SLSC
STREET LIGHTING | SMART CONTROLS

IPWEA

SLSC BRIEFING

Minimising the impact of public lighting on the night sky

19 June 2019

KEY POINTS:

Part of a city or region's night economy is the attraction of its night sky, to citizens, astronomers, tourists, living creatures, and those who earn a living in these areas. Cooler colour temperature white lighting is considered detrimental to night sky viewing. The "AS/NZS 1158 standardised 4000K option" is no longer an unchallenged selection, as councils become more astronomically and ecologically aware. It is increasingly common worldwide to see 3000K as the favoured selection for pedestrian road applications. This LED selection serves to minimise the short wavelength light spectral emissions (ie blue rich white light) that are opposed by night sky stakeholders. Additionally, it is widely regarded that the warmer 3000K colour temperature for pedestrian roads and precincts is more "human friendly" as it renders facial features and skin tones in a more appealing manner.

IPWEA recommends:

- limiting the colour temperature of LED lighting to 3000K or less in all residential areas and also where night sky considerations take precedence over public health issues of mitigating risks caused by high speed or high volume traffic at night.
- Selecting full-cut-off LED luminaires and ensuring they are installed correctly aligned; and
- Installing Central Management System (CMS) adaptive controls that can be used to limit and tailor lighting levels and hours of operation.

The purpose of this briefing paper is to inform professionals who are responsible for public lighting, whether they work in the exterior public lighting sector or in the public works engineering and asset management sectors.

This paper should be read in conjunction with the IPWEA briefing paper titled "*SLSC Briefing - Addressing health concerns about the blue light content in LEDs"* because the physics and technological issues relating to luminaires and their control are common to all of the impacts of lighting (human health, night sky and ecology).

Street lighting is an important aspect of the safety and economic development infrastructure which meets the purposes of Australia's Department of Transport to provide "Safe, efficient and sustainable domestic and international transport systems" … contributing "to the prosperity of the economy and the wellbeing of all Australians by supporting and enhancing our transport systems."

Part of a city or region's night economy is also the attraction of a pristine night sky and natural environment, for citizens and tourists, astronomers and ecologists, and those people who indirectly earn a living in these areas. Cooler colour temperature white lighting is considered detrimental to night sky viewing. This is due to a higher proportion of light emitted in the blue spectrum, which scatters in the atmosphere more than light of other wavelengths. The light spectrum of LED luminaires can however be selected and adjusted to meet specific needs at purchase, enabling adverse effects upon night sky viewing to be mitigated.

Artificial light at night can also have an impact on human sleep patterns and the reproduction, habitat use, movement, foraging behaviour, and physiology of wildlife in terrestrial, marine and freshwater ecosystems. The science on the impact of street lighting on human health is not settled – but has been covered in the previous paper "*SLSC Briefing - Addressing health concerns about the blue light content in LEDs"*. The effects of light spectrum on all wildlife are also not yet well understood though substantial research evidence exists for its effects on certain species and is covered in the sister briefing paper *"SLSC Briefing - Minimising the impact of public lighting on threatened species".*

4000K LED Street Lighting

It should be noted that in recent times the "AS/NZS1158 standardised 4000K option" is no longer an unchallenged selection, as councils become more astronomically and ecologically aware. It is increasingly common worldwide to see 3000K as the favoured selection for pedestrian road application[1]. This LED selection serves to minimise the short wavelength light spectral emissions (ie blue rich white light) that are opposed by astronomical and ecological stakeholders. Additionally, it is widely regarded that the warmer 3000K colour temperature for pedestrian roads and precincts is more "human friendly" as it renders facial features and skin tones in a more visually appealing manner.

From mid-2016 onward, the American Medical Association, International Dark-Sky Association, Illuminating Engineering Society, the US Department of Energy, the European Commission and other stakeholders began releasing reports on the possible impacts of lighting on health, the environmental and on the night sky. Some of these parties have strongly advocated for lower colour temperatures (generally below 3000K) citing likely reduced sky glow as a key consideration. However, other sources have found gaps and inaccuracies in a number of the claims made in these reports and have raised emphasised the need to also consider road safety considerations (particularly with respect to main roads).

There is considerable research information on this topic but also extensive evidence from cities that have surveyed their citizens preferences and a majority prefer 3000K over 4000K white lighting in residential streets and public precincts and numerous cities around the world have chosen 3000K over 4000K[2].

IPWEA recommends limiting the colour temperature of LED lighting to 3000K or less in all Category P road lighting (residential) areas where night sky considerations take precedence over public health issues of mitigating risks caused by traffic at night.

Lighting Control

As well as spectral adjustments, targeted light distribution and dimming LED lighting will help to mitigate these deleterious effects. Well-designed LED lighting can be very directional and does not emit light above the horizontal plane into the sky as HPS luminaires generally do. This is dramatically demonstrated when flying over a town or city

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[1] The AS/NZS 1158 Lighting for roads and public spaces standards series considers road lighting in two main application categories:
Category V - Lighting that is applicable to roads on which the visual requirements of motorists are dominant.
Category P - Lighting that is applicable to roads and other outdoor public spaces on which on which the visual requirements of pedestrians are dominant

[2] Some examples of web-links: Rome, Davis California, Chicago, and Brisbane.

which has both types of lighting. Each yellow light HPS luminaire can be identified as an individual point source of light whereas LED lighting can only be detected from the reflection on the surface it is illuminating – the ground. Unwanted light spill to the surrounding ground outside the roadway is also reduced with directional LED lighting.

Dimming lighting will also reduce the amount of light adversely affecting night sky viewing, intruding into residential properties causing neighbourhood nuisance. Street lighting is most useful as a safety measure only when humans are outside at night and going about their business. Most towns/cities find that after 11.30pm few people are driving, cycling or walking and thus modern control systems can reduce lighting output dramatically when the need for light is low or non-existent. For example, Auckland Transport reduces LED lighting down to 50% of its normal full light levels (from 11.30pm to 6am). UK research suggests that in many Category P instances street lighting could be turned off altogether at around 1 am, because in many residential areas so few people are active outside after this time[3]. However, this may not apply to all locations and lighting dimming and timing systems should be designed based on an understanding of traffic and pedestrian movement for the particular area.

Both IPWEA and the International Dark-Sky Association (IDA) recommends choosing and installing LED lighting that enhances public safety, reduces light pollution and creates improved night sky conditions. The recommendations include:

(i) Selecting full cut-off LED luminaires and ensuring they are installed correctly aligned;

(ii) Installing Central Management System (CMS) adaptive controls that can be used to limit lighting levels and hours of operation;

Luminaire Design and Orientation

A report by the US Department of Energy which investigated LED Street Lighting's Impact on Sky Glow found that:

"The three main characteristics of luminaires that influence sky glow are SPD[4], total light output, and light distribution (and, most importantly, the amount emitted as uplight above the horizontal plane).

Each of these characteristics can be varied during at least the initial selection of products and should therefore be carefully evaluated as part of the system design. In addition, street lighting is only one of many sources of light at night in urban areas."

Best practice specification and properly installed full-cut off LED luminaires allow almost no direct light upwards. In contrast, legacy HPS, MV, MH, CFL and T5LFL luminaires with bowl-type visor optics beam between 3% to 6% of luminous output directly up into the night sky.

As the same US Department of Energy study on this subject says, "*The relationship between light output and sky glow is linear; increases or decreases in the luminaire output levels are matched one-for-one in the resulting contributions to sky glow from the street lighting system*."

Careful lighting design and diligent installation of each single luminaire to minimise light pollution (especially direct uplight) is clearly a critical factor to minimise negative night sky effects.

IPWEA recommends that, like its sister paper "*SLSC Briefing - Addressing health concerns about the blue light content in LEDs",* MIESANZ or equivalent qualified lighting designers are appointed on all major lighting projects to ensure the selection of appropriate luminaires with good photometric design that minimises glare, light spill and, upward waste light, and are fit for the application for which they are intended.

Lighting Performance and Night Sky Surveys

Like all infrastructure assets, street lighting may also have negative effects that need to be balanced against the compelling benefits. The introduction of safer and more efficient LED street lighting has also brought with it disadvantages which are receiving significant public attention. There is some controversy over the effect of increased blue light exposure on the night sky. The introduction of scientific before and after, lighting performance and night sky measurement surveys brings valuable data to this debate, contributing tangible evidence towards addressing the

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[3] Steinbach R, Edwards, P., et al, The Effect of Reduced Street Lighting on Road Casualties and Crime in England and Wales: Controlled Interrupted Time Series Analysis, Department of Population Health, London School of Hygiene and Tropical Medicine. J Epidemiology Community Health 2015;0:1–7 doi:10.1136/jech-2015-206012, 3 June 2015

[4] SPD – Spectral Power Distribution, see the sister paper on health effects for definition and importance

assertion that modern adaptive 3000K LED lighting does not have environmentally beneficial outcomes. Cities that have embarked on this approach are Dunedin, New Zealand and to a partial extent, Tuscon[5], Arizona in USA.

Providers of such scientific surveys are active in the market and are used some Australasian city councils and roading authorities. The relatively modest cost is highly justified to inform the public debate with benchmarking evidence and information on the net outcomes of effective LED and CMS controls deployment. A street lighting performance measurement survey and a night sky measurement survey provides a tangible opportunity to evaluate and trade-off the before and after benefits and disadvantages of public good street lighting infrastructure.

IPWEA recommends that for cities or regions converting to LED lighting, serious consideration is given to conducting scientific measurement surveys of street lighting performance and the night sky, before and after LED replacement is undertaken.

MORE READING:

1. IPWEA, 2016, "Street Lighting and Smart Controls (SLSC) Roadmap" Chapter 4, for Department of the Environment and Energy, Australian Government, by Strategic Lighting Partners and Next Energy
2. LEDs Magazine, Volume 9, Issue 7, "Understand colour science to maximize success with LEDs – part 2"
3. European Commission, JRC Technical Reports, "Revision of the EU Green Public Procurement Criteria for Road Lighting", March 2018, Figure 19, p71
4. US Department of Energy, Energy Efficiency & Renewable Energy, "An Investigation of LED Street Lighting's Impact on Sky Glow", April 2017;
5. Kocifaj, Miroslav. (2014). "Night sky luminance under clear sky conditions: Theory vs. experiment." Journal of Quantitative Spectroscopy and Radiative Transfer. 139. 43–51. 10.1016/j.jqsrt.2013.12.001.~
6. Kinzey, B. Pacific Northwest National Laboratory, Portland Oregon, USA, IES Street and Area Lighting Conference September 17-21, 2016
7. International Dark-Sky Association (IDA) http://www.darksky.org/our-work/lighting/lighting-for-industry/fsa/
8. "Assessment of Blue Light Hazards and Correlated Colour Temperature for Public LED Lighting", Wood J, Black A, Isoardi G. School of Optometry and Vision Science, Institute of Health and Biomedical Innovation, Queensland Institute of Technology, March 2019.

[5] "Skyglow changes over Tucson, Arizona, resulting from a municipal LED street lighting conversion", Barentine, J, Walker, C., Kocifaj, M., et al, Journal of Quantitative Spectroscopy & Radiative Transfer 212 (2018) 10–23.