The Society of Light and Lighting

Position Statement on Integrative Lighting

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This document updates the Society of Light and Lighting Position Statement on Circadian Lighting published in July 2020. In this version, the Society of Light and Lighting has adopted the terminology used by the International Commission on Illumination (CIE) and refers to 'integrative lighting' throughout, in line with the CIE International Lighting Vocabulary (CIE S 017:2020) and the CIE Position Statement on Integrative Lighting: Recommending Proper Light at the Proper Time, 3rd Edition (CIE PS 001:2024), published in August 2024. The CIE defines integrative lighting as lighting that integrates both visual and non-visual effects to deliver physiological and psychological benefits to humans (CIE S 017:2020). This is distinguished from clinical light therapy and applies to everyday environments rather than medical treatments. The earlier terms 'circadian lighting,' 'human-centric lighting' and 'biodynamic lighting' are used interchangeably in the industry but are not formally adopted by the CIE.

Introduction

With ongoing research and commercial interest in integrative lighting, the Society of Light and Lighting (SLL) reaffirms its position on this topic. This statement reflects advances since the 2020 edition, including the consensus recommendations of Brown et al. (2022) for healthy day-active adults, the CIE metrological framework for ipRGC[1]-influenced responses (CIE S 026:2018; Price and Blattner, 2022), and the CIE position statement on integrative lighting (CIE PS 001:2024).

The purpose of this document is to define the SLL's understanding of integrative lighting, summarise the evidence that is mature enough to inform practice, and identify the uncertainties that still limit prescriptive guidance. It is a position statement, not a design standard. Practitioners should therefore use it to inform professional judgement, avoid over-claiming, and distinguish clearly between established principles, emerging evidence and open research questions.

The central organising principle is simple: bright days, dark nights. Daylight should be the primary means of delivering daytime melanopic exposure wherever possible, with electric lighting used as a complementary tool when daylight is unavailable, insufficient or poorly distributed.

Recent evidence indicates that many people experience relatively dim indoor days, but still excessive evening or night-time electric light. A multi-country wearable preprint study by Zauner et al. (2026) found that participants achieved the daytime recommendation of Brown et al. (2022) for ≥250 lx melanopic EDI during only about 24% of waking observations, while evening exposures often exceeded recommended levels. Average melanopic EDI was approximately 75 lx under indoor electric lighting, 172 lx under indoor daylight, and more than 700 lx outdoors. These findings underline the need to consider actual personal exposure at the eye, not design illuminance alone.

Daylight availability is necessary but not, by itself, sufficient to ensure adequate daytime melanopic exposure. Modelling of UK office spaces (Ticleanu et al., 2025) found that achieving 250 lx melanopic EDI indoors from daylight alone can be difficult

[1] Intrinsically photosensitive retinal ganglion cells.

in predominantly cloudy climates, especially for occupants located away from windows or facing away from them. High daylight provision improves the likelihood of meeting the recommendation, but may also increase glare risk, reinforcing the need to balance melanopic stimulus, visual comfort, energy performance and occupant behaviour.

International public-health interest is also increasing. Consensus statements and policy recommendations published in 2026 promoted “bright days and dark nights” as a public-health principle, positioning appropriately timed light exposure alongside sleep, physical activity and nutrition as a contributor to health and wellbeing (Piper et al., 2026).

Good lighting design can play an important role in making buildings healthier places to live and work, which is the emphasis of this position statement. However, even the best designs should complement, rather than replace, a healthy lifestyle that includes an appropriate balance between time spent indoors and outdoors.

Scientific background: How light influences human biology

Light does far more than enable vision. By acting on retinal photoreceptors connected to diverse brain regions, light contributes to physiological regulation and the maintenance of homeostasis across multiple body systems. Rhythmic biological patterns, including circadian entrainment, are closely linked to this broader homeostatic regulation and help coordinate sleep, alertness, hormone secretion, thermoregulation and other daily functions. Exposure to light at the eye produces rapid responses in the pupillary reflex and brain activity, including changes in heart rate and electroencephalographic patterns. The classic rapid pupil response is now understood to be followed by more sustained pupil responses mediated, at least in part, by ipRGCs. On short timescales, light can influence alertness, thermoregulation and other aspects of physiology and behaviour, while appropriately timed light exposure can also form part of evidence-based approaches to seasonal and non-seasonal depression. Critically, light is the primary synchroniser of the human biological clock, governing the timing and quality of sleep. Evening and night-time light can contribute to sleep disruption and can acutely suppress the nocturnal release of melatonin (CIE PS 001:2024), although sleep can of course also be disrupted by other factors such as noise, illness and stress.

Pioneering research since the 1980s on the effects of light beyond vision revealed that the eye contains a third class of photoreceptors: the ipRGCs, containing the photopigment melanopsin, with peak spectral sensitivity in the shorter (blue-enriched) wavelength portion of the visible spectrum (Provencio et al., 2000; Brainard et al., 2001; Thapan et al., 2001; Berson et al., 2002; Hankins and Lucas, 2002; Hattar et al., 2002). The ipRGCs are the primary drivers of a wide range of neuro-biobehavioural effects of light beyond vision, including circadian entrainment, melatonin suppression and acute alertness (CIE PS 001:2024). The CIE formally designates these as ipRGC-influenced light responses.

Emerging evidence indicates that all five photoreceptor classes (S-cones, M-cones, L-cones, rods and melanopsin-containing ipRGCs) can contribute to ipRGC-influenced responses under some conditions, with their relative contributions depending on light level, spectrum, duration, timing, prior light history, age and health status (Lucas et al., 2014; Najjar et al., 2024). However, evidence that a photoreceptor contribution observed in laboratory studies translates into a meaningful health effect in everyday settings remains incomplete. For practical guidance, melanopic EDI remains the principal standardised quantity used in current consensus recommendations, while other α-opic quantities may be useful for research and more detailed characterisation of light exposure.

While this position statement focuses primarily on circadian entrainment and its relationship with sleep, health and wellbeing, light influences human physiology and psychology through multiple pathways. These include effects on alertness, mood, cognitive performance, neuroendocrine function, pupillary responses and subjective perception. There is also growing interest in the potential physiological and psychological effects of specific wavelength regions, including long-wavelength radiation, although many of these mechanisms remain the subject of active research. A comprehensive review of these wider effects is beyond the scope of the present document.

Key point: Daytime light, especially in the morning, supports circadian entrainment, alertness and subsequent sleep quality; evening and night-time light can disrupt sleep and suppress nocturnal melatonin. Biological impact depends on spectrum, intensity, timing, duration and prior light history, and spectrum is not determined by correlated colour temperature (CCT) alone.

Measuring light-induced responses that can be elicited by ipRGCs: Melanopic EDI

The previous edition of this statement noted that metrics for circadian lighting were poorly defined and that 'melanopic lux' had not been formally standardised. This has now changed markedly through the availability of a standardised metrological framework. The CIE International Standard CIE S 026:2018 defines spectral sensitivity functions, quantities and metrics to describe the ability of optical radiation to stimulate each of the five α-opic photoreceptor types that contribute to integrative effects of light in humans. These α-opic quantities follow the International System of Units (SI), enabling traceable and internationally comparable measurements.[2]

For characterising the melanopic stimulus to the ipRGC system, CIE S 026:2018 defines the melanopic Equivalent Daylight (D65) Illuminance (melanopic EDI): the illuminance of CIE standard illuminant D65 (representing average daylight) that produces the equivalent melanopic stimulus as the test light source. The unit is lux (lx). This quantity replaces informal earlier references to 'melanopic lux' and the standard provides a rigorous, internationally consistent basis for specifying integrative lighting. The CIE recommends that melanopic EDI be used to describe the direct photic stimulus provided to the ipRGCs (CIE S 026:2018). The α-opic EDI system acknowledges the contributions of all five photoreceptor classes.

The CIE emphasises that describing a lit environment solely by the photopic luminous efficiency function $V(\lambda)$, which underlies conventional illuminance measurements, is insufficient for integrative lighting design. Light exposure should be assessed at the plane of the observer's eye (typically approximately vertical, facing the direction of

[2] Interestingly, the development of α-opic metrology had implications extending beyond lighting, leading the CIE to successfully propose changes to the SI system, including the incorporation of photon-based radiometry.

gaze), not the horizontal working plane. A comprehensive characterisation also includes horizontal illuminance, luminance distributions and colour quality indices (CIE TN 011:2020).

The CIE explicitly cautions that it is unhelpful, and potentially misleading, to use correlated colour temperature (CCT) to specify a 'healthy' or 'unhealthy' light source (CIE PS 001:2024). The melanopic stimulus depends on the relative spectral power distribution and luminous stimulus combined. For example, two light sources with the same CCT and illuminance can differ substantially in their melanopic EDI.

The revised international workplace-lighting standard ISO/CIE 8995-1:2025 incorporates considerations relating to the non-visual effects of ocular light exposure, including ipRGC-influenced responses to light. While recognising that evidence continues to evolve, the standard acknowledges the recommendations of Brown et al. (2022) as the best available scientific consensus at the time of publication.

Consensus recommendations: Proper light at the proper time

In August 2019, an independent workshop of 18 leading scientists ('Manchester II') translated current knowledge into practical guidance for healthy daily light exposure. The outcome, published by Brown et al. (2022) and based on a meta-analysis of 19 peer-reviewed studies (Brown, 2020), represents the first international consensus recommendations for a healthy pattern of day, evening and night light exposure. The recommendations are documented in CIE TN 015:2023 and endorsed in CIE PS 001:2024.

These recommendations apply to healthy young-to-middle-aged adults. Their applicability to younger and older populations, to those with visual or medical conditions, and to shift workers requires further study, as identified in CIE PS 001:2024.

Period	Melanopic EDI Target (vertical at eye level)	Purpose
Daytime (continuous)	≥ 250 lx	Supports alertness, circadian entrainment and good night-time sleep.
Evening (3 hours before sleep)	≤ 10 lx	Facilitates sleep initiation and consolidation, prevents shifting the biological clock and limits melatonin suppression.
Night (during sleep)	≤ 1 lx (target: as close to 0 as possible)	Supports strong circadian rhythm and sleep quality. If more detailed visual tasks are required at night, melanopic EDI ≤ 10 lx is recommended.

Source: Brown et al. (2022); adopted in CIE TN 015:2023 and endorsed in CIE PS 001:2024.

The daytime recommendation of melanopic EDI ≥ 250 lx should not be treated as a brief daily dose unless that interpretation is explicitly justified by evidence. From the evidence review in Brown et al. (2022) it is not clear how to apply this fixed threshold for a variable melanopic EDI profile that crosses the 250 lx mark. It is potentially a misinterpretation that a short period of high melanopic exposure would compensate for otherwise dim daytime conditions. Until evidence demonstrates equivalence between cumulative melanopic lux-hours and sustained daytime exposure, the SLL considers the recommendation to describe a daytime exposure condition to be supported as consistently as reasonably practicable during occupied daytime periods, with particular emphasis on the morning and earlier part of the day.

Research evidence and applied findings

The 2020 SLL position statement reviewed early evidence from the CIBSE/BRE *Circadian Lighting Effects on Health and Wellbeing* study (Ticleanu, 2020) and the LRC field study by Figueiro et al. (2020). While neither study produced statistically conclusive results, both provided useful insights: personal light exposure varies substantially within the same space, and appropriately timed spectral changes can influence circadian phase and alertness in ways consistent with established photobiology.

Since the consensus recommendations by Brown et al. (2022) were published, the evidence base has strengthened across controlled and field-based studies. The most relevant applied findings are:

- High daytime melanopic exposure is increasingly associated with improved sleep timing, stronger circadian rhythms and better physiological, cognitive and subjective outcomes, although effect sizes vary and high-quality field studies remain necessary (Lok et al., 2022; da Costa Lopes et al., 2024; Lasauskaite et al., 2026).
- The timing of daytime exposure is important. Morning light appears particularly effective for strengthening circadian entrainment and supporting earlier sleep timing, whereas exposure to short-wavelength light in the evening can delay circadian phase, suppress melatonin secretion and impair sleep quality (Vidafar et al., 2024; Constantino et al., 2025).
- Real-world exposure is often insufficient during the day and excessive in the evening. Wearable preprint evidence indicates that activity patterns, outdoor time, daylight access and view direction strongly influence the melanopic stimulus received at the eye (Zauner et al., 2026).
- Daylight remains the most effective and sustainable source of high melanopic exposure. Outdoor daylight commonly exceeds indoor electric-light levels by an order of magnitude or more (Schlangen and Price, 2021), but building form, glazing, shading, interior layout and occupant behaviour determine how much of that stimulus reaches the eye.
- Individual responses to light vary with age, sex, chronotype, prior light history, sleep status, ocular health and medical status. For example, emerging evidence suggests that women may exhibit greater circadian sensitivity to bright evening light than men, while chronotype may influence the relationship between daylight exposure and mental-health outcomes (Vidafar et al., 2024; Buschhausen et al., 2025). Guidance based on population averages should

therefore be applied with professional judgement and, where possible, supported by occupant controls within evidence-based limits.

- Certain settings and populations require tailored approaches. Shift workers, older adults, children, people with visual or medical conditions, and those living under different environmental or behavioural light exposure patterns, including differences in latitude, time spent outdoors, work schedules and daily routines, should not be assumed to respond in the same way as healthy young-to-middle-aged day workers, who formed the basis of many current recommendations (Adamsson et al., 2016; Lax et al., 2019; Burns et al., 2021; Figueiro and Kales, 2021; Brown et al., 2022; Eto and Higuchi, 2023; Varma and Rahman, 2024; Glickman et al., 2026; Spitschan and Zauner, 2026).
- Emerging public-health evidence links brighter daytime exposure and darker nights with better mental-health and metabolic outcomes, including findings from large cohort analyses and controlled office studies (Burns et al., 2023; Harmsen et al., 2026). These findings are promising but do not establish causality and should not be converted into product-specific health claims without appropriate evidence.

Energy and sustainability implications of integrative lighting

Integrative lighting must support human wellbeing while remaining compatible with energy efficiency, carbon reduction and responsible night-time lighting. It should not be interpreted as a justification for simply increasing electric lighting levels. The aim is to provide appropriate light at the right time, in the right place and for the right duration, while avoiding unnecessary light exposure, glare, spill light, sky glow and energy use.

Higher daytime melanopic exposure in buildings should not be pursued by increasing installed electric lighting load where daylight, layout, surface reflectance, controls or more efficient spectral design can achieve the same purpose. Similarly, darker nights should not be pursued by compromising essential visual tasks or public safety. The design challenge is to balance visual performance, circadian and neurophysiological considerations, comfort, accessibility, ecological responsibility and energy performance.

Outdoor lighting shapes the night-time light environment for people and communities. It must provide adequate visibility, accessibility and perceived safety, but it should also avoid unnecessary melanopic exposure at night, light intrusion into buildings, ecological disturbance and wasted energy. For this reason, integrative-lighting principles should be considered alongside established good practice for outdoor lighting, including careful targeting, appropriate light levels, glare control, suitable spectra, dimming, curfews and adaptive controls.

A systematic review of the energy impacts of integrative lighting (Taghizadeh et al., 2025) found that poorly conceived schemes can increase energy consumption when non-visual objectives are addressed only by adding more electric light. Increased energy use is not inevitable, but avoiding it requires daylight-led design, spectral optimisation and effective controls from the outset.

The SLL therefore supports a daylight-first, electric-light-supported approach. Key strategies include:

- Maximise useful daylight through building orientation, façade design, glazing, shading, interior layout and access to views.
- Improve daytime vertical illuminance at the eye through room geometry, surface reflectance and task/location planning before increasing electric lighting power.
- Select efficient light sources with spectra that provide appropriate melanopic effectiveness per unit of photopic illuminance and support the intended visual and melanopic outcomes without compromising visual quality, comfort or safety.
- Use intelligent controls, including daylight harvesting, occupancy sensing, dimming and time-based scheduling, to increase daytime exposure and reduce evening exposure only when needed.
- Ensure dimmed evening and night-time operation does not introduce unacceptable temporal light modulation, particularly at low dimming levels.
- For outdoor lighting, use the minimum light needed for the task, control glare and spill light, direct light only where needed, and apply dimming, curfews or adaptive control where appropriate.
- Consider the combined night-time exposure from indoor lighting, street lighting, signage, vehicle lighting and other outdoor sources when applying the principle of dark nights.

Key point: Sustainable integrative lighting is not simply "more light" or "less light". It is better-timed light, better use of daylight, appropriate spectral design and controls that support people without unnecessary energy use.

Individual control and occupant experience

Individual control remains an important element of integrative lighting design. Multiple studies have reported positive occupant responses when people are given meaningful control over their lighting environment, including intensity, spectrum and timing. This correlates with improved perceived wellbeing and satisfaction. However, the role of design is to make healthier light exposure easier and more accessible, not to impose it on occupants. As with other public-health interventions, lighting guidance should support informed choices by providing appropriate environments, clear information and practical tools. Where safety, visual performance and the needs of other occupants are not compromised, people should be able to turn the lighting down or off or select calmer lighting conditions.

This is particularly important because light can be stimulating as well as beneficial. Although brighter daytime exposure can support circadian entrainment, alertness and subsequent sleep, some occupants may at times need a lower-stimulation environment during the day. Integrative lighting should therefore combine evidence-based default settings with meaningful user control, especially in local or personal zones. In shared spaces, control strategies should balance individual preference with collective needs, avoiding both rigid centralised schedules and unlimited adjustment that could adversely affect others.

It is essential that the benefits of integrative lighting are not overstated. As Dr Peter Boyce noted in his 2016 editorial in Lighting Research & Technology, "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" (Boyce, 2016). While lighting can be an important contributor to health, wellbeing and performance, many outcomes are also influenced by behavioural, social, environmental and health-related factors. Consequently, claims regarding the benefits of integrative lighting should remain evidence-based and proportionate to the strength of the available evidence.

Open questions and research priorities

The evidence is mature enough to support general principles of bright days and dark nights, but not yet sufficient to prescribe universal design formulae across all populations, buildings and schedules. The SLL identifies the following priorities:

- Continuous versus intermittent daytime exposure: Research must determine whether, and if so how, cumulative melanopic lux-hours can substitute for maintaining approximately 250 lx melanopic EDI across occupied daytime periods. Until this is established, guidance should not imply that a short high-exposure episode is equivalent to a sustained bright daytime environment.
- Energy and comfort: Further guidance is needed on achieving daytime melanopic targets without glare, visual discomfort or excessive energy use, particularly in buildings with limited daylight availability.
- Evening visibility versus low melanopic exposure: Research and product development should address how to maintain safe visual performance in the evening while limiting melanopic EDI, especially for people with reduced visual capability.
- Low-light operation and temporal light modulation: Further research and guidance are needed to understand and manage flicker performance when lighting is dimmed to achieve low evening or night-time melanopic EDI. Current product compliance requirements for temporal light modulation are assessed at full light output and do not characterise performance across the dimming range. As a result, compliance at rated output should not be assumed to indicate acceptable flicker performance under dimmed conditions. Future standards and guidance should consider how temporal light modulation is assessed in low-light operation. In the meantime, where low-light operation is critical, additional assessment methods, such as those described in IEC TR 61547-1:2020, may provide a useful means of evaluating objective flicker performance during dimmed operation.
- Diverse populations: Specific evidence is needed for children, older adults, people with visual or medical conditions, shift workers, and populations in different latitudes and environmental and behavioural contexts.
- Individual variability: Further research is needed to quantify how age, sex, chronotype, health status and prior light exposure modify responses to light, and how such differences should inform future guidance and lighting standards.
- Personalised control: Research should establish evidence-based adjustment ranges that allow meaningful occupant control while supporting circadian objectives and ensuring that safety, visual performance and the needs of other occupants are not compromised.

- Night-work and rotating schedules: Shift-work recommendations must account for task demands, work timing, shift schedules, sleep timing and out-of-work light exposure; daytime guidance should not be applied unchanged to nocturnal schedules.
- Outdoor lighting and night-time exposure: Further work is needed on how integrative-lighting principles should be applied to outdoor lighting, including the balance between visibility, safety, accessibility, melanopic exposure, ecological impact, light intrusion, sky glow and energy use.

The SLL Position

The SLL affirms the following position:

- Use the principle of bright days and dark nights. The evidence supporting high daytime light exposure, reduced evening exposure and near-darkness during sleep is now substantial, although application details vary by population, setting and schedule.
- Adopt a daylight-first, electric-light-supported strategy. Daylight and outdoor exposure remain the most effective means of achieving high daytime melanopic stimulus; electric lighting should complement, not replace, daylight.
- Specify the correct metric. Melanopic EDI, defined in CIE S 026:2018 and recommended in CIE PS 001:2024, is the appropriate standardised metric for characterising ipRGC stimulus. CCT alone is insufficient and can be misleading.
- Treat melanopic EDI $\geq$ 250 lx as a minimal daytime exposure condition, not a brief dose. Until evidence shows that short high-exposure periods are equivalent to sustained daytime exposure, specifications should aim to support the recommendation as consistently as reasonably practicable during occupied daytime periods, particularly in the morning.
- Design for people, not averages. Lighting schemes should recognise individual differences and provide meaningful occupant control wherever practicable. Evidence-based default settings should support healthy light exposure, but occupants should be able to adapt local lighting where this does not compromise safety, essential visual performance or the needs of others.
- Protect evening low light and night-time darkness. The SLL supports the consensus recommendations of Brown et al. (2022) to limit light exposure during the three hours before intended sleep to a melanopic EDI of no more than 10 lx, and to keep exposure during sleep to a melanopic EDI of no more than 1 lx. Where visual tasks are unavoidable at night, exposure should remain as low as safely achievable and should not exceed the relevant melanopic EDI guidance unless justified by safety or overriding operational need where compliance with the recommended threshold would compromise adequate visual performance. Dimmed evening and night-time lighting should also avoid unacceptable temporal light modulation so that reductions in melanopic exposure do not compromise visual comfort or wellbeing.
- Align integrative lighting with sustainability. Circadian and wellbeing objectives should be achieved through daylight, efficient sources, appropriate spectra and intelligent controls, not unnecessary energy use.

- Apply integrative-lighting principles outdoors as well as indoors. Street lighting and other forms of outdoor lighting should support safe visual conditions while limiting unnecessary night-time light exposure, light spill, sky glow, ecological impacts and energy use.
- Avoid unsupported commercial claims. No lighting product is intrinsically integrative, circadian or human-centric. These are not properties of the product itself, but of the pattern of light exposure it helps create, which depends on how, when and where it is used, and on the characteristics, activities and circumstances of the individual receiving that exposure. Claims for specific health, wellbeing or performance benefits should be supported by relevant published evidence and should not imply certainty where the science remains incomplete or unsettled.

Conclusion

The science of integrative lighting has advanced substantially since the SLL's previous position statement. There is now an internationally standardised metric for melanopic stimulus, consensus recommendations for daily light-dark exposure, and growing evidence that appropriately timed light and darkness are relevant to sleep, circadian entrainment, wellbeing and public health.

The practical message is clear: provide brighter, well-timed daytime exposure; reduce melanopically stimulating light in the evening; protect darkness during sleep; and use daylight as the primary strategy wherever possible. Electric lighting can have an important role, but it must be specified using appropriate metrics and integrated with visual comfort, energy efficiency and user needs.

At the same time, the SLL cautions against over-precise or commercially convenient interpretations of the evidence. In particular, the daytime recommendation of a melanopic EDI of at least 250 lx at eye level should not be reduced to a short daily dose unless future evidence supports that interpretation. Integrative lighting should be designed by competent professionals, applied with judgement, communicated honestly, and evaluated against both human and environmental outcomes.

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