



International Commission on Illumination
Commission Internationale de l'Eclairage
Internationale Beleuchtungskommission

DOI: 10.25039/PS.b2twa77g

POSITION STATEMENT

**CIE Position Statement on Integrative
Lighting
Recommending Proper Light at the
Proper Time
3rd Edition**

THE INTERNATIONAL COMMISSION ON ILLUMINATION

The International Commission on Illumination (CIE) is an organization devoted to international co-operation and exchange of information among its member countries on all matters relating to the art and science of lighting. Its membership consists of the National Committees in about 40 countries.

The objectives of the CIE are:

1. To provide an international forum for the discussion of all matters relating to the science, technology and art in the fields of light and lighting and for the interchange of information in these fields between countries.
2. To develop basic standards and procedures of metrology in the fields of light and lighting.
3. To provide guidance in the application of principles and procedures in the development of international and national standards in the fields of light and lighting.
4. To prepare and publish standards, reports and other publications concerned with all matters relating to the science, technology and art in the fields of light and lighting.
5. To maintain liaison and technical interaction with other international organizations concerned with matters related to the science, technology, standardization and art in the fields of light and lighting.

The work of the CIE is carried out by Technical Committees, organized in six Divisions. This work covers subjects ranging from fundamental matters to all types of lighting applications. The standards and technical reports developed by these international Divisions of the CIE are accepted throughout the world.

A plenary session is held every four years at which the work of the Divisions and Technical Committees is reported and reviewed, and plans are made for the future. The CIE is recognized as the authority on all aspects of light and lighting. As such it occupies an important position among international organizations.

LA COMMISSION INTERNATIONALE DE L'ECLAIRAGE

La Commission Internationale de l'Eclairage (CIE) est une organisation qui se donne pour but la coopération internationale et l'échange d'informations entre les Pays membres sur toutes les questions relatives à l'art et à la science de l'éclairage. Elle est composée de Comités Nationaux représentant environ 40 pays.

Les objectifs de la CIE sont :

1. De constituer un centre d'étude international pour toute matière relevant de la science, de la technologie et de l'art de la lumière et de l'éclairage et pour l'échange entre pays d'informations dans ces domaines.
2. D'élaborer des normes et des méthodes de base pour la métrologie dans les domaines de la lumière et de l'éclairage.
3. De donner des directives pour l'application des principes et des méthodes d'élaboration de normes internationales et nationales dans les domaines de la lumière et de l'éclairage.
4. De préparer et publier des normes, rapports et autres textes, concernant toutes matières relatives à la science, la technologie et l'art dans les domaines de la lumière et de l'éclairage.
5. De maintenir une liaison et une collaboration technique avec les autres organisations internationales concernées par des sujets relatifs à la science, la technologie, la normalisation et l'art dans les domaines de la lumière et de l'éclairage.

Les travaux de la CIE sont effectués par Comités Techniques, organisés en six Divisions. Les sujets d'études s'étendent des questions fondamentales, à tous les types d'applications de l'éclairage. Les normes et les rapports techniques élaborés par ces Divisions Internationales de la CIE sont reconnus dans le monde entier.

Tous les quatre ans, une Session plénière passe en revue le travail des Divisions et des Comités Techniques, en fait rapport et établit les projets de travaux pour l'avenir. La CIE est reconnue comme la plus haute autorité en ce qui concerne tous les aspects de la lumière et de l'éclairage. Elle occupe comme telle une position importante parmi les organisations internationales.

DIE INTERNATIONALE BELEUCHTUNGSKOMMISSION

Die Internationale Beleuchtungskommission (CIE) ist eine Organisation, die sich der internationalen Zusammenarbeit und dem Austausch von Informationen zwischen ihren Mitgliedsländern bezüglich der Kunst und Wissenschaft der Lichttechnik widmet. Die Mitgliedschaft besteht aus den Nationalen Komitees in rund 40 Ländern.

Die Ziele der CIE sind:

1. Ein internationales Forum für Diskussionen aller Fragen auf dem Gebiet der Wissenschaft, Technik und Kunst der Lichttechnik und für den Informationsaustausch auf diesen Gebieten zwischen den einzelnen Ländern zu sein.
2. Grundnormen und Verfahren der Messtechnik auf dem Gebiet der Lichttechnik zu entwickeln.
3. Richtlinien für die Anwendung von Prinzipien und Vorgängen in der Entwicklung internationaler und nationaler Normen auf dem Gebiet der Lichttechnik zu erstellen.
4. Normen, Berichte und andere Publikationen zu erstellen und zu veröffentlichen, die alle Fragen auf dem Gebiet der Wissenschaft, Technik und Kunst der Lichttechnik betreffen.
5. Liaison und technische Zusammenarbeit mit anderen internationalen Organisationen zu unterhalten, die mit Fragen der Wissenschaft, Technik, Normung und Kunst auf dem Gebiet der Lichttechnik zu tun haben.

Die Arbeit der CIE wird durch Technische Komitees geleistet, die in sechs Divisionen organisiert sind. Diese Arbeit betrifft Gebiete mit grundlegendem Inhalt bis zu allen Arten der Lichtenwendung. Die Normen und Technischen Berichte, die von diesen international zusammengesetzten Divisionen ausgearbeitet werden, sind auf der ganzen Welt anerkannt.

Alle vier Jahre findet eine Session statt, in der die Arbeiten der Divisionen berichtet und überprüft werden, sowie neue Pläne für die Zukunft ausgearbeitet werden. Die CIE wird als höchste Autorität für alle Aspekte des Lichtes und der Beleuchtung angesehen. Auf diese Weise unterhält sie eine bedeutende Stellung unter den internationalen Organisationen.

Published by the

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CIE Position Statement on Integrative Lighting

RECOMMENDING PROPER LIGHT AT THE PROPER TIME

3rd Edition¹

August 30, 2024

Background

Light is defined as any electromagnetic “radiation that is considered from the point of view of its ability to excite the visual system” (CIE 2020a, term 17-21-012), which occurs by direct stimulation of the classical retinal photoreceptors: the rods and cones. In addition to enabling vision, retinal photoreceptors also connect to diverse brain locations through which light triggers biological effects that powerfully regulate human health, performance and well-being. Exposure to light elicits fast responses (in the range of milliseconds and seconds) in the pupillary reflex or in brain activity. These fast effects can include an increase in heart rate and changes in brain activity as measured with an electroencephalogram (EEG), among other physiological outcomes. On a somewhat slower time course (minutes rather than milliseconds), light exposure can improve alertness, influence thermoregulation, and alleviate seasonal and non-seasonal depression. Light is also the main synchronizer of the human biological clock. Depending on the timing and intensity of the exposure, light exposure can shift the phase of the circadian rhythm acting on the scale of days and weeks, and can regulate the timing and quality of sleep. Light in the evening and at night can disrupt sleep and can cause acute suppression of the nocturnal release of the hormone melatonin.

Advances in physiology over the past 40 years have revolutionized our understanding of the structure of the retina and its connections to the brain. The classical receptors for vision, the rods and cones, are relatively well understood and characterized by existing CIE publications. Pioneering work since the 1980s has revealed that the eye has other photoreceptors, known as the intrinsically photosensitive retinal ganglion cells (ipRGCs) (e.g. Berson et al. 2002; Foster et al. 1993; Provencio et al. 2000). Their photosensitivity is based on the photopigment melanopsin, with peak sensitivity in the shorter wavelength part of the visible spectrum (Brainard et al. 2001; Thapan et al. 2001). This body of research has led to a dramatic increase in the number of scientists investigating all manner of neuro-bio-behavioural effects of light and in the number of products developed with the intent of influencing the health and well-being of their users.

Several terms are in common (but imprecise) use to label the effects of light that are thought to be distinct from perceptual vision, including “non-image-forming” (NIF) or “non-visual” (NV)

¹ This edition replaces the 2019 CIE Position Statement on the same subject, which was titled “Position Statement on Non-Visual Effects of Light - Recommending Proper Light at the Proper Time, 2nd edition”.

responses to light, but emerging evidence shows interconnections between the photoreceptors, and not a strict division between functions (e.g. Najjar et al. 2024). Some in the lighting industry use marketing terms such as “human-centric lighting” (HCL), “circadian lighting”, and “biodynamic lighting” to describe lighting solutions that target such effects. The CIE has adopted, in the 2nd edition of the International Lighting Vocabulary, the term “integrative lighting” (CIE 2020a, term 17-29-028) as the official term for lighting that is specifically intended to integrate visual and non-visual effects, producing physiological and psychological effects on humans that are reflected in scientific evidence.

Based on the outcome of an independent workshop of leading scientists in the field of quantifying light for non-visual effects in Manchester, UK in 2013 (see CIE TN 003:2015 (CIE 2015)), the CIE developed an International Standard, CIE S 026:2018 (CIE 2018), that defines a system for metrology of optical radiation for light-induced responses that can be elicited by ipRGCs (ipRGC-influenced light (IIL) responses).

Lighting regulations and practice often continue to focus on visual and energy efficiency aspects of light, with little or no attention being paid to IIL responses. Conversely, there are many lighting products entering the market that are intended primarily to influence IIL without careful consideration of other lighting quality aspects. An improper balance between these approaches can result in lighting conditions that compromise human well-being, health and functioning and that fail in terms of overall lighting quality. Since the first edition of this Position Statement in 2015 and its update in 2019, the CIE has issued relevant publications and engaged in collaborative activities to advance this exciting aspect of lighting fundamentals, technology and applications. This third edition of the Position Statement reflects the state of knowledge in 2024.

1. How to characterize light with respect to its integrative effects: CIE S 026:2018 “CIE System for Metrology of Optical Radiation for ipRGC-Influenced Responses to Light”

The International Standard CIE S 026:2018 (CIE 2018) defines spectral sensitivity functions, quantities and metrics to describe the ability of optical radiation to stimulate each of the five (α -opic²) photoreceptor types that can contribute, via the melanopsin-containing ipRGCs, to retina-mediated integrative effects of light in humans³. The units of these α -opic quantities are in compliance with the International System of Units (SI) (BIPM 2019a; BIPM 2019b), which is essential to enable traceable measurements and to meet international guidelines. The standard establishes the phrase “ipRGC-influenced light effects” (IIL effects) as the preferred phrase when speaking of effects mediated by the ipRGCs.

When considering integrative lighting, a description of optical radiation solely according to the photopic action spectrum (represented by the photopic spectral efficiency function, $V(\lambda)$) is not sufficient. Moreover, there is no single action spectrum or proxy that can describe all eye-mediated responses to light. All five receptor types can contribute to these responses (Lucas et al. 2014). The relative contribution of each individual photoreceptor type can vary depending on the specific response and upon light exposure properties such as intensity, spectrum, duration, timing (external and internal/circadian), prior light exposure history and sleep deprivation state of

² The term α -opic represents S-cone-opic, M-cone-opic, L-cone-opic, rhodopic or melanopic.

³ The CIE S 026 action spectra of the five human α -opic photoreceptor classes (S-cones, M-cones, L-cones, rods and ipRGCs), tabulated in steps of 1 nm, are available at <https://doi.org/10.25039/CIE.DS.vqghzp5a>.

the individual. Moreover, light exposure should be assessed or predicted using the plane of the observer's eye (usually vertical and facing the direction of gaze) rather than the horizontal plane.

CIE S 026:2018 (CIE 2018) also defined an equivalent illuminance, the α -opic equivalent daylight (D65) illuminance (EDI) using the CIE standard illuminant D65 as the reference illuminant. This quantity gives the illuminance of CIE standard illuminant D65 (representing average daylight) that produces the equivalent α -opic illuminance as the test light. The unit is lx. It is recommended to use the melanopic EDI to describe the stimulus provided to the ipRGCs.

A comprehensive characterization of a lit environment also includes horizontal illuminances, vertical and horizontal luminances, colour quality and other indices to describe the stimulus provided to the visual system (CIE 2020b).

2. *Identifying the proper light at the proper time*

Identifying the proper light to be used at any given time remains a key question for many people. As outlined in the 2015 and 2019 position statements, the CIE actively engages with the international community in attempting to provide guidance that is based on solid scientific evidence and consensus. The CIE and ISO/TC 274 produced a joint Technical Report in 2022 (ISO/CIE TR 21783:2022 (ISO/CIE 2022)) that summarized the then-current state of knowledge concerning both the potential beneficial effects of integrative lighting and its possible risks.

In August 2019, a second independent workshop of 18 leading scientists took place in Manchester ("Manchester II") to discuss how insights in this field could be translated into guidelines for a healthy daily pattern of light exposure. This meeting resulted in the first consensus recommendations for a healthy pattern of day, evening, and night light exposure to support sleep, wakefulness and physiology (Brown et al. 2022). The recommendations were based on a meta-analysis of 19 papers published between 2000 and 2019 (Brown 2020), all with data from healthy young adults. The recommendations are for a minimum exposure to 250 lx melanopic EDI at the eye during daytime; a maximum exposure to 10 lx melanopic EDI in the evening for the three hours before bedtime; and a maximum exposure to 1 lx melanopic EDI overnight while sleeping (although if activities requiring vision take place during the night, the recommended maximum melanopic EDI is 10 lx). The deliberations at the workshop have been documented in Technical Note CIE TN 015:2023 (CIE 2023a).

The achievement of this consensus statement based on scientific fundamentals is an important step towards incorporating IIL considerations into general recommendations for lighting applications in order to achieve truly integrative lighting. There are, however, several open questions that need urgent research attention before this takes place:

- In order to be acceptable to occupants and to building authorities, it will be necessary to achieve the vertical illuminance minimum of 250 lx melanopic EDI without causing discomfort or reduced visibility, and it will be necessary to deliver the light exposure within the limits of energy regulations. Increasing the use of daylight (where possible) will assist with the energy considerations, but the avoidance of glare from both windows and electric light will require more advanced lighting design guidance.
- The recommendation is for a continuous exposure during the day, but this can be difficult to achieve. It is unclear whether there is a daytime light dose (expressed, perhaps, in lx-hrs) that can achieve the same beneficial effect. If there is, new application recommendations can call for intermittent exposures to a higher melanopic EDI rather than one continuous exposure. This would reduce the total energy used to deliver the 250

lx melanopic EDI minimum, especially if daylight were the principal source for the periods of very high exposure.

- The evening recommendation of not more than 10 lx melanopic EDI at the eye for three hours might be difficult to reconcile with individuals' task visibility needs, especially for those with limited visual capabilities. Both expert design guidance and carefully chosen light source spectra might help to achieve an integrative solution.
- As the Manchester II workshop participants noted, these recommendations address the ILL needs of healthy young to middle-aged adults, but their applicability to younger and older populations and to those with special needs is unknown. Funding bodies should prioritize projects that will provide information about more diverse samples varying in age and health status.
- An important source of data to understand daily light-dark patterns is exposure monitoring using personal light dosimetry. This is an area of active research, and the CIE has a very active Joint Technical Committee (JTC 20) with the goal of establishing best practice guidance and tools for precision metrology. In parallel, the lighting community needs the assistance of other scientists to develop accurate, practical, comfortable, wearable devices for ecological measurement of physiological and behavioural responses.
- Application guidance, both recommendations and standards, is written for spaces based on averages, not individuals. Guidance based on averages will discriminate against some occupants some or all of the time. Prior light exposure history and the state of one's physiological rhythms influence one's responses to light exposure – and the lighting designer and building managers cannot know the state of the individuals in the space. This makes standardizing on fixed values to support integrative lighting very difficult, and should lead to recommendations for ranges that can be achieved with lighting controls.
- Appropriate recommendations for individuals who must be active overnight require additional information and will need to be tailored to the specific shift schedule. Recommendations also must account for individuals' range of activities and light exposures during non-work hours.

The CIE is committed throughout all of its work to providing scientifically grounded recommendations and to advancing science that will support the next generation of standards. The questions raised here are elaborations of themes identified in the CIE Research Strategy 2023 (CIE 2023b). Researchers proposing to study topics relevant to the CIE Research Strategy may apply to the CIE for a letter of support for the proposal by emailing a [request form](mailto:ciecb@cie.co.at) to ciecb@cie.co.at⁴.

3. Preliminary guidance

Fully integrative lighting recommendations will require the knowledge described above, but enough is known today to provide simple public messaging that would enable individuals to use light and darkness to better advantage. The CIE Governing Board has agreed to participate in an international co-operative effort to develop and disseminate this important message, as proposed in May 2024 by the experts convened at the Ladenburg Roundtable on Light and Health (Kervezee et al. 2024).

⁴ See the [Research Strategy](#) section of the CIE website for more details and to download the form.

A key element of this message must be that the effects that occur as a result of the delivered light exposure are caused by the combination of the light level and spectrum together, and therefore the combination of all of the light sources in the immediate environment, whether electric, daylight, or flame. Any light source, viewed directly or reflected from surfaces, and depending on the time of day and the characteristics of the individual, can deliver either a desirable or undesirable light exposure. A corollary to this is that it is unhelpful, and potentially misleading, to use the correlated colour temperature to specify a “healthy” or “unhealthy” light.

- *A high melanopic EDI (a very high light exposure) during the day is supportive for alertness, the circadian rhythm and a good night’s sleep.*

The CIE recognizes that spending time outdoors during the day is associated with better health and well-being, and that exposure to daylight is a significant causal component in these effects. CIE also recommends not to unnecessarily restrict daylight within indoor settings. Increased daylighting in buildings will usually also reduce energy use for lighting.

- *A low melanopic EDI (on the order of 1/25, or less, of the daytime exposure) in the evening facilitates sleep initiation and consolidation.*
- *Darkness (a very low melanopic EDI, i.e. nearly none) at night supports a strong circadian rhythm and sleep quality, with subsequent benefits for performance and well-being resulting from physiological processes that take place during sleep.*

A very low melanopic EDI during sleep is essential for a strong circadian rhythm and sleep quality and ideally the illuminance on the eyelids should be as close to zero as possible. The CIE notes that closed eyelids, as occur during sleep, help to support a strong pattern of dark nights and light days.

Further CIE Strategy

Delivering the proper light at the proper time will require integrative approaches that meet the needs of all the people within a space. Ongoing CIE projects in this field include the joint activity with ISO/TC 274 to revise the International Standard for indoor workplace lighting, ISO 8995-1:2002/CIE S 008:2001 (ISO/CIE 2002). Joint Technical Committee JTC 20 works on developing guidance on personal light dosimetry. Technical Committee TC 4-61 explores the effects of exterior electric lighting on the natural environment. Other related Technical Committees are in development.

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About the CIE and its Position Statements

The International Commission on Illumination – also known as the CIE from its French title, the Commission Internationale de l’Eclairage – is devoted to worldwide cooperation and the exchange of information on all matters relating to the science and art of light and lighting, colour and vision, photobiology and image technology. The CIE publishes internationally recognized standards, reports and other publications concerned with all matters related to science, technology, and standardization in the fields of light and lighting.

CIE Position Statements are approved by the CIE’s Governing Board and Technical Management Board.

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