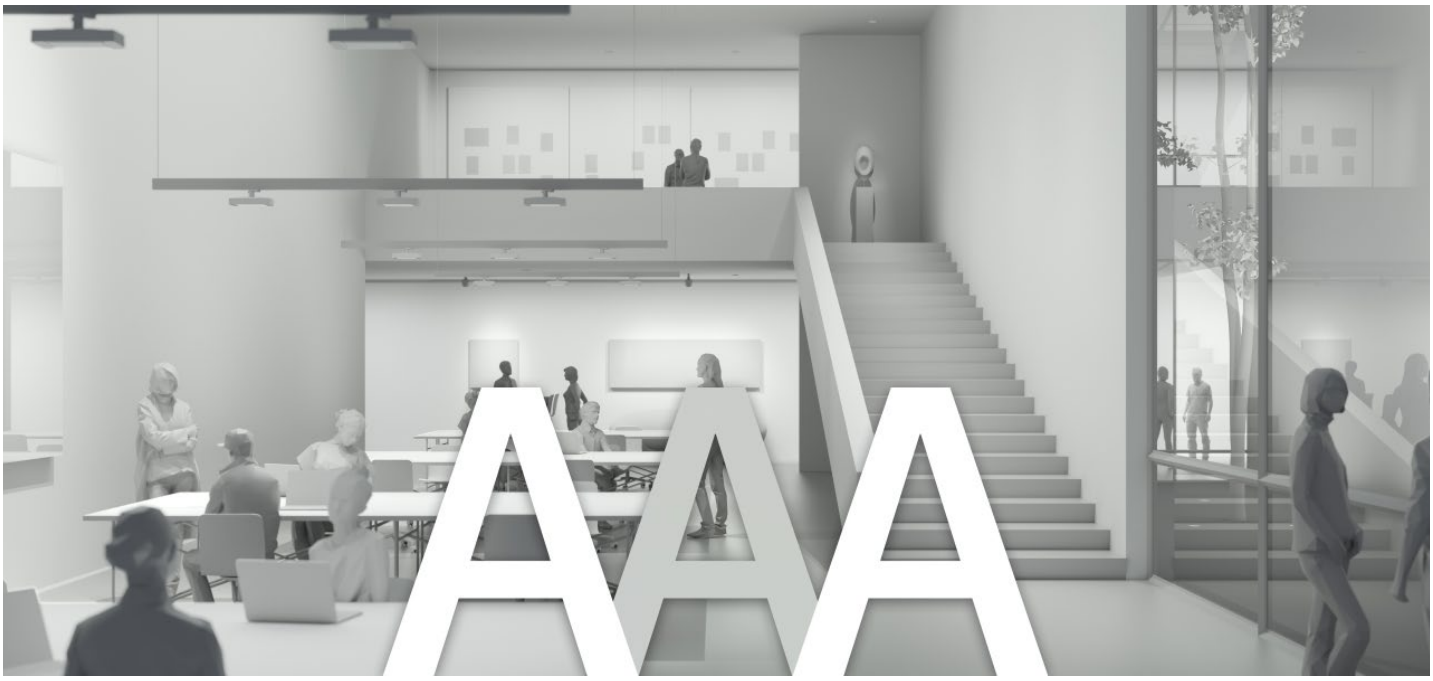
Human Centric Lighting



Human Centric Lighting – practical knowledge and planning strategy

With the concept of Human Centric Lighting, the understanding of quality of light has broadened to include the aspects of health and well-being. This white paper explains the effect of light on us humans and indicates the building blocks that go to make up a Human Centric Lighting concept. Our AAA approach and a case study will help you to implement Human Centric Lighting in your projects.

Human Centric Lighting

Content

Human Centric Lighting

Introduction

Artificial lighting is more than just light for seeing. Light makes architecture more palpable, atmospheric and supports orientation. Lighting designers have been successfully implementing this perception-based approach to lighting design for decades. However, the comparatively new term of Human Centric Lighting has only become established in recent years. This white paper explains what is behind the phrase and why it is, above all, an attitude of planning. With an office as an example, we show you how to integrate architecture, activity and atmosphere into your Human Centric Lighting concept and what this means in practice.

Human Centric Lighting

What is Human Centric Lighting?

Human Centric Lighting combines light for good vision with light that considers emotional and biological needs. An even more nuanced definition is provided by the German Electrical and Electronic Manufacturers' Association: "Light works in many ways and always visually, emotionally and biologically. Human Centric Lighting (HCL) provides specific, long-term support for health, well-being and the performance of people through holistic planning and implementation of the visual, emotional and especially biological effects of light." (German Electrical and Electronic Manufacturers' Association, 2016). Thus in summary, three factors are relevant to practice: the visual, emotional and biological effect of light.

The first scientific evidence of the emotional and biological effect of light dates back to the 1960s with experiments without daylight in a bunker to demonstrate how light affects the circadian rhythm (Aschoff, 1965). In 2001, research carried out by George Brainard and Kavita Thapan significantly contributed to understanding more about the human biorhythm: they described the active function on the basis of suppression of the hormone melatonin and attributed this to a receptor in the eye (Brainard et al., 2001; Thapan et al., 2001). In addition to the familiar cones and rods, a short time later David Berson described photosensitive ganglion cells functioning as a further photoreceptor in the eye as a circadian rhythm generator (Berson, 2002).

The receptors thus enable the human eye not only to see but also to synchronise the inner clock through light. From these insights, the Commission Internationale de l'Éclairage (CIE) formulated the term "integrative lighting", which takes into account not only the physiological effects, but also the psychological effects of lighting. More detailed discussions in this discourse led to an expansion of the definition of 'light', which since 2020 has no longer been limited by the CIE to the phenomenon of vision alone, but also includes non-visual responses.

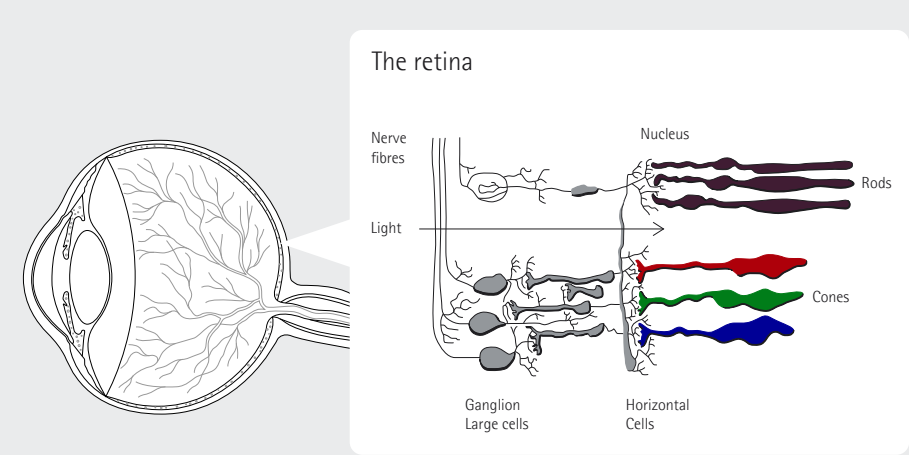


Fig. 1: We perceive our surroundings visually with the help of rods and cones whilst the melanopsin-containing ganglion cells control biological effects.

Human Centric Lighting

What are the advantages of Human Centric Lighting?

Lighting design that takes into account not only the visual effect of light but also the emotional and biological factors creates much more than 'just good light'. It is also a positive parameter in the value creation chain for building owners who increase the value of their property, users who benefit in offices from a working environment with better quality of light and a greater sense of well-being, and lighting designers who are able to offer a more nuanced range of services with HCL.

- ✓ **Value enhancement for investors**
  Human Centric Lighting is valid, for example, in connection with building certifications. In addition to the criteria for well-being and visual comfort, circadian lighting design is also evaluated here in terms of health. This is often accompanied by digitally controlled, dynamic change of light, which can now be implemented via wireless control without the need for re-wiring.

- ✓ **Increasing attractiveness and productivity for businesses**
  Human Centric Lighting enables employers to create attractive working environments that are tailored to the individual needs of employees. Flexible lighting concepts are also ideal for the different and often changing room concepts demanded by creative and productive work processes. If lighting is only used where it is needed, companies also make an important contribution to sustainability and corporate social responsibility. Thus competitive working environments are created that are also advantageous in the search for skilled workers.

- ✓ **Flexibility and autonomy for users**
  If employees can adjust the lighting themselves this has a positive effect on their well-being. Controlling the lighting according to different work situations as well as individual needs supports motivation and creativity. In this way, light can be optimally adjusted to very individual levels of visual acuity and visual habits.

- ✓ **Holistic design strategy for lighting designers**
  Architects are faced with the design task of considering daylight and artificial light visually, emotionally and biologically. Lighting designers contribute their professional expertise to the planning process. The different functional areas are thus planned according to times of use and visual tasks.

Human Centric Lighting

What is the difference between good lighting design in the past and Human Centric Lighting today?

The conviction that good lighting design puts people at the centre existed even before the term Human Centric Lighting: as early as the 1950s, the American lighting designer Richard Kelly distinguished between three types of illumination: light for seeing (ambient luminescence), light for looking at (focal glow) and light for viewing (play of brilliants). He focused on seeing for activities, but also included well-being in architecture (Kelly, 1952).

Around 20 years later, William M.C. Lam expanded the approach from the perspective of an architect and postulated a more nuanced analysis of visual tasks according to location, type, and frequency (Lam, 1977). He was convinced that the unconscious needs of human beings could be supported by good lighting design. If interior lighting is adapted to the lighting conditions of day and night, it also supports the human inner clock. (Lam, 1977).

The research findings of Brainard, Berson and Thapan on the photoreceptor and the circadian rhythm in the early 2000s scientifically proved the relevance of the factor of time for lighting design. For concepts relating to Human Centric Lighting however, one specific technical innovation was also decisive: the combination of LED technology with variable colour temperatures and digital networking made flexible and variable lighting possible. The term "tunable white" established itself around 2015, describing the method of changing the spectrum of luminaires along the Planckian curve.

Among specialists, who summarise different aspects of lighting such as brightness, colour temperature, quality of colour rendering and well-being with the term 'quality of light', the designation Human Centric Lighting has become widespread since 2013 (Lighting Europe, 2013). The main difference is that Human Centric Lighting, with its holistic planning approach, takes greater account than before of the visual, emotional and biological aspects of lighting design. Initial planning recommendations from associations and institutions demonstrate how biologically effective lighting can be designed, for example with DIN SPEC 67600. Lighting also plays a crucial role with regard to the certification of buildings for health and well-being (DIN, 2013; International WELL Building Institute, 2021).

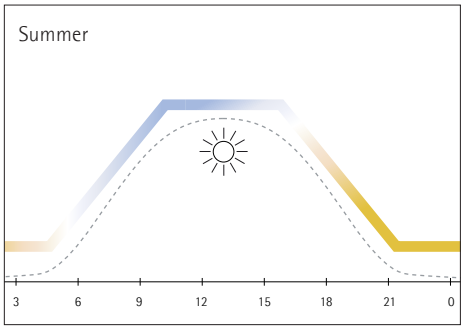
ERCO was an early advocate of good quality of light and human well-being in architecture: in the very first issue of its customer magazine 'Lichtbericht' in 1977, ERCO focused on the topic of glare limitation with its design and cost-efficiency. In subsequent editions, Lichtbericht documented how vertical visual tasks at workplaces had increased due to work on computer screens, and advocated a more dynamic approach to light and its use in line with current usage scenarios. With the 'Lighting Design Manual' (1992) and the reference book 'Light Perspectives: Between Culture and Technology' (2009), ERCO once again emphasised the important role of qualitative lighting design. The company introduced the term 'Efficient Visual Comfort' in 2010 – a further impetus to understand lighting as a comprehensive planning strategy. For ERCO, Human Centric Lighting means consistently developing this position further and adapting lighting design even more to the well-being of people and their circadian rhythm.

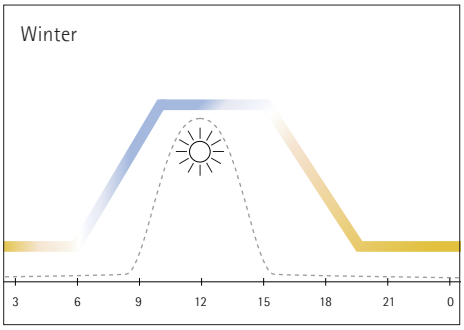
Human Centric Lighting

Which characteristics of light are relevant for the circadian rhythm?

Four aspects of light are among the essential features of non-visual perception: time, brightness, spectrum, and light distribution (Houser et al., 2021). Because these parameters impact the circadian rhythm to different amounts, prioritisation during planning is recommended. We provide some guidance below.

We initially dedicate ourselves to the factor of time, because the different light conditions of day and night are immensely decisive for the inner clock. As people spend most of their time indoors, it is important to synchronise the temporal patterns of daylight, lighting and the inner clock as efficiently as possible. It should be noted in this sense that an orientation to daylight can only be relative, not in absolute values. Age also influences the non-visual effect of light: from the age of 32 onwards, an additional illuminance requirement of around 2% is assumed per year of life to compensate for ageing phenomena such as pupil reduction and clouding (DIN, 2015).





Figs. 2.1 and 2.2: Summer and winter lead to different patterns of natural daylight in many regions. In summer, artificial lighting behaves more or less in line with the natural course of daylight; in winter however, lighting extends the daytime phase. In accordance with the circadian rhythm, a cool colour temperature is recommended for the morning and warm white light for the evening.

Which characteristics of light are relevant for the circadian rhythm?

Brightness and spectrum should next be prioritised. The shorter wavelengths are relevant for the inner clock in order to e.g. influence via the non-visual system the release of the hormone melatonin (Fig. 3), which controls the day-night rhythm of the organism. Whilst in the eye for normal vision the highest light sensitivity (Fig. 4) is 555nm, for non-visual perception this may be 490nm (CIE, 2018; Industry Standards Organization / Commission Internationale de l'Eclairage, 2019).

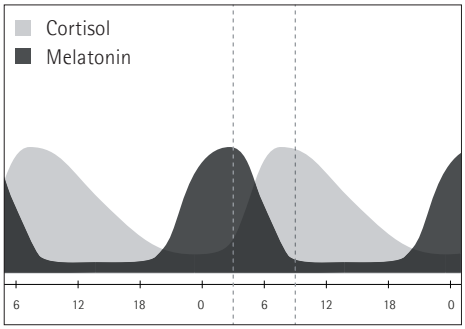


Fig. 3: The hormones cortisol and melatonin have an anti-cyclical effect. In the morning the body produces more cortisol to activate metabolic processes with the concentration in the blood dropping again during the day.
The concentration of melatonin is greatest at 3 am in the morning.

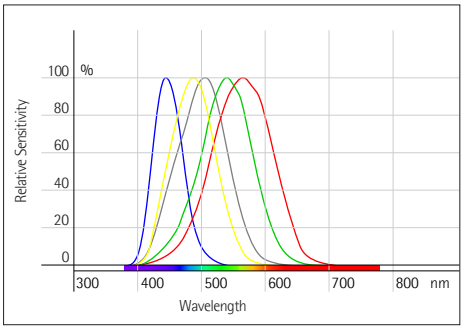


Fig. 4: The light sensitivity of the cones, the rods and the melanopsin-containing ganglion cells differ greatly. For non-visual perception the highest sensitivity is at 490nm.

In a normal working environment the colour rendering is high, and for a fairly neutral white impression the colour temperature is approximately 3000 to 5000K: decisive for non-visual reactions is thus not the colour temperature but illuminance (cf. Houser et al., 2021).

How the spatial distribution of light within the field of vision (Fig. 5) affects non-visual reactions has not yet been investigated in detail. Some research indicates that light is more effective for non-visual reactions in the upper field of vision than in the lower field (Glickman et al., 2003).

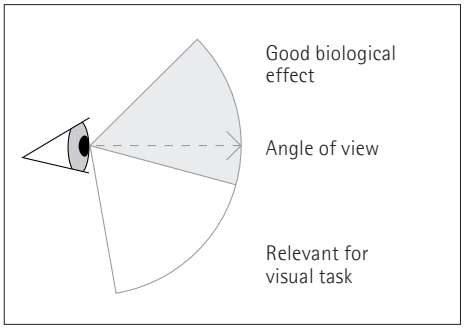


Fig. 5: Since the photoreceptors for biological light effects are predominantly located in the lower region of the retina, the light that is most effective for non-visual perception is that which is incident at approximately -15° to +45° from the horizontal.

Human Centric Lighting is not just tunable white

Human Centric Lighting is characterised not by the individual technical characteristics of a luminaire but by a nuanced approach to the lighting effect. The term 'tunable white' is often used in media as a synonym for Human Centric Lighting. However, this feature applies to only one of the four essential lighting parameters of the holistic planning method. Equipping an entire office floor uniformly with tunable white luminaires ignores the fact that different areas of use require different light distributions. Specific visual tasks must be illuminated, whilst avoiding monotony, a nuanced atmosphere should be created and a sense of structure applied to functional areas within the architecture. Compared to the factor of time, the light spectrum is readily overestimated as a parameter for biological effects.

Human Centric Lighting

AAA – the ERCO approach to Human Centric Lighting

Human Centric Lighting is not a completely new planning approach, because perception-oriented lighting design has been known for a long time. Nevertheless, the question arises as to which method can be used for a suitably efficient lighting solution. Since Human Centric Lighting is a holistic approach, we recommend including the following aspects: architecture – activity – atmosphere. These three phrases can be used to both analyse the project and review the design.

Light for architecture

- Illuminate vertical surfaces:
  Improve spatial perception via uniformly illuminated walls.
- Separate functional areas:
  Illuminate rooms or areas according to their function.
- Emphasise architectural elements:
  Create perceptual hierarchies by e.g. highlighting the supporting structure with accent lighting.
- Observe materials:
  Match the direction of light to the texture of surfaces – grazing light for example emphasises highly textured materials.
- Selection of the mounting location:
  Integrate luminaires into the architecture with the appropriate mounting method, luminaire shape and arrangement.
- Pay attention to visual comfort:
  Opt for high visual comfort using glare-reduced luminaires that trace the structure of the room without glare.

Light for activity

- Adjust the brightness level:
  Create an attractive lighting scene by adjusting the brightness level to the visual task and adjacent areas.
- Avoid glare:
  Use luminaires with good glare control and use correct luminaire arrangements to effectively support users in their visual tasks with glare-free light.
- Consider the time of day:
  Match the illuminance and light colour to the natural light.
- Facilitate facial recognition:
  Support person-to-person communication by achieving harmonious lighting ratios on faces.
- Consider the room functions:
  Plan zoned lighting to respond to different usage requirements.

Light for atmosphere

- Provide spatial orientation:
  Facilitate spatial orientation by highlighting entrances, routes and vertical surfaces with light.
- Create temporal orientation:
  Give a sense of time by mapping the natural course of the day in light scenes.
- Create hierarchies:
  Create perceptual hierarchies by emphasising important areas in the room with focal points of brightness.
- Individual adjustment:
  Allow users to dim light according to personal preferences or switch between light scenes.
- Consider visual comfort:
  Ensure users are not subjected to glare by using glare-controlled luminaires and correct luminaire arrangements.

Human Centric Lighting

Case study: Human Centric Lighting in offices

Since many people spend most of their time indoors during a working day, good lighting is decisive for their well-being and health. With the 'light for architecture, activity and atmosphere' strategy, a holistic lighting design can be developed for offices.

Light for architecture
With uniform wallwashing, walls in the office are emphasised as a whole and thus contribute significantly to the impression of brightness. Bright vertical surfaces create an ideal contrast ratio between screens and the room. An illuminated ceiling gives the architecture additional height.

Light for activity
The zoned lighting of the desks structures the room and provides high visual comfort at the workplace. Mounting on the track allows flexible positioning, individually adapted to the specific use.

Light for atmosphere
Focal points enliven the room and create atmosphere. Contrasts in brightness effectively highlight objects and thus create a hierarchy of perception. In a similar way, projectors in outdoor spaces display the tree as an eye-catcher.

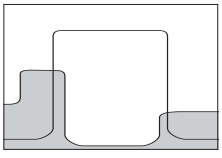
Human Centric Lighting

Case study: Human Centric Lighting in offices

A + A + A

Holistic lighting design as a result of 3 x A

Human Centric Lighting supplements the parameter of light quality with the aspects of health and well-being. The light levels for architecture, activity and atmosphere help to develop a holistic concept. The lighting can thus be adjusted to the needs of the user at any time of day.



Flexible light control
Use sensors and timers to automatically adjust the brightness level of the three light levels according to the course of daylight. This saves energy and creates the right lighting ambience for the time of day, with the additional option of individually adjusting the light.

Checklist for lighting design

- ✓ **Think holistically:**
  Lighting design strategies should support the three aspects of architecture, activities and atmosphere with light.
- ✓ **Light, not luminaires:**
  Develop solutions based on the lighting effect in the respective room and not based on individual luminaires.
- ✓ **Vertical lighting:**
  Focus on the illumination of vertical surfaces before including horizontal lighting in your lighting concept.
- ✓ **Use daylight as a basis:**
  Good orientation is provided by the natural course of the day with its constantly changing brightness and colour temperatures.
- ✓ **Set priorities:**
  Consider the sequence of the lighting parameters in circadian lighting design: time, illuminance, spectrum and light distribution.
- ✓ **Adjust brightness:**
  Brightness during the day and dimmed light in the evening have a positive effect on the inner clock.
- ✓ **Vary the spectrum:**
  Support the circadian rhythm with cool colour temperatures during the day and warm light colours in the evening
- ✓ **Consider the technology:**
  High-tech luminaires are no guarantee for Human Centric Lighting.
- ✓ **Take into account visual comfort:**
  Achieve a high level of visual comfort through correct glare control of the luminaires. Avoid light spill and ensure suitable arrangement of the luminaires to prevent reflected glare.

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