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THE ROLE OF LIGHTING IN ARCHITECTURAL DESIGN

by Erika Baffico

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From the concept of a surface as a solid tool to mark a boundary, a limit, to seal a space, we can transition to the idea of a surface as a repository of light, a luminous instrument to expand space, to open it, not to define it but to allow the gaze to transcend its boundaries, its limits.

Light, coloured lights, lack solidity; they possess an evanescent, uncertain, mobile, and untouchable presence.
The design of uncertain, shifting spaces—psychologically and culturally traversable—perhaps addresses new existential needs.

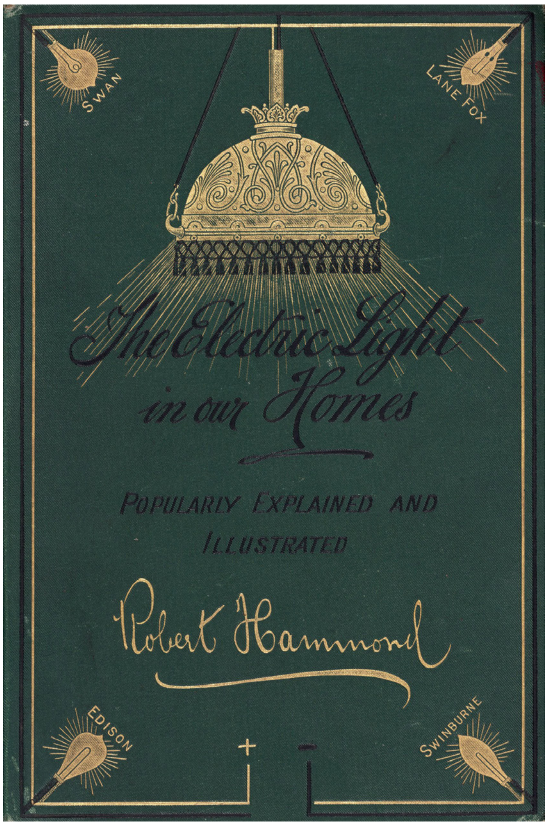
—Ettore Sottsass, in Abet Laminati e Ettore Sottsass,
40 anni di lavoro insieme, Palazzo della Triennale di Milano (2005)

What interests me is the possibility of building space with light even more than with any other material. I am fascinated by how space takes shape depending on where light falls and how this formation is in relation to us.

—James Turrell

IMPORTANCE OF LIGHTING IN ARCHITECTURE AND INTERIOR DESIGN

THE ADVENT OF ELECTRICITY AND THE LOSS OF DARKNESS



For centuries, humans lived according to the sun's cycle, from dawn to dusk, relying on the moon, fire, and later candlelight for illumination during the night. The introduction of the electric light bulb in the late 19th century marked a revolutionary shift, enabling highly focused activities to take place at night and in remote locations. Following the Industrial Revolution, cities became increasingly crowded, and artificial light proved indispensable in adapting to this new way of life.

In just over a century, humanity has entirely emancipated itself from the limitations of natural light. The improvement in energy efficiency of light sources has made it increasingly feasible to replace natural light with artificial lighting in interior design. Traditional sleep-wake cycles have been disrupted, artificial time has superseded natural time, and new uses for spaces and architectural possibilities have emerged. Continuous coverage in professional fields such as healthcare has become possible, enabling round-the-clock operations. Similarly, artificial light has opened pathways to explore remote environments, from underground and underwater activities to space exploration.

Today, the average person spends 90% of their life indoors, exposed to significant amounts of artificial light. However, as often happens, human adaptability to epochal changes occurring over a short time is limited. Scientific research has demonstrated that prolonged confinement in environments with insufficient natural light has a profoundly negative impact on well-being, both psychologically and physiologically. Adverse effects of natural light deprivation include sleep disorders, anxiety, mental health challenges, depression, headaches, fatigue, and social isolation. Stress-related problems caused by extended periods indoors are widespread globally, particularly in densely populated urban areas.

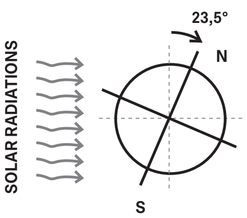
This makes high-quality lighting design essential to creating environments that promote wellness and comfort.

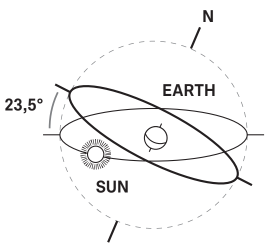
THE VARIABILITY OF NATURAL LIGHT IN SPACE AND TIME

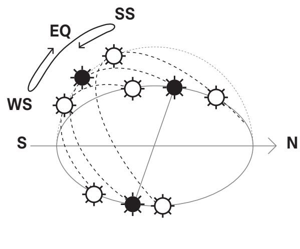
The allure of natural light lies in its constant variability: it shifts in intensity and colour throughout the day, from dawn to dusk, from day to day, season to season, and from one location to another. Scientifically, natural light—part of the visible electromagnetic spectrum emitted by the sun and reaching the Earth—is remarkably changeable in composition and intensity due to the following variables:

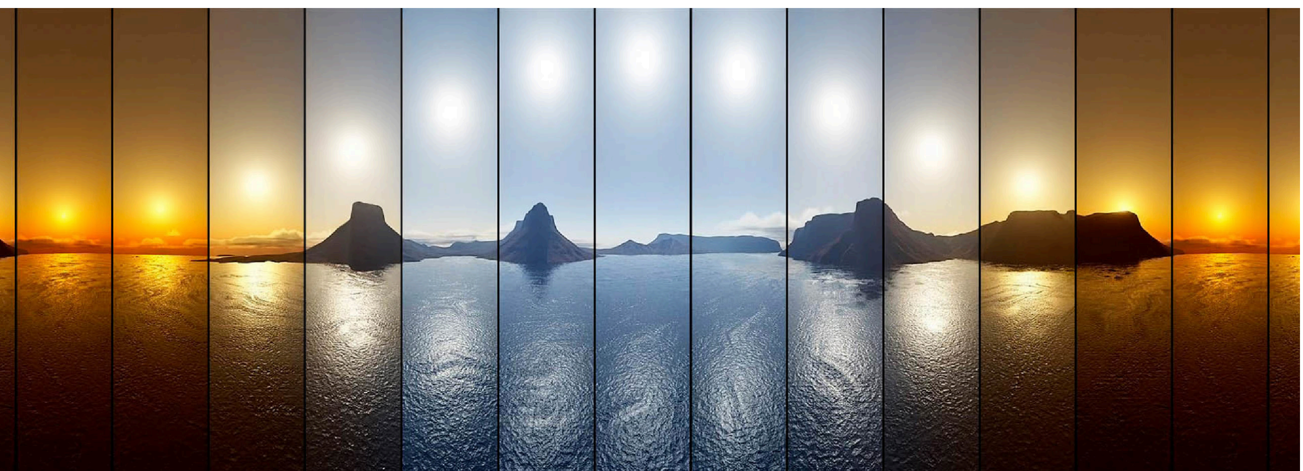
- **Day:** A day is defined by the Earth's rotation on its axis relative to the sun's position (24 hours).
- **Seasons:** The seasons are influenced by the Earth's axial tilt of up to 23 degrees and 27 minutes relative to the plane of the ecliptic (the plane on which the planet orbits). Because of this tilt, the Northern Hemisphere receives maximum solar radiation on the summer solstice (June 21) and minimum radiation on the winter solstice (December 21). This pattern reverses in the Southern Hemisphere, where winter coincides with summer in the north, and spring coincides with autumn. The equinoxes (March 20 and September 22) represent transitional states where sunlight strikes the Earth perpendicularly.
- **Latitude:** Solar radiation conditions change as one moves from the equator to the poles. Near the equator, conditions remain relatively constant year-round. At the poles, extremes occur, with perpetual night in winter and a sun that never sets in summer.
- **Declination:** The sun rises in the east and sets in the west, following a trajectory toward the south in the Northern Hemisphere and toward the north in the Southern Hemisphere. Solar declination determines the sun's altitude along this path, varying with the seasons—lower in winter and higher in summer.
- **Atmosphere:** The atmosphere affects the transmission of sunlight, altering its spectral distribution and colour. These changes depend on atmospheric composition, such as the presence of clouds, fog, or snow, and are influenced by local parameters like air temperature, humidity, and pressure.

In general, the intensity of natural light ranges from a maximum of 100,000 lux under direct summer sunlight at noon to 10,000 lux on an overcast day, and as low as 0.25 lux under moonlight.









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ARCHITECTURE AS AN INTERPRETATION OF LOCAL NATURAL LIGHT SPECIFICITIES

Light is a unique design element, capable of creating awe-inspiring sublime effects while also being an objectively measurable and controllable resource, much like any other material in architecture.

Throughout history, traditional architecture has evolved to maximise the entry of direct sunlight during winter months and shield interiors from the same rays during summer. By adhering to this principle of bioclimatic optimisation, architecture has developed distinctive traits tailored to each geographical region. An immediate example is the dimension of windows in buildings: the size of openings increases with latitude. Natural light, therefore, not only defines the geographical identity of a place but also its cultural essence.

Here are three emblematic examples from European architecture—representative of diverse contexts—that masterfully interpret the specificities of natural light:

In the Mediterranean context, **Carlo Scarpa** utilised dynamic light and strong contrasts to craft dramatic backdrops for the artworks displayed in the extension of the Gipsoteca di Canova in Possagno.

In Northern Europe, **Alvar Aalto** employed soft, uniform, and diffused light to create a serene atmosphere in the Library of Viipuri.

Lastly, in a bold design challenge, **Sverre Fehn** recreated the distinctive quality of Nordic light in a Mediterranean setting with the Nordic Pavilion at the Venice Biennale in 1958.

These examples showcase how the thoughtful interpretation of natural light can become a defining feature of architectural identity, rooted in local environmental and cultural contexts.

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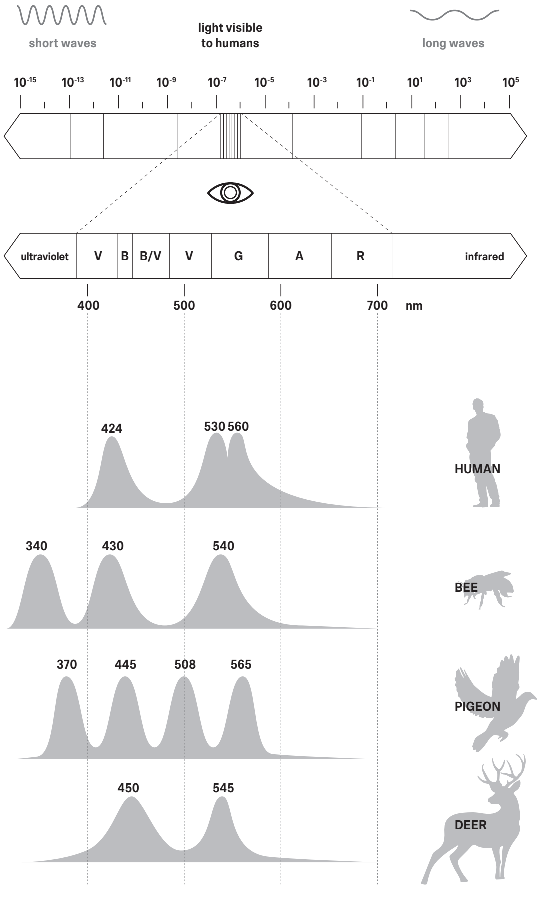
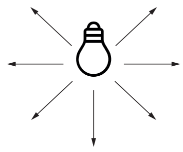
FUNDAMENTALS OF LIGHT AND CIRCADIAN RHYTHM

PHYSICS OF LIGHT

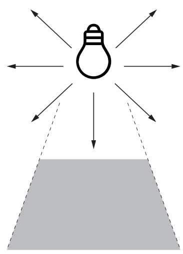
Light is the range of electromagnetic radiation visible to the human eye, with wavelengths between 380 nanometres (short waves) and 760 nanometres (long waves). Each wavelength corresponds to a specific colour in the electromagnetic spectrum: violet around 380 nm, followed by blue, green, a peak of yellow near 550 nm, orange, and finally red around 700 nm. The combination of all these wavelengths results in additive synthesis, perceived as white light.

Visible radiation is only a small part of the electromagnetic spectrum emitted by the sun. Other living beings can perceive wavelengths invisible to humans, such as ultraviolet and infrared. For example, bees see all colours except red, with peaks in blue and ultraviolet frequencies. Pigeons can distinguish millions of colour shades due to a higher number of photoreceptors (cones) in their retinas. Like many herbivores, deer cannot perceive red and their vision peaks in blue and yellow frequencies, creating various shades of green and grey.

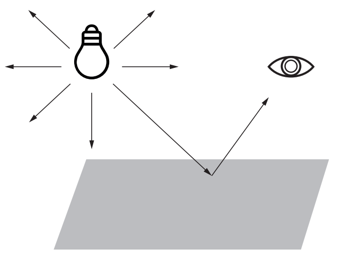




LUMINOUS FLUX



ILLUMINANCE



LUMINANCE

Not all white light is perceived equally, as its composition also affects its tone. **Colour Temperature,** measured in Kelvin (K), represents the temperature of an ideal black body when it emits specific radiation and thus a particular colour:

- **Warm light:** below 3,300 K
- **Neutral light:** between 3,300 K and 5,300 K
- **Cool light:** above 5,300 K

Examples:

- Candlelight: approximately 1,000 K
- Midday sunlight: approximately 4,900 K
- Overcast sky: approximately 7,000 K

Colour Rendering refers to a light source's ability to reproduce colours as faithfully as possible to natural daylight. It is expressed by the CRI (Colour Rendering Index) or Ra, ranging from 50 to 100:

- Excellent: Ra above 90
- Good: Ra between 80 and 90
- Moderate: Ra between 60 and 80
- Poor: Ra below 60

Luminous Flux represents the total amount of light energy emitted by a source per unit of time, measured in lumens (lm).

Illuminance is the luminous flux incident on a surface. Its intensity decreases proportionally to the square of the distance and is measured in lux (lx).

Luminance measures the light reflected from a surface, depending on the surface's colour and nature. Ambient lighting can be controlled through reflected light by using light-coloured surfaces (more reflection) or dark ones (less reflection). It is measured in candelas (cd), representing the ratio between the luminous intensity in a specific direction and the size of the emitting surface.

Examples:

- Direct sunlight: approximately 32,000–100,000 lx
- Office lighting per UNI EN 12464 standards: 500 lx
- Full moon reflection: approximately 1 lx

Applications:

- Precision tasks (e.g., drawing, quality control): 500–1,000 lux
- Common tasks (e.g., reading, screen work): 300–500 lux
- General activities (e.g., orientation, circulation): less than 100 lux

THE HUMAN VISUAL SYSTEM

The retina of the eye contains over a million photosensitive nerve terminals, known as photoreceptors, which convert light signals into bioelectrical signals. These signals are transmitted via the optic nerve to the brain, where they are processed into visual sensations.
There are three types of photoreceptors: cones, rods, and ganglion cells.

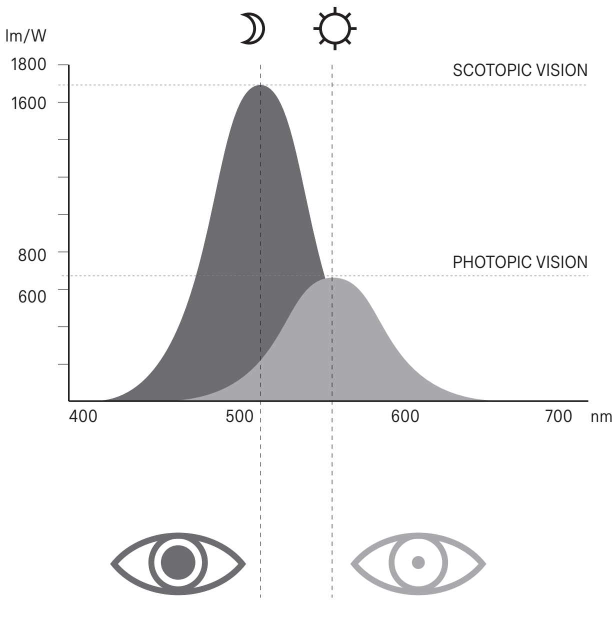
Cones are responsible for daytime, or photopic, vision. They are highly sensitive to colours but less responsive to low light intensities and are primarily located in the central area of the retina. There are three types of cones, each tuned to a specific peak wavelength of light: red (600 nm), green (550 nm), and blue (350 nm). Colourless light perception arises from the balanced stimulation of all three types of cones, while chromatic sensations occur when one or more types are stimulated.

Examples:
- Blue + green cones: perception of cyan
- Green + red cones: perception of yellow
- Blue + red cones: perception of magenta
- Blue + green + red cones: perception of white

Rods enable nighttime, or scotopic, vision. They are extremely sensitive to low light levels, even below 1 lux, and are primarily distributed on the outer edges of the retina. Rods are adept at detecting changes in light levels and motion but do so achromatically.

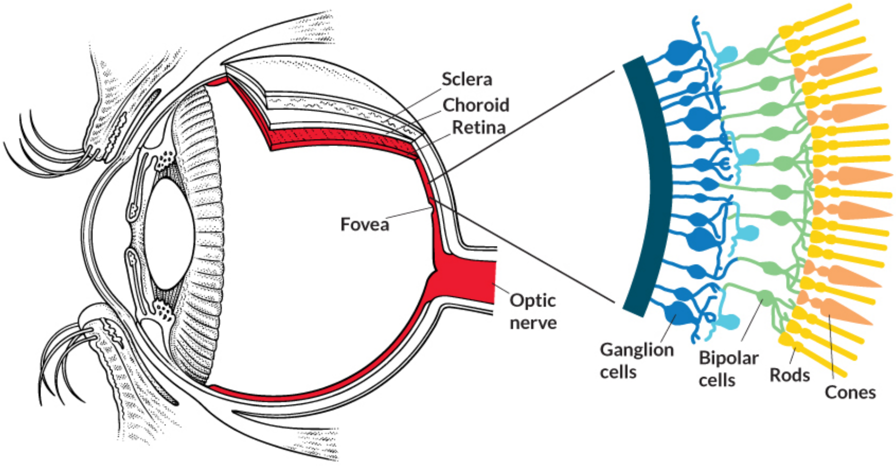
Rods are most sensitive to wavelengths shorter than those perceived by cones. Surface colour also affects this sensitivity; for example, between two equally lit surfaces of different colours, the one closer to 550 nm appears brighter. This explains why red objects, like apples or poppies, are the first to darken in evening light, while green grass remains visible for longer.

The human perceptual system is highly adaptable. The eye adjusts to varying light levels through both the mechanical regulation of the pupil and the activation of photoreceptors. For example, when entering a dark tunnel while driving, the eye takes a few seconds to adapt, just as it does when exiting into bright sunlight. Adaptation occurs faster when transitioning from low to high light levels, as the mechanical action of the pupil is quicker than the photoreceptors' response, though both are highly effective.



NON-VISIBLE EFFECTS OF LIGHT AND CIRCADIAN RHYTHM: DESIGNING FOR WELL-BEING

The third group of photoreceptors consists of retinal ganglion cells, also known as **IpRGCs (Intrinsically Photosensitive Retinal Ganglion Cells).** These cells are not involved in image formation but are responsible for synchronising the **circadian rhythm** (from the Latin circa diem, meaning "about a day"). They transmit external light signals to the **suprachiasmatic nucleus (SCN),** which regulates an endogenous body process called "entrainment" through the release of hormones, including melatonin. When darkness falls, melatonin levels naturally increase, while exposure to light inhibits its release. **Short wavelengths** (commonly referred to as blue light, 460–480 nm) have the greatest impact on ganglion cell sensitivity, suppressing melatonin production. This is why using screens before bedtime is strongly discouraged.

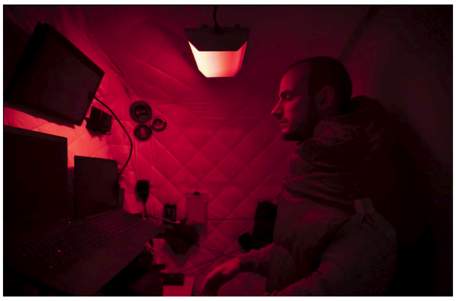


Ganglion cells regulate a wide range of vital functions, including the sleep-wake cycle, body temperature, heart rate, digestion, alertness, mood, and work efficiency. Remarkably, these cells remain functional even in visually impaired individuals.

Life on Earth has always been governed by the natural light cycle, and nearly all organisms exhibit biological rhythms aligned with Earth's rotation period of approximately 24 hours. However, human exposure to artificial light is a relatively new phenomenon in evolutionary terms. Light not only enables vision but also triggers significant **non-visible effects** on psychological and physiological well-being.

This understanding has given rise to concepts such as **human-centric lighting, circadian effectiveness (acv), melanopic efficacy (EML), and biodynamic light.** The goal is to design artificial lighting that not only enhances the visibility of the surrounding environment but also replicates the quality of natural light to improve life quality **(Human-Centric Lighting).** This approach supports human well-being, fostering better relationships, increased productivity, and greater personal satisfaction.

Examples of pioneering projects in this field include the Circadian Light Project by Saga Space Architects. Designed for astronauts in space, it features a lighting device that simulates natural light changes, including weather variations, and was installed on the **International Space Station** in 2023.



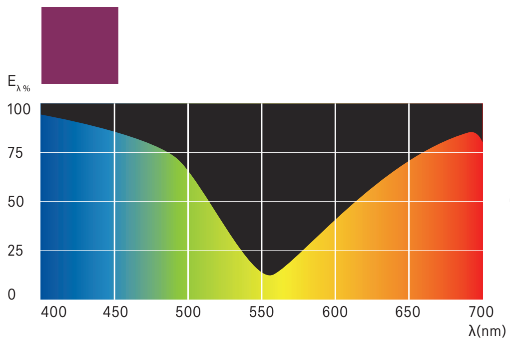
Another notable innovation is the **CoeLux system,** an advanced lighting product that convincingly mimics direct sunlight using a sophisticated optical setup.

THE IMPACT OF MATERIALS ON LIGHT REFLECTION AND ABSORPTION IN RELATION TO HUMAN PERCEPTION

THE PHYSICS OF RE-EMITTED LIGHT

The perceptual paradox of light lies in its necessity to materialise in order to be seen. Thanks to its complex composition, light also alters the perception of the elements it interacts with.

When light strikes an object, a portion of its energy is absorbed while another is re-emitted, depending on the surface's characteristics and its re-emission spectrum.



Spectrum of absolute re-emission of a purple color.

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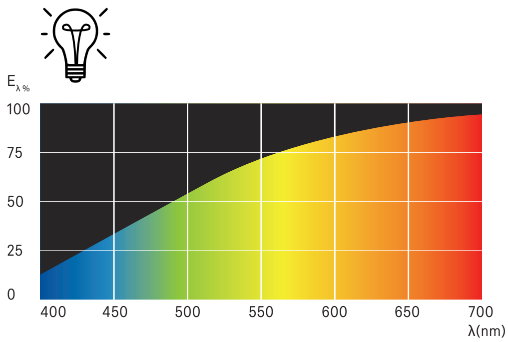

Emission spectrum of an incandescent (tungsten) bulb.

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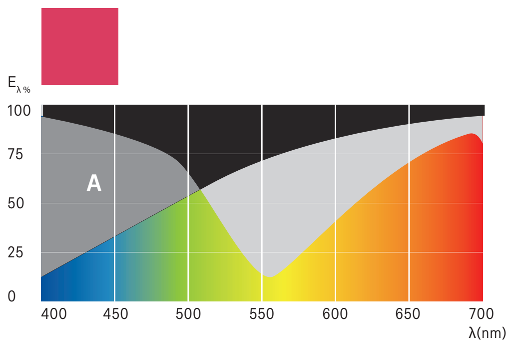


Re-emission spectrum of the purple color, related to the warm light received: the color can not re-emit the amount of energy "A", because it is not present in the emission spectrum.

In absolute terms, **white** surfaces re-emit all received light, **black** absorbs it entirely, and **grey** absorbs part of it. However, in reality, even white surfaces, such as paper, retain some portion of light. Colours are composed of specific re-emission spectra that define the colour we perceive. Under white light, this process is relatively straightforward and intuitive. However, the perception of an object can shift under light sources with different emission spectra.

For instance, food displayed in certain supermarkets with advanced lighting systems illustrates this phenomenon. Meat in display cases is often lit with specific wavelengths that emphasise red tones. At home, when illuminated by cooler light sources, these products appear different. Returning them to sunlight restores some of their original coloration since natural light provides the most comprehensive spectrum.

From a scientific perspective, this occurs because **each colour has a unique absolute re-emission spectrum.** When combined with the specific emission spectrum of the light source, the result is a **relative re-emission spectrum.** The accompanying diagram demonstrates a scenario where a colour cannot re-emit the energy component labelled “A” because this component is absent in the specific light source’s emission spectrum. As a result, the perceived colour changes.

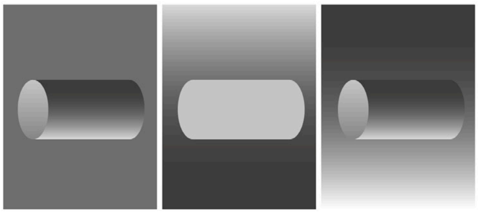
Conversely, **two different colours may appear identical under specific lighting conditions,** despite their distinct spectral compositions. This phenomenon is called **metamerism,** and it happens when the barycentres of their absolute re-emission spectra align on the same dominant wavelength, producing similar visual sensations. These colours, which seem identical under one type of light, can look dramatically different under another.

Modern industry actively seeks to minimise this effect by developing colours with **stable spectral properties,** aiming for a flat and consistent re-emission spectrum across different lighting conditions.

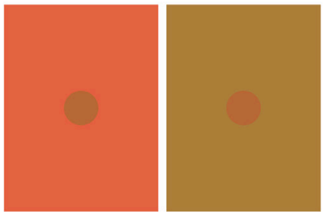
PERCEPTION AND VISION

Vision is a physical and biological process involving the eyes and the visual system, allowing us to detect light and visual information from the surrounding environment. This process enables us to perceive the physical characteristics of the environment, such as colour, shape, size, and position of objects. However, the brain interprets the information received by the eye, and often the perception of space does not correspond to actual space.

Perception is a process that involves interpreting visual information within the broader context of emotional, cultural, and biological experiences. It is closely related to stimuli and their contrasts: light is perceived in contrast to dark, a colour is interpreted in relation to its complementary, and even similar colours can appear different under specific conditions. Every stimulus, without contrast, loses its ability to be perceived.



Perception of three-dimensionality through chiaroscuro

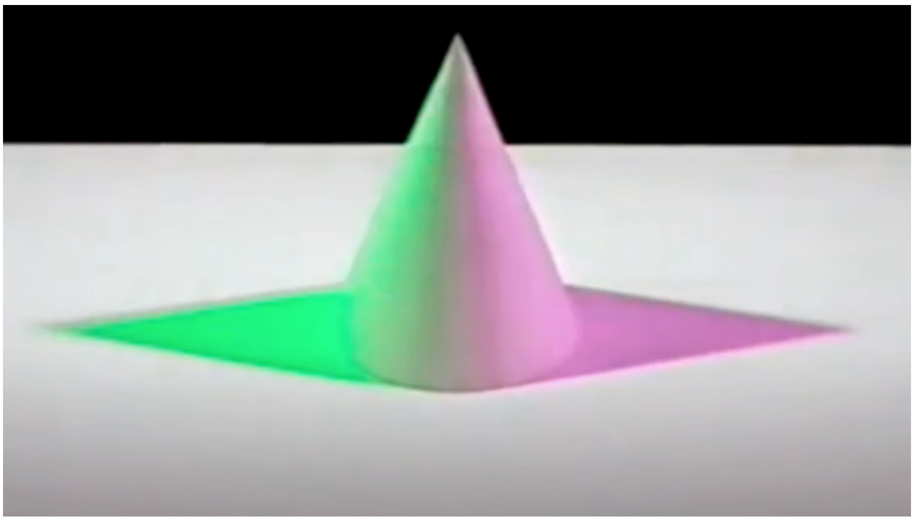


Simultaneous contrast

Thus, vision is never an objective factor but rather an interpretation of elements contextualised within the visual field. This visual or perceptual field can be compared to the frame of a painting or the window through which we observe a landscape. It is scalable, like a Russian doll: the closer we get to an object, the smaller the visual field becomes, and its interpretation changes accordingly.

Common examples of perception include the use of **chiaroscuro** to create an illusory sense of three-dimensionality on a two-dimensional object, and the so-called **simultaneous contrast,** where the same colour appears different depending on the background on which it is perceived.

Regarding the perception of colour, **Johann Wolfgang von Goethe** conducted a very interesting experiment: a cone illuminated by two sources of white light shows their respective grey shadows. Then, a coloured filter is applied to the light source on the left, and the right light source is turned off, leaving only a grey shadow. When the white light on the right side is turned on again, the result is astonishing: our brain interprets the shadow on the right as the complementary colour to green, even though, in reality, it remains a grey shadow.



EXPANDING THE PERCEPTUAL BOUNDARIES OF SPACE THROUGH LIGHTING

Through variations in intensity, colour, and light saturation within a space, the human eye perceives areas of light and shadow and assigns shapes and dimensions to the environment. The interaction between the characteristics of lighting and finishes plays a fundamental role in spatial design. Following are some significant examples that explore the expansion of perceptual boundaries within space through lighting.

The pinnacle of perceptual research, which attributes a fundamental role to light in the visual process for understanding and experiencing space, reaches its highest expression in the works of **James Turrell**. A pioneer in translating the tactile nature of light into tangible form, he is renowned for using the “Ganzfeld effect” to create spaces where the observer is unable to establish landmarks, transforming confined spaces into boundless landscapes. The observer is immersed in a space devoid of visual and acoustic stimuli and is unable to establish points of reference due to the presence of homogeneous light that fills the surfaces of the environment.

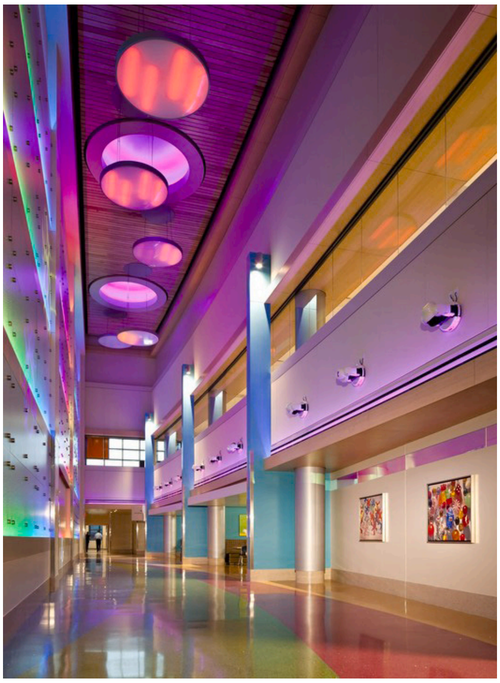
Another notable example is the work of **Jorrit Tornquist**, an Austrian-Italian colour consultant and theorist, who throughout his career has demonstrated how the strategic use of colour can enrich architectural design, helping to create functional and distinctive spaces.

One of his most representative works is the chromatic design for the Brescia waste-to-energy plant, a cutting-edge facility designed to recover energy from urban waste. Located next to the Milan-Venice highway, it required particular attention to its integration into the landscape, also serving as a showcase for the company and the city. The 120-meter tower was designed with a sequence of blue-grey tones that allow it to blend with the surrounding sky, dynamically adapting to varying weather conditions. The colours chosen take into account the predominant luminosity, and even the arrangement of surrounding green areas was planned to create harmonious colour combinations with the buildings, adapting to seasonal changes. This chromatic choice promotes the integration of the structure into the surrounding environment, offering a dynamic and constantly evolving visual experience.

Interior design in spaces where the perception of light continuously changes, evoking the transformation of the natural environment, proves effective in **transit areas.** Airplanes, in particular, as well as train stations and other transit spaces, implement advanced lighting solutions that provide a perception of space distinct from its tangible form.

In long-haul flights, a night-and-day cycle is recreated through luminous hues. Particularly successful examples in this field include the lighting for Island Air, which recreates the Northern Lights, including the movement effect, and Emirates Air, which not only replicates the colours of the sky but also the starry sky. Other notable projects include the designs for Stockholm Central Station and Oslo Train Station, managed by Light Bureau.

Another emblematic case involves healthcare spaces, from patient rooms to diagnostic equipment, where lighting solutions are implemented to create a perception of space that differs from the tangible one, offering a more welcoming and natural atmosphere. It is scientifically proven that the perception of a natural environment has a strong positive impact on patient recovery. Notable projects in this field include the Phoenix Children’s Hospital in Arizona and the Philips Healthcare Spectral CT 7500 diagnostic machine, where patients are exposed to changing and reassuring lighting scenarios.



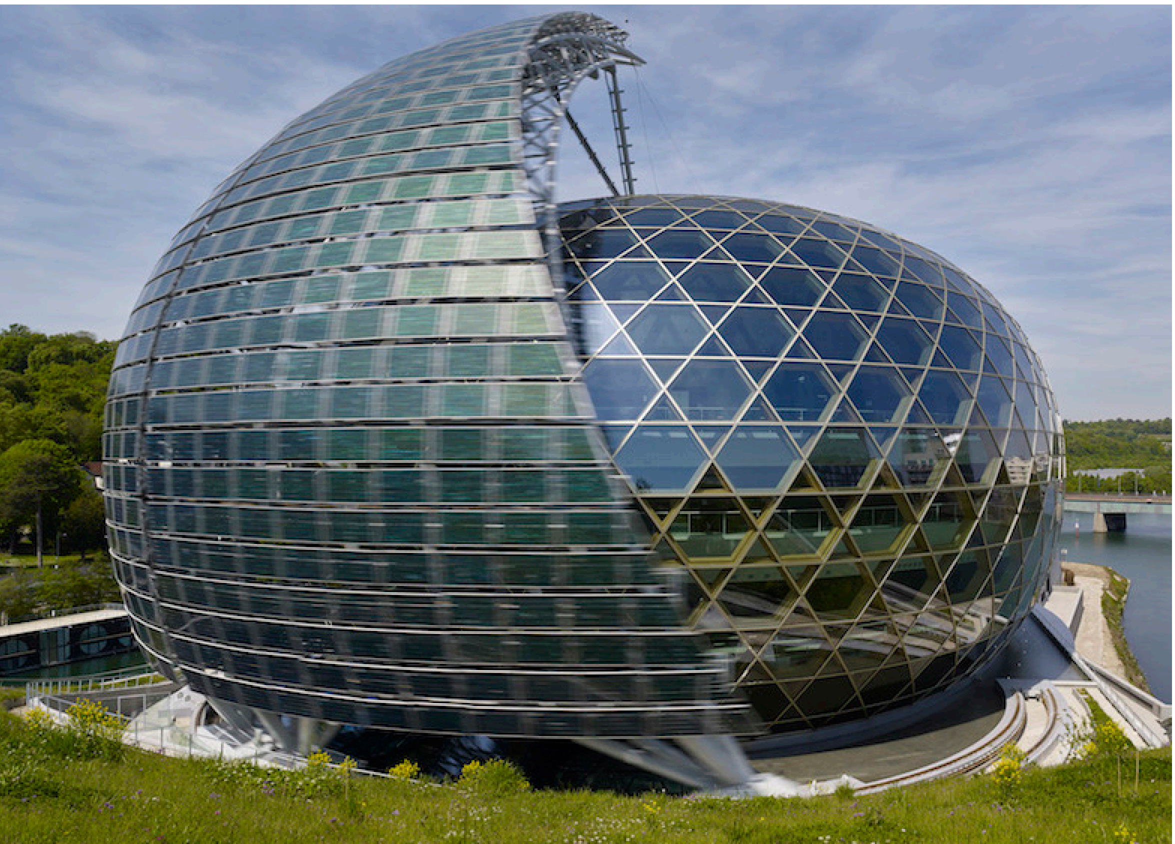
TECHNOLOGICAL INNOVATION AND ENVIRONMENTAL IMPACT OF LIGHTING SOLUTIONS

ENERGY-EFFICIENT LIGHTING STRATEGIES AND SUSTAINABILITY

Energy efficiency is a fundamental pillar in modern lighting design. Low-energy solutions not only reduce operational costs but also help to decrease the environmental footprint of residential, commercial, and public buildings. The rapid development of LED technology has significantly reduced energy consumption, using up to 80% less energy compared to incandescent bulbs, while also extending the lifespan of lighting fixtures. This reduction in energy consumption lowers the need for frequent replacements, minimising waste impact. Additionally, advanced lighting management systems enable precise monitoring and control of energy consumption, allowing for timely interventions to optimise overall efficiency.

When considering the **lighting fixture** itself, critical factors include the selection of products made through sustainable manufacturing processes, using materials that can be reintroduced into the production cycle, and the ability to replace individual components rather than the entire fixture.

In terms of lighting design, one of the most effective strategies is **Daylight Harvesting,** which involves integrating natural light with automated control systems. Intelligent sensors adjust the intensity of artificial lighting based on the amount of natural light available in a space, ensuring a well-lit environment without wastage. This approach is particularly useful in offices with large windows or in commercial spaces, where the amount of natural light varies throughout the day.



In parallel, a strong emphasis on energy efficiency continues to shape lighting design. The use of highly efficient LED technologies is increasingly paired with renewable energy systems, such as solar panels, seamlessly integrated into architectural projects and products.

An exemplary case is **La Seine Musicale** in Paris, where the entire external lighting system is powered by a rotating photovoltaic sail. Designed by Shigeru Ban and Jean de Gastines, the sail tracks the sun's movement to maximise energy generation, while the LED lighting system minimises consumption.

These trends represent the convergence of human-centred innovation and environmental responsibility, paving the way for lighting solutions that enhance both human experience and ecological sustainability.

Designing with sustainability in mind means not only respecting the environment but also responding to regulations in a market that is increasingly focused on these issues. This makes buildings not only more efficient but also more liveable and in harmony with the natural context.

SMART LIGHTING SYSTEMS: IOT, AI INTEGRATION AND REMOTE CONTROLS

Smart lighting represents one of the most significant developments in recent years, transforming architectural environments into dynamic, efficient, and customisable spaces. At the heart of this revolution lies the **Internet of Things** (IoT), which enables lighting fixtures to communicate with one another, with other types of devices, and with users through digital networks. Motion sensors, for example, allow lighting to activate only when necessary, drastically reducing energy consumption. Similarly, environmental sensors can adjust the intensity and colour temperature of the light based on the natural brightness from outside or the user's preferences.

Another tool that can be integrated into lighting management and control systems is the incorporation of **Artificial Intelligence** (AI). Advanced algorithms analyse data collected from sensors to optimise the use of lighting resources in real time, ensuring maximum visual comfort with minimal energy waste. For example, in an office setting, an AI system can predict peak occupancy times and adjust the lighting to provide optimal working conditions while balancing energy savings.

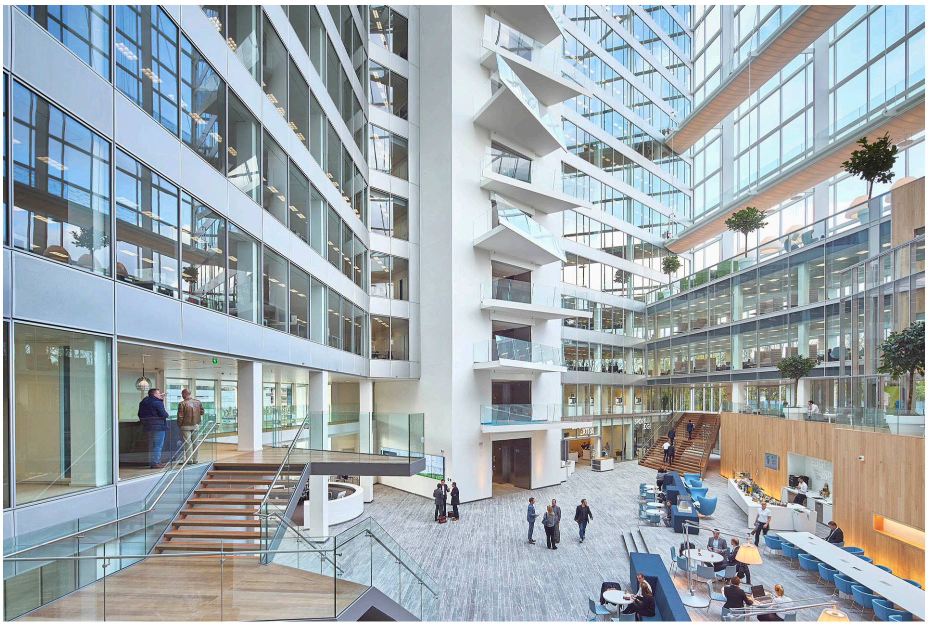
The **control** of these management systems can then be done remotely through mobile apps or centralised software, enabling the efficient management of large buildings in a simple and intuitive manner. This technology, which is already widely adopted in commercial projects, is gaining ground in residential spaces as well, redefining standards for comfort and sustainability.

The parallel development of **nanotechnology** opens the door to advanced home automation and the Quantified Self (Q.S.) movement, allowing intelligent management of lighting systems not only from an energy standpoint. These new technologies enable the control and modulation of effects on the body and mind, interpreting real-time data. The ability to collect and utilise physiological data, which accurately reflects responses to external stimuli without the risk of subjective interpretation, is a previously unknown privilege.

These types of automation are particularly suitable for spaces with long-term occupancy, such as offices or homes, where variable artificial lighting throughout the day helps mimic the natural light transition from morning to evening, effectively synchronising the body's circadian rhythm.

Known as one of the most sustainable buildings in the world, The Edge ad Amsterdam, project of PLP Architecture with lighting solutions by Philips Lighting, it embodies energy efficiency and user-centric illumination. The building employs an advanced network of LED fixtures connected to a digital lighting system powered by IoT technology. Each light is individually addressable and adjusts in real time to daylight levels, occupancy, and user preferences.

Floor-to-ceiling windows maximising daylight penetration, while daylight harvesting sensors optimise artificial lighting usage. This approach significantly reduces energy consumption while maintaining a visually engaging environment. The Edge's lighting design, paired with its energy-efficient systems, earned a BREEAM Outstanding certification, making it one of the greenest and smartest office buildings in the world.



CERTIFICATIONS AND STANDARDS FOR SUSTAINABLE LIGHTING

International certifications are essential benchmarks for designing projects that prioritise both the psychological and physiological well-being of occupants, as well as the energy consumption of lighting systems. Among the most recognised are the WELL Building Standard and LEED (Leadership in Energy and Environmental Design), which ensure that buildings meet strict criteria for energy efficiency and environmental quality.

The **WELL Building Standard** system focuses on the health and well-being of occupants, including specific criteria on lighting. For example, it requires designs to incorporate circadian lighting systems to support users' natural biological rhythm, avoiding excessive exposure to blue light that can negatively affect sleep and overall health. WELL also promotes the use of flicker-free lighting to reduce eye strain.

LEED, on the other hand, evaluates the entire life cycle of a building, rewarding the use of low-energy lighting technologies and the integration of automated control systems. To earn LEED credits, projects must demonstrate a significant reduction in energy consumption compared to baseline standards and the use of renewable energy sources, such as photovoltaic systems for powering the lighting.

Other certifications, such as BREEAM and Green Globes, focus on specific aspects like reducing light pollution and using sustainable materials for lighting fixtures. These standards not only guide design choices toward sustainability but also contribute to increasing the market value of buildings, attracting investors and tenants who are increasingly aware of environmental issues.

Adopting certifications is not only a sign of social responsibility but also a competitive advantage that positions designers and their buildings as leaders in the ecosystem-conscious and wellness-focused design landscape.

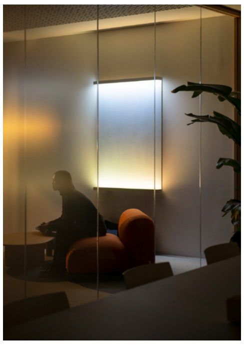
ANTICIPATING FUTURE NEEDS IN LIGHTING FOR EVOLVING SPACES

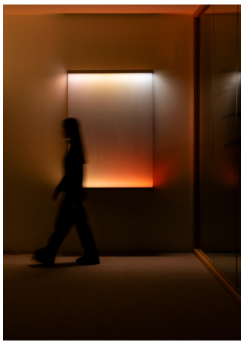
INTEGRATING LIGHTING WITH MATERIALS

It is clear that a successful interior design project is one that harmonises proper lighting with the specific qualities of the materials and finishes within the space. Below are some examples of exemplary design practices in this regard:

- Artificial Light Interacting with Metameric Surfaces
  An example in this field is the innovative system Ora Blu by Erika Baffico (Fulcro Design). The “Ora Blu” lighting device offers a site-specific simulation of the dynamic sky, designed to align with natural biorhythms in confined spaces. This innovative system uses intelligent controls powered by algorithms and AI to adapt site-specific variables, producing consistent yet varied light scenarios. The emitted LED light interacts with a specially formulated wall paint, highly responsive to light variations, giving the surface a mutable, almost “alive” quality.
- Natural Light Interacting with Filtering Surfaces
  A noteworthy example of filtering surfaces is the *Nostra Signora della Misericordia* Church in Baranzate, designed by Mangiarotti, Favini, and Morassutti in 1957. The external walls are made of expanded polystyrene insulation encased in glass panels, which diffuse natural light uniformly throughout the church, creating a soft and serene atmosphere. Similarly, the filtered light in Gothic cathedrals, passing through stained glass windows, casts playful reflections of coloured light onto floors and architectural elements, enriching the spatial experience.
- Interaction with Surface Textures
  Walls and floors naturally interact with light. Textures with varying depths and embossed patterns create striking contrasts and projected shadows. When positioned on vertical surfaces, these features can produce fascinating shifts in appearance throughout the day, as the direction of the light changes.

These examples demonstrate how the thoughtful integration of light with material and texture can elevate interior spaces, creating environments that are both functional and visually compelling.





WHITEPAPER

THE IMPACT OF LIGHT ON FLOORING

Lighting significantly influences the appearance and functionality of flooring. Whether composed of natural or artificial materials, floors interact with light in unique ways, as their characteristics absorb, reflect, or diffuse light differently.

The floor's colour plays a pivotal role in shaping the perceived lighting intensity: darker shades tend to absorb more light, while lighter tones enhance brightness. It is hypothesised that ancient Romans leveraged this principle to illuminate streets at night. For example, in Pompeii, archaeological evidence reveals road surfaces made of large grey stone slabs interspersed with smaller white stones, designed to reflect moonlight or torchlight.

Coloured surfaces can also project their hues as reflected light. An inspiring example comes from the work of artist Liz West, who uses dichroic filters placed on the floor and employs colour bleeding techniques to create unexpected plays of light on walls and ceilings.

White floors, on the other hand, can function as true reflectors. For instance, by positioning ceiling-mounted spotlights aimed downward, the light bounces off the white flooring and returns to the ceiling, creating an almost magical illumination effect.

These examples highlight how flooring, when paired with thoughtfully designed lighting, can become a critical element in the visual and sensory experience of a space.




CURRENT TRENDS IN ARCHITECTURAL AND INTERIOR LIGHTING

Dominant trends in contemporary architectural and interior lighting design reflect an increased focus on psychological and physiological well-being, enabled by advancements in technology for light control and source miniaturisation, alongside a commitment to energy efficiency.

The integration of **Human-Centric Lighting (HCL),** designed to harmonise with natural ecosystems through dynamic lighting systems, is gaining momentum. This approach aims to enhance human well-being by mirroring the natural rhythms of sunlight. HCL is increasingly implemented in offices, hospitals, schools, and residences, utilising systems that adjust colour temperature and light intensity throughout the day to align with circadian cycles.

A landmark project in this field is the Double Dynamic Lighting (DDL) initiative, a collaborative research effort by lighting technology leaders Tridonic, iGuzzini, Fagerhult, Zumtobel, and Aalborg University. DDL introduces a design concept for dynamic indoor lighting that combines natural daylight with artificial light to respond to changing sky conditions.

The electric lighting dynamically adapts in real-time to complement natural daylight, creating more engaging and health-supportive environments. In studies conducted at Aalborg University, participants exposed to DDL over extended periods reported a more comfortable atmosphere, along with improvements in motivation, concentration, and workflow. These findings underline DDL's potential to revolutionise the design of creative workplaces, educational institutions, and health-focused care facilities.

CONCLUSION AND FUTURE CONSIDERATIONS FOR LIGHTING IN DESIGN

The future prospect is to create lighting that not only enhances the surrounding environment but also replicates the quality of natural light indoors. This approach aims to improve quality of life, promoting physical, emotional, and intellectual well-being. By fostering these aspects, lighting can positively influence interpersonal relationships, productivity, and overall satisfaction. Looking ahead, lighting design will increasingly integrate advanced technologies, such as AI and IoT, to create responsive, energy-efficient environments that support both human needs and sustainability. The future of lighting will seamlessly merge human experience with environmental stewardship, nurturing both people and the planet.

WHITEPAPER

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