

BEST PRACTICE PUBLIC LIGHTING

DARK SKY IRELAND

PROF. BRIAN ESPEY



Executive Summary

The drive to reduce both costs and carbon production from public lighting is leading to the national adoption of more energy efficient light emitting diode (LED) lighting. Due to the longevity of LED lamps (typically 25 years), any equipment installed now will have a long-term effect, so we have a responsibility to implement the best choice in terms of lighting as well as its wider impact based on an informed balance of current evidence.

There are environmental and health impacts with high temperature LEDs containing more “blue-rich” light.

We promote the adoption of lower temperature (warmer colour) lighting, which provides the best balance of cost saving, road and personal safety through better balanced light and improved perception, as well as reducing environmental impact. We encourage both “trimming” (part-night lighting) and “dimming” policies to reduce the light burden in the night-time environment and, at the same time, produce significant cost savings.

Recommendations

These are in line with developing best environmental practice in other locations in the UK, across Europe, and globally and will make the most of the benefits of new LED technology. The following recommendations meet government obligations to reduce energy use, cost, and carbon emissions:

- Maximum energy can be saved through not lighting areas, therefore careful consideration should be given to evaluating the requirement for lit areas;
- Up to 30% savings are possible through careful lighting design;
- Current lighting installations are designed to maximum light level required, i.e. for maximum traffic. Timing and duration should be limited to when needed through “trimming” (also called “part-night lighting”) and/or level (through dimming);
- As light travelling close to, or above the horizontal, impacts strongly on the environment we recommend full cut-off lighting, with such lights having no light emitted above the horizontal, and with the minimum practical emitted within twenty degrees of the horizontal;
- Blue light in LEDs should be limited to warmer-coloured lighting (so-called “warm white” light, i.e. light with a Correlated Colour Temperature (CCT) at or below 3000K;
- The impact of existing “neutral white” light installations (i.e. lighting with CCT approx. 4000K) can be reduced by a reduction in the level of lighting, as described in UK British Standard 5489 which takes account of the influence of this light on night vision;
- Local authorities should have autonomy to reduce light levels or spectrum (such as the adoption of amber lighting) for the benefit of tourism, biodiversity and citizen wellbeing;
- A consistent local and national approach should be adopted so that lighting from national routes, for instance, does not undo the effects of improved local lighting.

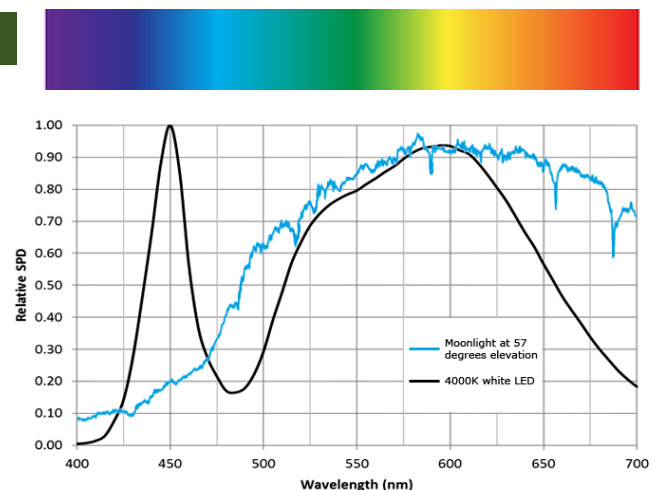


Figure 1 This figure shows a comparison between the intensity across the spectrum of a typical 4000K LED and that of the Full Moon when highest in the sky. The band at the top shows the colour at each point of the spectrum. Although it is sometimes said that such LED light is similar to moonlight, note that the LED output is significantly different in terms of both spectrum and intensity.

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Visual perception

The purpose of street lighting is to permit better vision at night, while at the same time limiting the deleterious effect of the light itself, e.g. glare. Studies have shown that near-perfect colour discrimination is achieved for warm white lighting and does not improve significantly as the colour temperature is increased further.¹ On the contrary, the blue content of higher temperature lighting triggers contraction of the eye's pupil and subsequent dark adaptation time increases which can lead to poorer vision when passing beyond the lit area. Glare issues and eye response issues are even more important for older people.

Blue-rich lighting also scatters more in the atmosphere (e.g. the sky's colour is the result of scattered blue light from the Sun) and this scattered light affects darker regions nearby.

The best overall balance between visibility under all weather conditions, colour reproduction and glare has been found to be for LED light with a CCT of approximately 3000K.

Public Opinion

In conjunction with the Irish Times we have conducted a Citizen Science questionnaire which received 464 responses from Irish residents. Responses from city inhabitants noted changes in both night-time bird behaviour and the natural activity of insects, bats and foxes, with a moderate association between bird behaviour and the increase in local light over the recent past.² Elsewhere in Europe, residents report that public lighting was the most commonly identified source of light pollution and that commercial lighting was the most annoying source of light-at-night in a predominantly urban and educated sample with a high level of interest in astronomy (Lyytimaki and Rinne, 2013).

Safety

Anecdotally, current "neutral white" (CCT = 4000K) lighting is regarded as harsh and overly bright to the eye even when installed to the same level of lighting (lux level) as the units it replaces. The result is strong glare from the lighting source along with dark shadows, leading to higher contrast and lower lighting quality. Additionally, perceived safety correlates with better colour reproduction found in warmer white lighting as it is closer to a daylight balance. A major UK study has found that neither the move to part-night lighting nor dimming has had any impact on either traffic collisions or crime rates.³

Environmental

Ireland's nine bat species account for approximately one third of our native mammal species and are protected by law. Their insect prey, with a lifetime of one to two years, are particularly vulnerable to population changes and are strongly affected by the blue content of light. Larger declines in nocturnal insects have been seen relative to daytime species, though a recent study has implicated light pollution in the overall strong overall decline of all types of insects.⁴

Other diurnal species can also be affected by night-time light. For example, salmon will not pass a light barrier where the light intensity is comparable to full moonlight and are also sensitive to light at the blue end of the spectrum. Consideration should be given to the restriction of light level and duration in areas close to waterways, e.g. by rivers and on bridges and the use of warmer colour light. These waterways are also feeding zones for bat species.

The decline in biodiversity and insect populations was mentioned in a recent Dáil statement by the Minister for Culture, Heritage and the Gaeltacht when she expressed her commitment to encourage councils to maintain biodiversity. In the same statement she announced that the Government is creating a legal onus, or a biodiversity duty, on public bodies to have regard to policies, guidelines, and objectives to promote the conservation of biodiversity and the National Biodiversity Action Plan.⁵

Footnotes:

¹ Jin, H, Jin, S., Chen, L, Cen, S. and Kun, Y. 2015 "Research on the Lighting Performance of LED Street Lights With Different Color Temperatures," 7 (6), December 2015. <https://ieeexplore.ieee.org/document/7328247>

² <https://www.irishtimes.com/news/science/help-scientists-understand-the-influence-of-light-on-the-environment-1.3416898>

³ Local Authority Collaborators' National Evaluation of Reduced Night-time Streetlight (LANTERNS)

⁴ <https://doi.org/10.1016/j.biocon.2019.108259>

⁵ <https://www.oireachtas.ie/en/debates/debate/dail/2019-05-29/35/>

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Best Practice

In response to an American Medical Association report on the potential health impact of blue-rich lighting a number of major North American cities, including Montreal, San Diego and New York have abandoned plans to install 4000K LED street lights and instead adopted lamps with CCT of 3000K – or lower in some instances – which are endorsed by the AMA.¹ On the other side of the world, a number of New Zealand councils have installed warm white lighting of 3000K due to demand from citizens, with 2200K units in more environmentally sensitive areas.² The International Dark Sky Association anticipates that a move to 2700K lighting may become the norm over the next several years.³

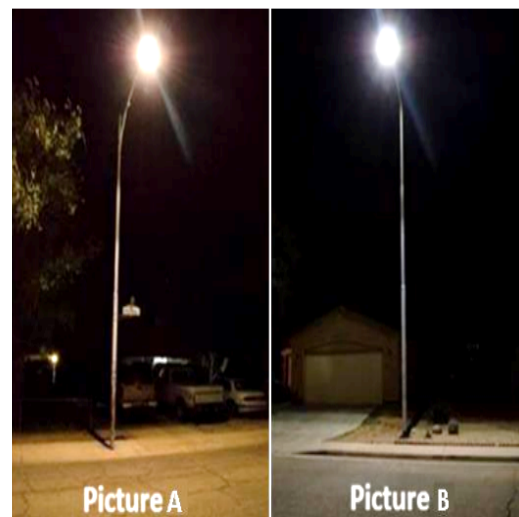
As an example of costs due to correcting lighting issues, the City of Davis in California was half way through an LED street relighting initiative when forceful complaints from residents halted the project. After public review of several alternatives, the streetlights selected are lower brightness and, at 2700K, much warmer. As many of high-CCT luminaires had already been installed under the original plan, the additional cost to the city for retrofitting these was \$350,000.⁴

Concerns for the implications of blue-rich lighting are raised in the UK's Chief Medical Officer's report for 2017. This document dedicates a full page to light pollution and health, referencing LEDs and blue rich lighting with the following comment:

"Local authorities [in the UK] have been replacing mercury and sodium street lights with LEDs. If this is done purely on the basis of energy efficiency and cost, it is possible to end up with installations that may not be fit for purpose."

The widespread installation of LEDs has taken place in a relatively short pace of time due to the rapid development of light technology and without assessment for environmental impacts. UNESCO's Earth Charter states the prevention of harm before it happens *"is the best method of environmental protection. When knowledge is limited, apply a precautionary approach:*

- Take action to avoid the possibility of serious or irreversible environmental harm even when scientific knowledge is incomplete or inconclusive.
- Place the burden of proof on those who argue that a proposed activity will not cause significant harm, and make the responsible parties liable for environmental harm."



Warm White
3000 kelvin

Neutral White
4000 kelvin

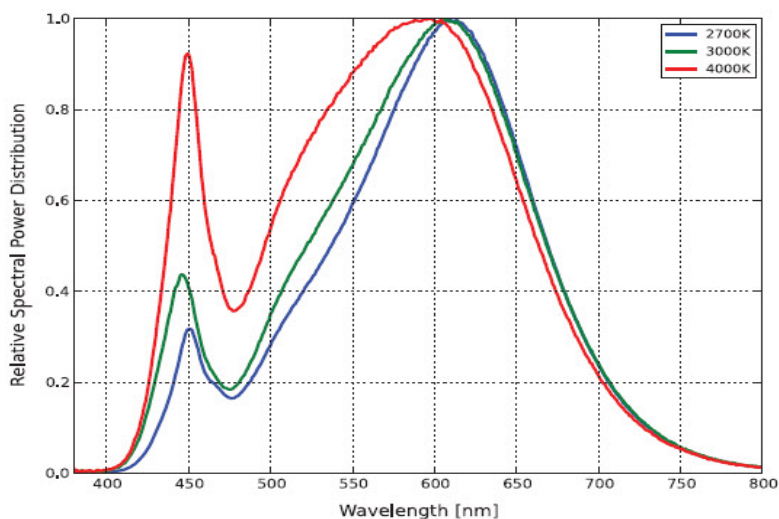


Figure 2 Adoption of 3000K lighting rather than 4000K results in a 37% reduction in blue light; moving to 2700K (suggested for more sensitive areas) provides a 48% reduction. The appearance of warm white and neutral white lighting is shown at night.

Footnotes:

¹ <https://luxreview.com/article/2017/02/will-tunable-street-lighting-first-silence-led-critics->

² <http://rnz.co.nz/news/national/403751/otago-to-get-lower-level-more-expensive-led-street-lights?fbclid=IwAR2pTb1TYyZLI6k0U7Vkb3QETA-iIH3XVPZuLyISWI0aNZLmHMK9IbXhMkg>

³ <http://darksky.org/our-work/lighting/lighting-for-citizens/3k/#list>

⁴ <https://www.lightshowwest.com/eco-effects-of-high-cct-led-lighting-outdoors-building-a-case>

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EU Practice

The EU Commission's Green Public Procurement (GPP) document is intended to advise decision makers on implementation once the decision is taken to install new lighting. In terms of lighting levels it adheres to the principle of "as low as reasonably achievable" (ALARA) and also recommends that warmer colour LEDs be installed to restrict impacts on wildlife and sky quality as well as potential effects on human health. The document also recommends the installation of LEDs with CCT values of 3000K or less. The document also states that potential impacts on wildlife and skyglow, as well as human health, are sufficient justifications to set restrictions on blue light.

At least five EU countries have either enacted legislation or are adopting practices that restrict both the amount and blue content of public lighting. Warm white light with a CCT of 3000K or less will be the advised upper limit across these jurisdictions, with even lower temperature lighting down to 2200K or less (similar to current high pressure sodium lighting) being required in national parks or other sensitive habitats. In the UK the lighting industry is moving away from 4000K lighting and to 3000K, and the lighting industry is likely to move to even lower values over the next few years.

Warm white LED lighting with CCT of 3000K has been installed in Ballycroy, Co. Mayo, and Mallow, Co. Cork and both locations have been positively received. Both Kerry and Mayo County Councils are planning warm white lighting of 3000K or less to protect their dark sky areas and promote sustainable tourism.

Practical Guidelines

The information outlined in this document can probably be best summarised using the guidelines produced by the EU COST Action Loss of Night Network (LoNNe) to combat light pollution and a precautionary standpoint suggests these are also good guidelines from the points of view of environmental and human health aspects as well as in terms of energy-efficiency:¹

1. Every light needs to be justifiable
2. Limit the use of light to when it is needed
3. Direct the light to where it is needed
4. Reduce the light intensity to the minimum needed
5. Use light spectra adapted to the environment
6. When using white light, use sources with a "warm" colour temperature (less than 3000K)

Summary

In 2017 the High Court recognised the constitutional right to protect the environment and the precautionary principle is enshrined as one of the fundamental principles of the European Union.² We have a global responsibility to reduce our carbon emission as well as save costs and our national strategy to reduce public lighting impacts relies on the changeover to LED lighting. What we must not forget, however, is that the actions to reduce both energy use and carbon output have been taken with the aim of protecting the environment, hence we should consider the potential environmental consequences of our choices in the long-term.

We therefore recommend the adoption of lower CCT (warmer) lighting, which provides the best balance between efficiency, safety, and environmental impact.

The introduction of the current LED lighting, with a growth in installed units from a few percent to 16% over the past four years has resulted in an increase in intensity and blue-rich content, is a phenomenal change which has an environmental impact.

As an island nation, movements from adjacent areas cannot replace damage to our native species so we have an imperative to protect them in situ.

Dark Sky Ireland strongly urges the use of warm white lighting with a maximum CCT of 3000K, and lower values in more sensitive areas such as National Parks and conservation regions.

Given environmental, health and economic imperatives the onus should be on justifying the installation or increase of lighting rather than justifying its removal.

In practical terms, we recommend the adoption of the recommendations of the Campaign to Protect Rural England³ which were developed from the responses of 83 local authorities. Lighting policy documents, including designation of environmental zones, should be developed by each authority to provide a practical framework and to address potential legal issues.

Footnotes:

¹ EU Collaboration on Science & Technology ES1204

<http://www.cost-lonne.eu/recommendations/>

² <https://www.ecologic.eu/1126>

³ Campaign to Protect Rural England "Shedding Light"

[https://www.cpre.org.uk/wp-](https://www.cpre.org.uk/wp-content/uploads/2019/11/Shedding_light_leaflet.pdf)

[content/uploads/2019/11/Shedding_light_leaflet.pdf](https://www.cpre.org.uk/wp-content/uploads/2019/11/Shedding_light_leaflet.pdf)