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INTRODUCTION TO HUMAN CENTRIC LIGHTING

V.Luz - Lighting+Projects is at the forefront of lighting design, and we are excited to share our unique and innovative approach to Human Centric Lighting (HCL). In this document, we will explore the benefits and transformative potential of HCL, highlighting its importance for quality of life and well-being.

In modern life, lighting has transcended its functional role and emerged as a powerful influence on our mood, health, and productivity. We now recognize the undeniable connection between lighting and well-being. Light not only allows us to see the environment but also plays a vital role in regulating our biological clock, known as the circadian rhythm.

By understanding and harnessing the impact of lighting on the body and mind, we can create environments that are not only aesthetically appealing but also promote well-being, productivity, and overall health.

The Definition of Human Centric Lighting

Human Centric Lighting, or HCL, is a relatively recent approach in the field of lighting design that aims to create environments that promote health and well-being through lighting. Based on scientific evidence, HCL balances the visual, emotional, and biological benefits of lighting, emphasizing the role of lighting in human vision, psychology, and physiology. HCL acknowledges that artificial light has a significant impact on our circadian rhythm, emotions, productivity, and overall health. HCL aims to improve quality of life by providing a lighting experience closer to the natural environment.

Circadian Lighting

Circadian Lighting is an essential component of Human Centric Lighting. It is based on an understanding of the circadian rhythm, which influences our sleep, alertness, cognitive performance, and various physiological processes. Circadian Lighting seeks to adjust the light spectrum and intensity throughout the day to synchronize the body's internal clock with the natural cycle of light and darkness.

During the morning and daytime, brighter lighting with a cooler color temperature is preferable to promote alertness and productivity. As the evening approaches, softer lighting with a warmer color temperature is desirable to facilitate relaxation and prepare the body for sleep. Circadian Lighting aims to balance the influence of artificial light on biological rhythms, improving sleep quality, performance, and overall health.

The Importance of HCL in Modern Society

Natural light has played a fundamental role in shaping society throughout history. Our connection to the daily cycle of the sun has influenced our daily routines, sleep-wake patterns, and overall well-being. As we evolved with natural light, our bodies developed a complex system known as the circadian rhythm, which synchronizes our physiological processes with the external environment.

In our modern and fast-paced society, the importance of Human Centric Lighting cannot be underestimated. As we spend more and more time indoors, often exposed to artificial lighting, our biological clocks and overall well-being can be disrupted. HCL offers a transformative solution to this challenge, allowing us to harness the power of light to create healthier and more harmonious environments.

By implementing HCL principles, we can improve productivity, enhance mood, regulate sleep patterns, and have a positive impact on people's physical and mental health.

Human Centric Lighting has the potential to revolutionize our homes, offices, schools, hotels, restaurants, and other spaces, creating healthier and well-being-oriented environments.

THE ILLUMINATION AND THE CIRCADIAN RHYTHM

The first scientific evidence of the emotional and biological effect of light dates back to the 1960s, with experiments conducted in a bunker without natural light to demonstrate how light affects the circadian rhythm (Aschoff, 1965). Since then, many scientific studies have confirmed the significant effect that natural and artificial light have on the circadian rhythm and our health and well-being.

In 2017, the Nobel Prize in Physiology or Medicine was jointly awarded to Jeffrey C. Hall, Michael Rosbash, and Michael W. Young "for their discoveries of molecular mechanisms controlling the circadian rhythm." The biological clock controls metabolism, contributing to the proper functioning of all organs in our body. Light and darkness are the main markers of our circadian rhythms. If we don't use the appropriate light at the right time, the biological clock can become disoriented and stop functioning correctly.

Circadian Rhythm and Its Impact on Health and Well-being

The circadian rhythm is the internal biological clock that regulates various physiological functions in the body, including sleep, hormone secretion, metabolism, and alertness. It is mainly influenced by the daily cycles of light and darkness. When our circadian rhythm is properly aligned, we benefit from optimal health, well-being, and cognitive

performance. However, disruptions to this rhythm, such as irregular sleep patterns or exposure to inadequate lighting, can lead to a range of adverse effects on our physical and mental health.

The Effects of Artificial Lighting on the Circadian Rhythm

Unfortunately, certain types of artificial lighting, especially those with high levels of blue spectrum light, can disrupt our natural circadian rhythm. Artificial light can suppress the production of melatonin, the hormone responsible for regulating sleep and many other health benefits. Exposure to artificial lighting at night can delay the onset of sleep, leading to reduced sleep quality, fatigue, and a range of health problems.

The Effects of Disrupted Circadian Rhythm

When the circadian rhythm is out of sync, various aspects of our health and well-being can be affected. Disrupted sleep patterns can lead to decreased cognitive function, impaired concentration, mood disorders, and an increased risk of chronic diseases such as obesity, diabetes, and cardiovascular disorders. Additionally, individuals who spend a lot of time in environments with inadequate lighting may experience decreased productivity, reduced alertness, and an overall sense of discomfort.

Understanding the profound influence of natural light on the circadian rhythm and overall health provides the basis for understanding the importance of Human Centric Lighting (HCL). By simulating the dynamic qualities of natural light, HCL can help restore and optimize the circadian rhythm, mitigating the adverse effects of artificial lighting. In the following pages, we will explore the scientific principles, benefits, and evidence supporting the effectiveness of HCL, providing insights into how it can positively impact human health, well-being, and productivity.

Key Lighting Characteristics Relevant to the Circadian Rhythm

There are four aspects of light that are essential for non-visual perception: timing, brightness, spectrum, and light distribution (Houser et al., 2021). As these parameters affect the circadian rhythm to varying degrees, it is recommended to prioritize them during the planning of a lighting project. Below, we provide some guidelines.

Firstly, attention should be given to the timing factor as different daylight and nighttime lighting conditions are immensely decisive for the internal clock. As people spend most of their time indoors, it is important to synchronize the temporal patterns of natural light, artificial lighting, and the internal clock as efficiently as possible. Age also influences the non-visual effect of light: from the age of 32, an additional illuminance requirement of about 2% per year of life is assumed to compensate for aging-related phenomena such such as pupil reduction and blurring (DIN, 2015).

Next, priority should be given to brightness and spectrum. Shorter wavelengths are relevant to the internal clock in order to influence, through the non-visual system, the release of melatonin, which controls the body's day-night rhythm. While the eye's highest sensitivity to light for normal vision is at 555nm, for non-visual perception, it can be around 490nm (CIE, 2018; Industry Standards Organization/Commission Internationale de l'Eclairage, 2019).

Choosing lighting products with specific characteristics, such as an RG0 (risk-free) index from the EN62471 standard, which defines the levels of ultraviolet, infrared, and blue radiation emitted by LEDs, is one of the fundamental aspects to ensure that lighting does not harm health and the circadian rhythm.

PROVEN BENEFITS OF HUMAN CENTRIC LIGHTING

Human Centric Lighting has received significant attention in scientific research, with numerous scientists highlighting its extensive benefits. Scientific studies have shown that HCL has various advantages for health, well-being, and productivity.

A study conducted by LightingEurope examined the quantified benefits of Human Centric Lighting, revealing its potential to improve productivity, increase energy levels, alleviate depression, and enhance sleep quality. Additionally, research published in the journal *Frontiers in Neurology* emphasizes how HCL takes into account both the visual and non-visual effects of lighting, promoting positive outcomes for human well-being.

One of the most prominent benefits of HCL highlighted in scientific studies is its ability to regulate the circadian rhythm. As mentioned earlier, disruptions in this natural rhythm have been associated with various health problems, including diabetes, obesity, cancer, and heart disease.

Sleep Quality

Sleep quality plays a crucial role in our health and well-being. During sleep, our body recuperates, repairs, and strengthens itself, preparing us to face the next day with renewed energy. Good sleep quality is essential for the proper functioning of our immune system, cognitive performance, emotional balance, and cardiovascular health.

Sleep deprivation and poor sleep quality can lead to a range of health problems, including chronic fatigue, lack of concentration, weakened immune system, increased risk of cardiovascular diseases, and mood disorders such as anxiety and depression. Human Centric Lighting (HCL) plays an important role in this regard by allowing the

creation of environments with lighting adjusted to the body's natural rhythms, promoting restful sleep.

Mood Enhancement and Emotional State

Light has a profound effect on our emotions and mental well-being. HCL can be customized to provide appropriate lighting conditions that promote positive moods, reduce stress, and alleviate symptoms of disorders such as depression and anxiety. By optimizing light exposure, HCL has the potential to improve mental and emotional well-being.

Increased Productivity and Performance

Proper lighting is essential for cognitive performance and productivity. Human Centric Lighting offers the appropriate lighting conditions to support concentration, focus, and task performance. By providing lighting that aligns with the natural progression of daylight, HCL can improve alertness, reduce fatigue, and enhance cognitive functions such as memory, attention, and problem-solving.

Furthermore, HCL presents significant benefits for night shift workers who often face challenges due to working during nighttime hours. With Human Centric Lighting, companies can help employees adjust to these unique working conditions, resulting in improved performance, high comfort levels, and increased job satisfaction. A study conducted by the International Labour Organization demonstrated that better lighting in factories led to a notable 10% increase in productivity and a substantial 30% reduction in errors.

Moreover, appropriate lighting design can effectively combat fatigue associated with repetitive tasks. By providing a stimulating and comfortable work environment, HCL contributes to creating a pleasant and productive atmosphere for employees in various sectors.

Health and Well-being

Lighting has a significant impact on our physical health. Human Centric Lighting takes into account the biological effects of light on various physiological processes, including hormonal regulation, immune function, and metabolism. By providing appropriate lighting conditions, HCL can help improve overall health, increase energy levels, and contribute to a healthier lifestyle.

Human Centric Lighting has shown promising results in improving the quality of life for specific populations, such as the elderly, individuals with neurological disorders, and people with Seasonal Affective Disorder (SAD). By adapting lighting conditions to their specific needs, Human Centric Lighting can provide these individuals with a better quality of life.

Several scientific studies confirm that incorporating an HCL system, for example, in hospitals, clinics, and nursing homes, can benefit patients with improved sleep quality, reduced average hospital stay, reduced perception of pain, faster recovery and an overall sense of well-being. Additionally, Human Centric Lighting can help regulate the circadian rhythm of healthcare professionals, reducing fatigue and improving their performance.

Visual Comfort and Eye Health

Proper lighting design is crucial for visual comfort and maintaining eye health. HCL ensures that lighting is balanced, reducing glare and visual fatigue. By considering factors such as light intensity, color temperature, and Unified Glare Rating (UGR), HCL can create visually comfortable environments that promote eye health and prevent headaches.

Human Centric Lighting has been extensively studied and scientifically proven to offer numerous benefits for health, well-being, productivity, and visual comfort. By incorporating HCL principles into lighting design and environments, individuals can

experience improved sleep, enhanced mood, increased productivity, and overall better quality of life.

It's important to note that these benefits are supported by scientific research and studies, indicating the potential of Human Centric Lighting to positively impact various aspects of human well-being.

ENERGY EFFICIENCY AND ENVIRONMENTAL SUSTAINABILITY

Energy efficiency, environmental sustainability, and cost reduction are crucial considerations in implementing a lighting project. HCL not only improves well-being but also offers significant advantages in terms of energy conservation, environmental impact, and cost reduction.

HCL incorporates advanced lighting technologies such as high-energy-efficient LED lighting. LEDs consume significantly less energy compared to traditional lighting sources, and choosing high-energy-efficient LEDs can result in even greater savings in energy costs.

Furthermore, HCL allows for the integration of intelligent lighting control systems, such as twilight sensors, which further enhance energy efficiency by adjusting lighting levels based on natural light availability. An additional option of such systems is the ability to tailor lighting to individual needs, optimizing energy consumption.

By implementing HCL, organizations contribute to a greener future by reducing their carbon footprint through more sustainable lighting practices.

Cost Reduction

HCL offers significant cost reduction opportunities for organizations. In addition to the potential for reducing energy costs, some HCL systems have a longer lifespan, reducing maintenance and replacement costs over time. Choosing high-quality and efficient products in HCL projects is crucial to achieve long-term cost reduction.

THE EVOLUTION OF LIGHTING DESIGN

The belief that good lighting design places people at the center existed before the term Human Centric Lighting. As early as the 1950s, American lighting designer Richard Kelly distinguished three types of lighting: ambient lighting, focal glow, and play of brilliants. He focused on vision for activities but also included the well-being of architecture (Kelly, 1952).

About 20 years later, architect William M.C. Lam expanded the approach and postulated a more detailed analysis of visual tasks based on location, type, and frequency (Lam, 1977). He believed that the unconscious needs of humans could be addressed through good lighting design.

The research findings of Brainard, Berson, and Thapan on photoreceptors and the circadian rhythm in the early 2000s scientifically confirmed the relevance of time factor in lighting design.

Human Centric Lighting, with its holistic approach, takes into consideration the visual, emotional, and biological aspects of lighting design more comprehensively. Biologically effective lighting can be designed, for example, using the DIN SPEC 67600 standard. Lighting also plays a crucial role in certifying buildings for health and well-being (DIN, 2013; International WELL Building Institute, 2021).

Human Centric Lighting is an ever-evolving concept, and V.Luz - Lighting+Projects, with over 45 years of experience in the lighting industry, aims to contribute to this evolution. Therefore, we have developed an innovative methodology based on HCL that expands its benefits.

OUR APPROACH TO HUMAN CENTRIC LIGHTING

At V.Luz - Lighting+Projects, we go beyond lighting for spaces; we create lighting for people. We have developed a unique lighting design concept based on Human Centric Lighting, taking Human-Centered Lighting to the next level!

Our lighting system, BioLighting Technology™, combines HCL with specific lighting products and principles and techniques of phototherapy, chromotherapy, and neuromarketing. We offer a comprehensive and unique lighting design that adds even more advantages to Human Centric Lighting.

Our goal is to provide individuals, businesses, and communities with a multidimensional lighting experience that respects the needs and objectives of each client.

The Essential Elements of BioLighting Technology™

Professional lighting design service

Our approach to lighting design service is based on best practices and supported by lighting calculation programs (Dialux). We integrate the principles of human-centered lighting into our lighting design services, with a focus on promoting well-being, productivity, and regulating the circadian rhythm. Our lighting solutions are meticulously designed to improve health, occupant well-being, and energy efficiency.

Phototherapy

Phototherapy, the therapeutic use of light, has been recognized for its beneficial effects on health and well-being. For example, phototherapy has shown promising results in the prevention and treatment of Seasonal Affective Disorder (SAD), a type of depression that typically occurs during winter months when natural sunlight is limited. We integrate the therapeutic benefits of light to optimize mental and physical well-being. Through careful selection of light spectrums, intensities, and durations, we harness the beneficial properties of light, promoting relaxation, stress and anxiety reduction, mood improvement, and prevention of depressive states.

Chromotherapy

Our lighting methodology utilizes the psychology of colors to create immersive and transformative experiences. By strategically incorporating specific colors, we stimulate desired emotional responses, increase creativity, enhance psychological well-being, and cultivate an environment that supports specific activities or moods.

Neuromarketing

Neuromarketing, a field that combines neuroscience, psychology, and marketing, has revolutionized how brands connect with their target audience. By understanding cognitive and emotional responses of consumers, companies can create impactful experiences on a deeper level. With BioLighting Technology™, we can subtly influence perception and human behavior through lighting, adapting each lighting project to evoke desired emotions, enhance brand identity, and create lasting impressions on consumers. For example, in a retail space, we can use lighting techniques that draw attention to specific products and encourage purchasing decisions. By integrating neuromarketing into our lighting projects, we empower companies to connect with their customers on a deeper level, stimulating engagement and loyalty.

Personalization and Brand Integration

We value the importance of personalization and brand cohesion. With our lighting design experts and a variety of customizable lighting products, we can tailor lighting solutions to align with the unique vision, identity, and goals of each project. Whether it's a hotel, office, or store, we ensure seamless integration of lighting design with brand image and the desired experience.

Our Products

To implement lighting projects with BioLighting Technology™, specific technical features are required. That's why we have developed lighting products with cutting-edge technology and high energy efficiency. Manufactured in Portugal under the strictest quality controls, our products offer a unique design and exceptional durability.

RETURN ON INVESTMENT (ROI)

Return on Investment (ROI) is a critical factor in determining the feasibility and success of implementing a project with BioLighting Technology™, based on Human Centric Lighting. While the long-term financial benefits and cost savings of HCL have been widely recognized, it is equally important to consider the advantages for clients and employees in terms of ROI. Furthermore, exploring the marketing benefits that BioLighting Technology™ can provide from an ROI perspective is essential.

Financial Benefits

Implementing projects with this technology brings various financial benefits that contribute to ROI. This includes energy savings through the use of efficient lighting solutions such as LED technology and the implementation of lighting control systems that optimize energy consumption. By quantifying the reduction in energy costs and comparing it with the investment in HCL technologies, organizations can determine the financial gains achieved through energy efficiency.

Long-Term Cost Savings and Sustainability Advantages

In addition to immediate financial benefits, it provides long-term cost savings and advantages in terms of environmental sustainability. HCL systems often have a longer lifespan, reducing maintenance and replacement costs. By considering this extended lifespan, organizations can estimate cost savings over time. Moreover, implementing HCL aligns with sustainability goals, reduces carbon emissions, and promotes energy savings. These sustainability advantages not only contribute to environmental preservation but can also result in cost savings through incentives, subsidies, and reduced energy bills.

Benefits for Clients and Employees from an ROI Perspective

Clients experience improved comfort, well-being, and satisfaction through lighting environments that meet their physiological and emotional needs. This translates into increased customer loyalty, positive word-of-mouth recommendations, and increased profit potential. Similarly, employees benefit from the implementation of BioLighting Technology™ as it positively affects their productivity, mood, and overall job satisfaction. Increased productivity, reduced absenteeism, and improved employee retention contribute to business success.

Marketing Benefits from an ROI Perspective

By highlighting the integration of BioLighting Technology™ and Human Centric Lighting principles, organizations can differentiate themselves in the market. The ability to create visually appealing and welcoming spaces that prioritize customer well-being attracts health-conscious individuals and sets the organization apart from competitors. Utilizing BioLighting Technology™ adds value and demonstrates a commitment to customer satisfaction, resulting in increased brand reputation and market positioning.

Return on Investment (ROI) is a fundamental consideration in implementing a lighting project. The financial benefits of BioLighting Technology™, including energy savings and reduced maintenance costs, contribute to operational efficiency and a highly positive cost-benefit ratio. Additionally, the benefits for clients and employees, such as comfort, satisfaction, and productivity, further strengthen the ROI proposition.

CONCLUSION

With BioLighting Technology™ and Human Centric Lighting, we can revolutionize the way we design and experience spaces. By integrating HCL principles, we can create environments that are not only aesthetically pleasing but also support the biological and psychological needs of space users.

We invite readers to imagine a future where lighting goes beyond mere functionality and aesthetics and becomes an integral part of our well-being. With our concept of lighting based on Human Centric Lighting, we can create healthier and more beneficial environments that inspire and elevate the human experience.