

Position Statement



Circadian Lighting

April 2019

With ongoing research and increasing publicity focused on circadian lighting, the Society of Light and Lighting would like to outline its position on this topic, with a view to providing some much needed clarity. The SLL works on behalf of all who are interested in light and lighting, promoting the importance of these topics and disseminating guidance. This document will define the Society's understanding of the term circadian lighting. It will look to highlight areas of established research that relate to the topic, providing an overview of what is commonly accepted, as a result of sufficiently robust research and evidence. Additionally, this document will seek to identify areas where further research is required. The intention is not to reach a decisive conclusion but to raise awareness of the areas where more information may be required.

Whilst this paper uses the term circadian lighting, there are a number of terms which are used interchangeably. For example, the term human centric lighting, which is arguably problematic in that lighting design and the use of artificial light generally centres on human beings. It refers to the creation of a lighting system which adapts to the changing needs of an individual throughout the day to allow them to receive the varied spectrum and quantity of light in relation to their natural circadian rhythm. This paper focuses on artificial lighting that is described or marketed as circadian or human centric lighting. However, it is recognised that, for stimulation of the circadian system and support of human health, there is no substitute for daylight.

In his editorial piece for Volume 48, Issue 2 of *Lighting Research & Technology*, Professor Peter Boyce wrote that human centric lighting;

'...considers both the visual and non-visual effects of light and that widens the range of possible visual effects from visual performance and comfort to sleep quality, alertness, mood and behaviour with consequences for human health...'

In this sense, human centric or circadian lighting implies a transition from traditional approaches to lighting design and application, referring to the creation of a lighting system, dynamic in both intensity and spectrum, which can be controlled to stimulate the human circadian system.

In gaining a better understanding of the effect that light has on an individual's health and well-being, elements including timing and duration of exposure to light; quantity and spectrum

of light; and the spatial distribution also need to be considered.

Dr Mariana Figueiro highlights developments in our understanding of non-visual responses to light since the discovery of the intrinsically photosensitive Retinal Ganglion Cells (ipRGCs) in 2001 in her research paper, *Non-visual effect of light: How to use light to promote circadian entrainment and elicit alertness*, published in Vol. 50, Issue 1 of *Lighting Research & Technology*. It is understood that the light-dark cycle informs our biological clock, with the level of light signalling the appropriate responses within the human sleep-wake cycle. The body will release or suppress hormones, depending on the need to be alert or to rest in relation to the time of day and incidence of light on the retina. As a result, circadian lighting has the potential to support biological rhythms where they may otherwise be disrupted.

In recognising that a high intensity, shorter wavelength of light acts to suppress the release of melatonin, helping us to wake up in the morning and a less intense, warmer white light assists in the release of melatonin, helping us relax in the evening, these elements can be incorporated within a dynamic lighting scheme in an attempt to support circadian rhythms. The potential benefits of this are increased alertness during the day, with improved sleep at night, resulting in a positive effect on well-being. Obviously, this leaves out myriad other factors which also have an impact on an individual's well-being.

Alongside CIBSE and the BRE, the Society is involved in an ongoing study on the effects of circadian lighting on health and well-being. We look forward to seeing the results from this study which are due to be published in 2019. The research has compared two lighting conditions so far, one with existing fluorescent lighting and another with tuneable LED lighting.

Researchers are monitoring both the objective measures, including the light levels within the test space and the light exposure of the participants, along with the subjective measures such as questionnaires at the end of each lighting condition and regular computer based tests to monitor participant's reaction time.

Further studies have suggested that by introducing circadian lighting to a work environment, there is the potential to mitigate some of the negative side effects of circadian misalignment or de-synchronisation. This is generally accepted as a positive application of circadian lighting, with the intention of reducing disruption to occupant sleep-wake cycles by actively

manipulating the suppression and release of melatonin. However, as highlighted by Deborah Burnett, Principal and Partner at Benya Burnett Consulting in her article for LED Magazine, *First do no Harm*;

“...with the link between light and health, there are no time honoured rules, an established body of rules or proven best practices that can be used to redefine this paradigm of lighting design with health benefits.”

In this sense, Burnett compares the installation of circadian lighting to projects, based on unsupported claims, to ‘a poor man’s version of practicing medicine without a license.’

Introducing an element of individual control also plays a part in the application of circadian lighting. A number of studies have shown a positive occupant response, when given control over certain elements of their surrounding environment, including lighting, temperature and the amount of natural light entering the space. This in turn has led to a feeling of increased well-being whilst in the space. However, it is important that there is a balance between areas with individual control according to preference and any centrally controlled colour and timing schedules that may be in place for a space or building.

It is essential for the lighting industry to recognise the current limitations in our knowledge of the implications of introducing circadian lighting. Under no circumstances should commercial sales be prioritised, when there is a lack of factual or proven evidence for the claims being made. Referring back to Professor Peter Boyce’s editorial, he states, ‘The further the outcome is from the direct effects of lighting on human physiology, the more likely it is that factors other than lighting will intervene.’

There have been various attempts to quantify circadian light and its impacts, with a view to creating a metric for practical application. For example, the WELL Building Standard. The WELL Standard introduced the concept of melanopic Lux, which focuses on luminous efficiency function, peaking at 480 nanometres and based on the action spectrum of melanopsin. As opposed to the more traditional photopic luminous efficiency function, peaking at around 555 nm, based on the foveal cone photoreceptors.

Within their article, *Quantifying Circadian Light and its Impact*, Dr Mariana Figueiro and Dr Mark Rea state the following in reference to WELL and melanopic lux;

“Photometric units have not yet been established for the circadian luminous efficiency function; consequently, quantifying light in terms of melanopic lux has yet to be defined.”

They go on to explain that as the impact of melanopic lux on the suprachiasmatic nuclei is unknown, it is impossible to use the action spectrum for the suppression of melanopsin to de-

scribe how affective artificial light or daylight are for stimulating the human circadian system. Within this article, Dr Figueiro and Dr Rea conclude:

“...a metric based on melanopsin alone will be fundamentally inaccurate and incomplete as a representation of the spectral and absolute sensitivities of the human circadian systems.”

In their work at the Lighting Research Center at Rensselaer Polytechnic Institute, Dr Figueiro and Dr Rae have been developing alternative metrics and tools to assist designers and specifiers in the practical application of circadian light in the built environment. They have proposed a metric called the circadian stimulus (CS). As outlined in the LD+A article, *Designing with Circadian Stimulus*, by determining the spectral irradiance distribution of light incidence at the cornea, you can then calculate circadian light (CLA);

“...which is irradiance at the cornea weighted to reflect the spectral sensitivity of the human circadian system as measured by acute melatonin suppression after a one-hour exposure, and CS, which is the effectiveness of the spectrally weighted irradiance at the cornea from threshold (CS = 0.1) to saturation (CS = 0.7).”

Whilst efforts to produce a metric for circadian lighting are a step in the right direction, with regard to providing a quality lit environment that does not have a detrimental effect on the health and well-being, it is premature in relation to our understanding of the elements that affect the human circadian system.

It is these other intervening factors that we need to understand before we can provide a useful evaluation of the benefits of circadian lighting. At present, we understand that individual lighting requirements will differ on basis of age, chronotype and duration of exposure amongst other factors. A light history or context is required in order to provide a circadian lighting solution that will cater to individual requirements. The factors which contribute to good circadian health are cumulative and will vary from person to person.

The Society recognises the need for additional properly designed and monitored field studies of this kind, along with further laboratory research in order to recommend or advise the use of circadian lighting. Additionally, whilst research is ongoing, certain questions should be asked with regard to the validity of products or services claiming to offer the suggested benefits of circadian lighting. The SLL looks forward to the publication of the BRE and CIBSE research findings and will continue to monitor the work of lighting researchers around the world, both in Lighting Research & Technology Journal and more generally.



www.sll.org.uk
[@SLL100](https://twitter.com/SLL100)
sll@cibse.org

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