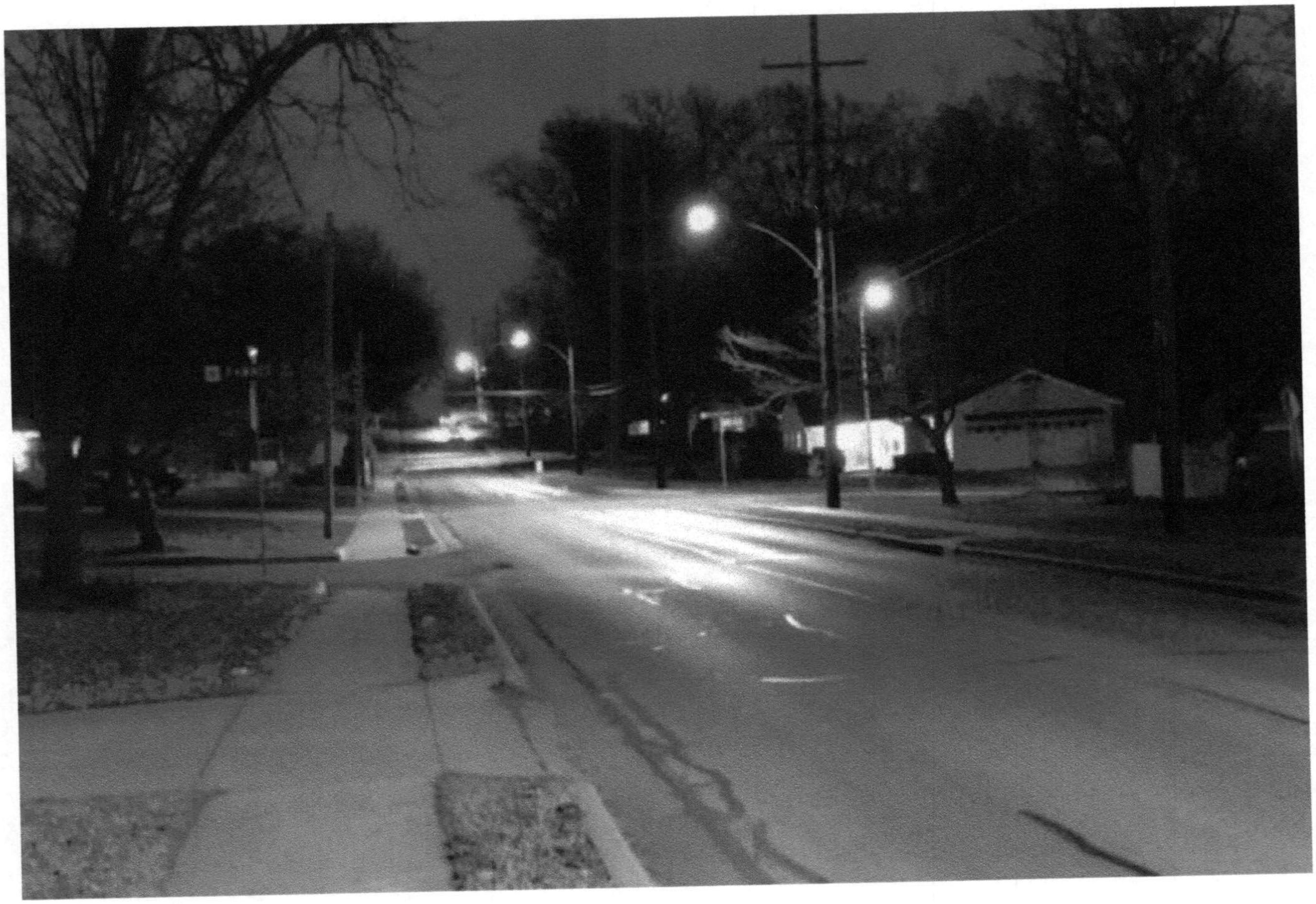
The IES respectfully disagrees with the 2016 AMA Policy H-135.927 Statement 2 and the first sentence of Statement 3 specific to limitations on spectral content for outdoor area and roadway lighting. We want to emphasize, that while the principal motivators for the AMA report are understandable, the CSAPH 2-A-16 report filed as background for these statements does not provide sufficient evidence to substantiate these statements, and a more comprehensive analysis of the public health impacts of outdoor and roadway lighting should be considered prior to adopting policies that could have a negative effect on the safety of drivers and pedestrians. Given the state of current knowledge, it is not possible to weigh the probabilities of health care concerns regarding light-at-night and its effect on sleep disruption from outdoor and roadway lighting against the needs of nighttime driver and pedestrian safety, but such deliberations should precede any policy statement that affects both concerns.

The IES also disagrees with 2016 AMA Policy H-135.927 on the basis that Correlated Color Temperature (CCT) is inadequate for the purpose of evaluating possible health outcomes; and that the recommendations target only one component of light exposure (spectral composition) of what are well known and established multi-variable inputs to light dosing that affect sleep disruption, including the quantity of light at the retina of the eye and the duration of exposure to that light. A more widely accepted input to the circadian system associated with higher risk for sleep disruption and associated health concerns is increased melanopic content, which is significantly different than CCT. LED light sources can vary widely in their melanopic content for any given CCT; 3000 K LED light sources could have higher relative melanopic content than 2800 K incandescent lighting or 4000 K LED light sources, for example. Common household incandescent lighting could therefore have significantly higher melanopic dosing than 3000 K outdoor or roadway lighting at night due to relatively higher melanopic content, higher light levels and longer durations of exposure. For all the listed reasons, the upper CCT limit of 3000 K contained in AMA Policy H-135.927 lacks scientific foundation and does not assure the public of any certainty of health benefit or risk avoidance.

The Illuminating Engineering Society is the American National Standards Institute (ANSI) Standards Development Organization for illuminating engineering. Our standards development process is based on the consensus of technical committees that serve the lighting profession and general public, and are not bound by AMA policy. The IES is committed to working with the AMA to address these concerns and invites AMA participation in IES technical committees. We believe that multidisciplinary research of occupational and environmental exposure to light at night is necessary, and we encourage collaborative deliberations with contributions from both organizations to develop Standards for the benefit of public health and safety.

» IES Position Statement PS-09-17 Background

[redacted]



Prairie Village installed five of the new LED street lights at 79th Street and Reinhardt as a test. Photo via Prairie Village Public Works.

Later this year, you'll likely start to notice a new look on Prairie Village streets after dark.

The Prairie Village City Council on Monday approved the purchase of 1,736 new LED street light heads that will be installed throughout the city.

Prairie Village began piloting use of the more energy-efficient street lights back in 2010 as part of a program operated by KCP&L. Since then, it's replaced approximately 300 of the high pressure sodium lights that were standard in the city with LED models. Last year, the council approved the purchase of all of the street lights in the city from KCP&L as part of a long-term cost savings initiative. It also determined that it would upgrade all of the remaining high pressure sodium heads to more energy efficient LED models.

Philips Lighting out of Salina had the low bid in a competitive process for the contract at $334,323. Installation will be handled by Black & McDonald out of Kansas City, Mo., at a cost of $121,086. Contractors installed a test run of five of the new LED lights at 79th Street and Reinhardt earlier this year to ensure that they met the city's requirements.

Public works officials decided to bid for LED lights that have a lower color temperature than the models used as part of earlier pilot projects. Those initial LED lights had a color temperature of 4000 Kelvin, meaning it contained more blue wavelengths, and emitted light that appeared whiter than standard street lights. The American Medical Association in 2016 issued a recommendation that new street lights have color temperatures not to exceed 3000 Kelvin. That recommendation was based on concerns that the whiter color temperatures can disrupt circadian rhythms. The street light head selected by Prairie Village for the new installations has a color temperature of 3000 Kelvin.

REPORT OF THE COUNCIL ON SCIENCE AND PUBLIC HEALTH

CSAPH Report 2-A-16

Subject: Human and Environmental Effects of Light Emitting Diode (LED) Community Lighting

Presented by: Louis J. Kraus, MD, Chair

Referred to: Reference Committee E (Theodore Zanker, MD, Chair)

INTRODUCTION

With the advent of highly efficient and bright light emitting diode (LED) lighting, strong economic arguments exist to overhaul the street lighting of U.S. roadways.[1-3] Valid and compelling reasons driving the conversion from conventional lighting include the inherent energy efficiency and longer lamp life of LED lighting, leading to savings in energy use and reduced operating costs, including taxes and maintenance, as well as lower air pollution burden from reduced reliance on fossil-based carbon fuels.

Not all LED light is optimal, however, when used as street lighting. Improper design of the lighting fixture can result in glare, creating a road hazard condition.[4,5] LED lighting also is available in various color correlated temperatures. Many early designs of white LED lighting generated a color spectrum with excessive blue wavelength. This feature further contributes to disability glare, i.e., visual impairment due to stray light, as blue wavelengths are associated with more scattering in the human eye, and sufficiently intense blue spectrum damages retinas.[6,7] The excessive blue spectrum also is environmentally disruptive for many nocturnal species. Accordingly, significant human and environmental concerns are associated with short wavelength (blue) LED emission. Currently, approximately 10% of existing U.S. street lighting has been converted to solid state LED technology, with efforts underway to accelerate this conversion. The Council is undertaking this report to assist in advising communities on selecting among LED lighting options in order to minimize potentially harmful human health and environmental effects.

METHODS

English language reports published between 2005 and 2016 were selected from a search of the PubMed and Google Scholar databases using the MeSH terms "light," "lighting methods," "color," "photic stimulation," and "adverse effects," in combination with "circadian rhythm/physiology/radiation effects," "radiation dosage/effects," "sleep/physiology," "ecosystem," "environment," and "environmental monitoring." Additional searches using the text terms "LED" and "community," "street," and "roadway lighting" were conducted. Additional information and perspective were supplied by recognized experts in the field.

ADVANTGAGES AND DISADVANAGES OF LED STREET LIGHTS

Action of the AMA House of Delegates 2016 Annual Meeting: Council on Science and Public Health Report 2 Recommendations Adopted and Remainder of Report Filed.

The main reason for converting to LED street lighting is energy efficiency; LED lighting can reduce energy consumption by up to 50% compared with conventional high pressure sodium (HPS) lighting. LED lighting has no warm up requirement with a rapid "turn on and off" at full intensity. In the event of a power outage, LED lights can turn on instantly when power is restored, as opposed to sodium-based lighting requiring prolonged warm up periods. LED lighting also has the inherent capability to be dimmed or tuned, so that during off peak usage times (e.g., 1 to 5 AM), further energy savings can be achieved by reducing illumination levels. LED lighting also has a much longer lifetime (15 to 20 years, or 50,000 hours), reducing maintenance costs by decreasing the frequency of fixture or bulb replacement. That lifespan exceeds that of conventional HPS lighting by 2-4 times. Also, LED lighting has no mercury or lead, and does not release any toxic substances if damaged, unlike mercury or HPS lighting. The light output is very consistent across cold or warm temperature gradients. LED lights also do not require any internal reflectors or glass covers, allowing higher efficiency as well, if designed properly.[8,9]

Despite the benefits of LED lighting, some potential disadvantages are apparent. The initial cost is higher than conventional lighting; several years of energy savings may be required to recoup that initial expense.[10] The spectral characteristics of LED lighting also can be problematic. LED lighting is inherently narrow bandwidth, with "white" being obtained by adding phosphor coating layers to a high energy (such as blue) LED. These phosphor layers can wear with time leading to a higher spectral response than was designed or intended. Manufacturers address this problem with more resistant coatings, blocking filters, or use of lower color temperature LEDs. With proper design, higher spectral responses can be minimized. LED lighting does not tend to abruptly "burn out," rather it dims slowly over many years. An LED fixture generally needs to be replaced after it has dimmed by 30% from initial specifications, usually after about 15 to 20 years.[1,11]

Depending on the design, a large amount blue light is emitted from some LEDs that appear white to the naked eye. The excess blue and green emissions from some LEDs lead to increased light pollution, as these wavelengths scatter more within the eye and have detrimental environmental and glare effects. LED's light emissions are characterized by their correlated color temperature (CCT) index.[12,13] The first generation of LED outdoor lighting and units that are still widely being installed are "4000K" LED units. This nomenclature (Kelvin scale) reflects the equivalent color of a heated metal object to that temperature. The LEDs are cool to the touch and the nomenclature has nothing to do with the operating temperature of the LED itself. By comparison, the CCT associated with daylight light levels is equivalent to 6500K, and high pressure sodium lighting (the current standard) has a CCT of 2100K. Twenty-nine percent of the spectrum of 4000K LED lighting is emitted as blue light, which the human eye perceives as a harsh white color. Due to the point-source nature of LED lighting, studies have shown that this intense blue point source leads to discomfort and disability glare.[14]

More recently engineered LED lighting is now available at 3000K or lower. At 3000K, the human eye still perceives the light as "white," but it is slightly warmer in tone, and has about 21% of its emission in the blue-appearing part of the spectrum. This emission is still very blue for the nighttime environment, but is a significant improvement over the 4000K lighting because it reduces discomfort and disability glare. Because of different coatings, the energy efficiency of 3000K lighting is only 3% less than 4000K, but the light is more pleasing to humans and has less of an impact on wildlife.

Glare

Disability glare is defined by the Department of Transportation (DOT) as the following:

"Disability glare occurs when the introduction of stray light into the eye reduces the ability to resolve spatial detail. It is an objective impairment in visual performance."

Classic models of this type of glare attribute the deleterious effects to intraocular light scatter in the eye. Scattering produces a veiling luminance over the retina, which effectively reduces the contrast of stimulus images formed on the retina. The disabling effect of the veiling luminance has serious implications for nighttime driving visibility.[15]

Although LED lighting is cost efficient and inherently directional, it paradoxically can lead to worse glare than conventional lighting. This glare can be greatly minimized by proper lighting design and engineering. Glare can be magnified by improper color temperature of the LED, such as blue-rich LED lighting. LEDs are very intense point sources that cause vision discomfort when viewed by the human eye, especially by older drivers. This effect is magnified by higher color temperature LEDs, because blue light scatters more within the human eye, leading to increased disability glare.[16]

In addition to disability glare and its impact on drivers, many residents are unhappy with bright LED lights. In many localities where 4000K and higher lighting has been installed, community complaints of glare and a "prison atmosphere" by the high intensity blue-rich lighting are common. Residents in Seattle, WA have demanded shielding, complaining they need heavy drapes to be comfortable in their own homes at night.[17] Residents in Davis, CA demanded and succeeded in getting a complete replacement of the originally installed 4000K LED lights with the 3000K version throughout the town at great expense.[18] In Cambridge, MA, 4000K lighting with dimming controls was installed to mitigate the harsh blue-rich lighting late at night. Even in places with a high level of ambient nighttime lighting, such as Queens in New York City, many complaints were made about the harshness and glare from 4000K lighting.[19] In contrast, 3000K lighting has been much better received by citizens in general.

Unshielded LED Lighting

Unshielded LED lighting causes significant discomfort from glare. A French government report published in 2013 stated that due to the point source nature of LED lighting, the luminance level of unshielded LED lighting is sufficiently high to cause visual discomfort regardless of the position, as long as it is in the field of vision. As the emission surfaces of LEDs are highly concentrated point sources, the luminance of each individual source easily exceeds the level of visual discomfort, in some cases by a factor of 1000.[17]

Discomfort and disability glare can decrease visual acuity, decreasing safety and creating a road hazard. Various testing measures have been devised to determine and quantify the level of glare and vision impairment by poorly designed LED lighting.[20] Lighting installations are typically tested by measuring foot-candles per square meter on the ground. This is useful for determining the efficiency and evenness of lighting installations. This method, however, does not take into account the human biological response to the point source. It is well known that unshielded light sources cause pupillary constriction, leading to worse nighttime vision between lighting fixtures and causing a "veil of illuminance" beyond the lighting fixture. This leads to worse vision than if the light never existed at all, defeating the purpose of the lighting fixture. Ideally LED lighting installations should be tested in real life scenarios with effects on visual acuity evaluated in order to ascertain the best designs for public safety.

Proper Shielding

With any LED lighting, proper attention should be paid to the design and engineering features. LED lighting is inherently a bright point source and can cause eye fatigue and disability glare if it is allowed to directly shine into human eyes from roadway lighting. This is mitigated by proper design, shielding and installation ensuring that no light shines above 80 degrees from the horizontal. Proper shielding also should be used to prevent light trespass into homes alongside the road, a common cause of citizen complaints. Unlike current HPS street lighting, LEDs have the ability to be controlled electronically and dimmed from a central location. Providing this additional control increases the installation cost, but may be worthwhile because it increases long term energy savings and minimizes detrimental human and environmental lighting effects. In environmentally sensitive or rural areas where wildlife can be especially affected (e.g., near national parks or bio-rich zones where nocturnal animals need such protection), strong consideration should be made for lower emission LEDs (e.g., 3000K or lower lighting with effective shielding). Strong consideration also should be given to the use of filters to block blue wavelengths (as used in Hawaii), or to the use of inherent amber LEDs, such as those deployed in Quebec. Blue light scatters more widely (the reason the daytime sky is "blue"), and unshielded blue-rich lighting that travels along the horizontal plane increases glare and dramatically increases the nighttime sky glow caused by excessive light pollution.

POTENTIAL HEALTH EFFECTS OF "WHITE" LED STREET LIGHTING

Much has been learned over the past decade about the potential adverse health effects of electric light exposure, particularly at night.[21-25] The core concern is disruption of circadian rhythmicity. With waning ambient light, and in the absence of electric lighting, humans begin the transition to nighttime physiology at about dusk; melatonin blood concentrations rise, body temperature drops, sleepiness grows, and hunger abates, along with several other responses.

A number of controlled laboratory studies have shown delays in the normal transition to nighttime physiology from evening exposure to tablet computer screens, backlit e-readers, and room light typical of residential settings.[26-28] These effects are wavelength and intensity dependent, implicating bright, short wavelength (blue) electric light sources as disrupting transition. These effects are not seen with dimmer, longer wavelength light (as from wood fires or low wattage incandescent bulbs). In human studies, a short-term detriment in sleep quality has been observed after exposure to short wavelength light before bedtime. Although data are still emerging, some evidence supports a long-term increase in the risk for cancer, diabetes, cardiovascular disease and obesity from chronic sleep disruption or shiftwork and associated with exposure to brighter light sources in the evening or night.[25,29]

Electric lights differ in terms of their circadian impact.[30] Understanding the neuroscience of circadian light perception can help optimize the design of electric lighting to minimize circadian disruption and improve visual effectiveness. White LED streetlights are currently being marketed to cities and towns throughout the country in the name of energy efficiency and long term cost savings, but such lights have a spectrum containing a strong spike at the wavelength that most effectively suppresses melatonin during the night. It is estimated that a "white" LED lamp is at least 5 times more powerful in influencing circadian physiology than a high pressure sodium light based on melatonin suppression.[31] Recent large surveys found that brighter residential nighttime lighting is associated with reduced sleep time, dissatisfaction with sleep quality, nighttime awakenings, excessive sleepiness, impaired daytime functioning, and obesity.[29,32] Thus, white LED street lighting patterns also could contribute to the risk of chronic disease in the populations of cities in which they have been installed. Measurements at street level from white LED street lamps are needed to more accurately assess the potential circadian impact of evening/nighttime exposure to these lights.

ENVIRONMENTAL EFFECTS OF LED LIGHTING

The detrimental effects of inefficient lighting are not limited to humans; 60% of animals are nocturnal and are potentially adversely affected by exposure to nighttime electrical lighting. Many birds navigate by the moon and star reflections at night; excessive nighttime lighting can lead to reflections on glass high rise towers and other objects, leading to confusion, collisions and death.[33] Many insects need a dark environment to procreate, the most obvious example being lightning bugs that cannot "see" each other when light pollution is pronounced. Other environmentally beneficial insects are attracted to blue-rich lighting, circling under them until they are exhausted and die.[34,35] Unshielded lighting on beach areas has led to a massive drop in turtle populations as hatchlings are disoriented by electrical light and sky glow, preventing them from reaching the water safely.[35-37] Excessive outdoor lighting diverts the hatchlings inland to their demise. Even bridge lighting that is "too blue" has been shown to inhibit upstream migration of certain fish species such as salmon returning to spawn. One such overly lit bridge in Washington State now is shut off during salmon spawning season.

Recognizing the detrimental effects of light pollution on nocturnal species, U.S. national parks have adopted best lighting practices and now require minimal and shielded lighting. Light pollution along the borders of national parks leads to detrimental effects on the local bio-environment. For example, the glow of Miami, FL extends throughout the Everglades National Park. Proper shielding and proper color temperature of the lighting installations can greatly minimize these types of harmful effects on our environment.

CONCLUSION

Current AMA Policy supports efforts to reduce light pollution. Specific to street lighting, Policy H-135.932 supports the implementation of technologies to reduce glare from roadway lighting. Thus, the Council recommends that communities considering conversion to energy efficient LED street lighting use lower CCT lights that will minimize potential health and environmental effects. The Council previously reviewed the adverse health effects of nighttime lighting, and concluded that pervasive use of nighttime lighting disrupts various biological processes, creating potentially harmful health effects related to disability glare and sleep disturbance.[25]

RECOMMENDATIONS

The Council on Science and Public Health recommends that the following statements be adopted, and the remainder of the report filed.

1. That our American Medical Association (AMA) support the proper conversion to community-based Light Emitting Diode (LED) lighting, which reduces energy consumption and decreases the use of fossil fuels. (New HOD Policy)

2. That our AMA encourage minimizing and controlling blue-rich environmental lighting by using the lowest emission of blue light possible to reduce glare. (New HOD Policy)

3. That our AMA encourage the use of 3000K or lower lighting for outdoor installations such as roadways. All LED lighting should be properly shielded to minimize glare and detrimental human and environmental effects, and consideration should be given to utilize the ability of LED lighting to be dimmed for off-peak time periods. (New HOD Policy)

Fiscal Note: Less than $500

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Acknowledgement: The Council thanks George Brainard, PhD (Thomas Jefferson University); Richard Stevens, PhD (University Connecticut Health Center); and Mario Motta, MD (CSAPH, Tufts Medical School) for their contributions in preparing the initial draft of this report, and the commentary by Travis Longcore, PhD, on the ecological impact of nighttime electrical lighting.

NEMA Comments on American Medical Association Community Guidance: Advocating and Support for Light Pollution Control Efforts and Glare Reduction for Both Public Safety and Energy Savings

06/24/2016 3:00PM

ROSSLYN, Va.—The National Electrical Manufacturers Association (NEMA) is a long-time proponent of good quality lighting design and application with technical standards and guidance for manufacturers and their end-use customers. The American Medical Association's community guidance on LED outdoor lighting is aligned with lighting manufacturers' long-standing recommendations on how to design safe and efficient light for night, including:

- Using lighting control options such as motion or dusk-to-dawn sensors
- Shielding the light source to curtail excessive uplight, sidelight, and glare
- Designing for the minimum light levels and energy necessary for the task

NEMA and its lighting manufacturer Members support the proper application of light at the right placement, right time and in the right amount. NEMA Members actively assist installers and customers with the best application and maintenance of their products. Consequently, there are few technical reasons or limitations to stand in the way of preventing misdirected light and glare. NEMA Member products are readily available for a wide array of solutions.

The AMA makes further recommendations regarding the spectral content of outdoor lighting installations that raise serious concerns for electrical manufacturers. NEMA agrees that spectral content should be one factor in effective lighting for outdoor installations. However, a single solution is simply not appropriate for all situations. NEMA also questions the wisdom of assigning significant weight to this recommendation since outdoor lighting design requires a complex analysis of many criteria. Outdoor lighting systems will vary depending on the application and local conditions. Tradeoffs in the considerations of visibility, environmental impacts, energy efficiency, cost, personal safety and security need to be optimized, which cannot be achieved with a single solution.

The AMA recommendation encouraging the use of 3000K correlated color temperature (CCT) or lower may compromise the ability of the lighting system to meet all critical design criteria for each unique application. As indicated by the U.S. Department of Energy (DOE) in its June 21, 2016, statement, CCT does not explicitly characterize the potential for nonvisual effects, which also depend on quantity and duration of exposure to light. The DOE further clarifies than an LED light source with the same CCT as a non-LED source has about the same amount of blue spectral content. The AMA recommendation for 3000K or lower is not an appropriate solution for all applications, nor is it is supported by the current body of research. NEMA will issue additional technical guidance specific to the issues and tradeoffs related to the spectral content of lighting solutions.

NEMA welcomes the opportunity to work with AMA and other organizations on projects to further research the complexities of night lighting. We are committed to science-based improvements to night lighting so that people the world over can safely and efficiently enjoy the extension of their living space as well as the beauty of the nighttime natural world.

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The National Electrical Manufacturers Association (NEMA) represents 350 electrical and medical imaging manufacturers at the forefront of electrical safety, reliability, resilience, efficiency, and energy security. Our combined industries account for more than 400,000 American jobs and more than 7,000 facilities across the United States. Domestic production exceeds $114 billion per year and exports top $50 billion.

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