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Review

LpR 102

Mar/Apr 2024

LIGHT + BUILDING POST-SHOW REPORTS AND INTERVIEWS

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VERTICAL FARMING

IMPACT OF LEDS ON
GLOBAL WARMING

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NEWS, TRENDS
& HIGHLIGHTS



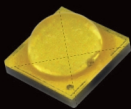
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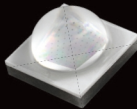
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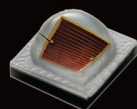
Cree LED XLamp® S Line Portfolio



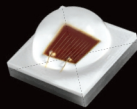
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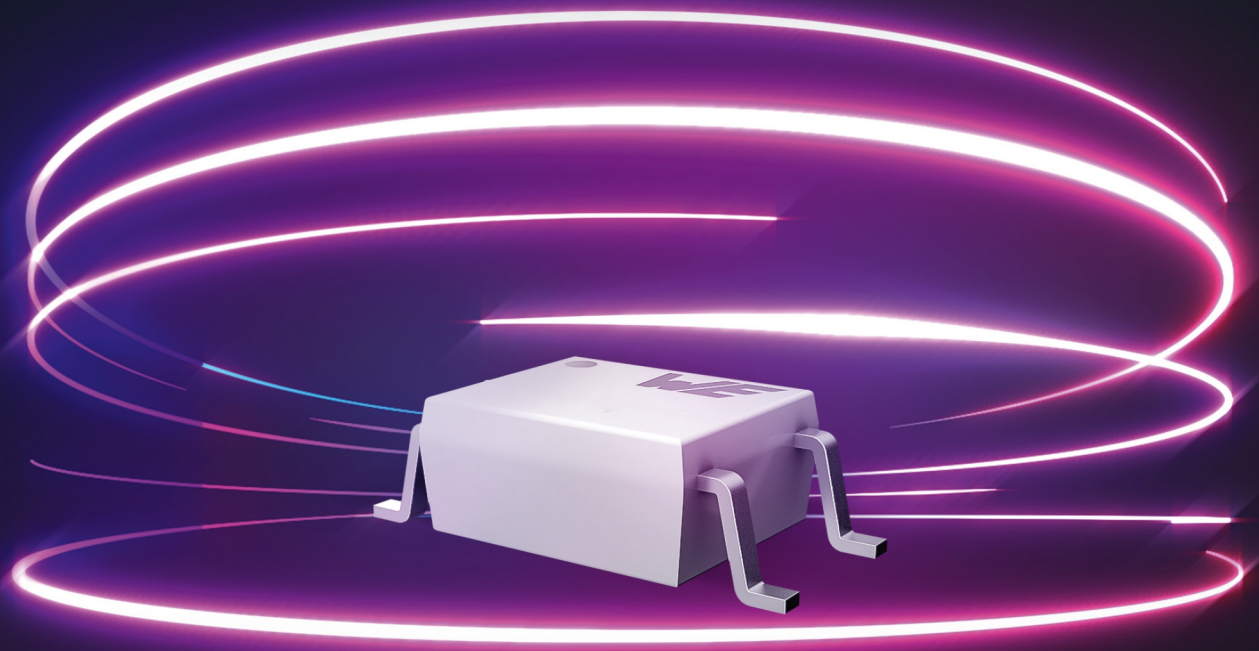
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Highlights

- Innovative coplanar design
- High grade silicon encapsulation
- Copper leadframe for high reliability
- Stable CTR over whole temperature range
- High CTR in low current operation



DIP-4



SOP-4



LSOP-4

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Exploring the New Era of Responsible Lighting



Light + Building was a fantastic event, and it was brilliant meeting so many friends and acquaintances in person again and many others for the first time. We focused on the highlights, innovations, and news in Frankfurt, with the intention of uncovering some highlights for you, dear readers. They are included both in the news section and in interviews with key figures from the lighting world.

A special thanks to all our conversation partners!

Beyond Light + Building, we are excited to present other outstanding articles. These include near-infrared lighting, the new initiative for circadian tools, the intriguing topic of free-form optics in automotive applications, the impact of the lighting world on global warming, the life-cycle assessment tool, cloud-based control systems, and lighting simulations.

A concise summarization of the observed general trends can be outlined using key terms such as Sustainability, Miniaturization, Modularity, Controllability, IoT, Wireless, Cloud-based Systems, Light Quality, Human Centric Lighting, Acoustics, or perhaps the overall term: "Responsible Lighting".

By and large, this edition serves as a compact source of knowledge that will introduce you to some new aspects of the lighting world.

Enjoy your read!

Yours Sincerely,

A blue ink handwritten signature of Siegfried Luger, consisting of a stylized 'S' followed by 'L' and 'U'.

Siegfried Luger

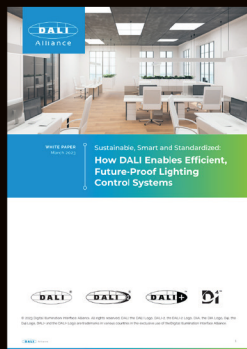
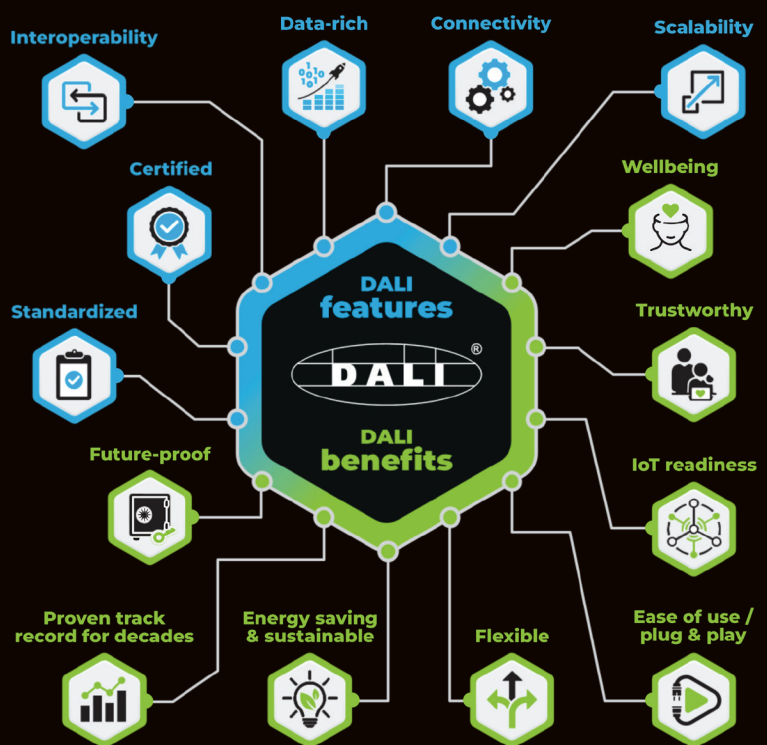
Luger Research e.U., Founder & CEO
LED professional, Trends in Lighting, LpS Digital & Global Lighting Directory
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How DALI Enables Efficient, Future-Proof Lighting Control Systems

Designers, architects and building owners must consider a wide range of lighting-related issues, including sustainability, the circular economy, energy consumption, data and analytics.

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Whatever the lighting system's requirements, standardization with DALI can deliver an efficient, flexible, sustainable and cost-effective solution.



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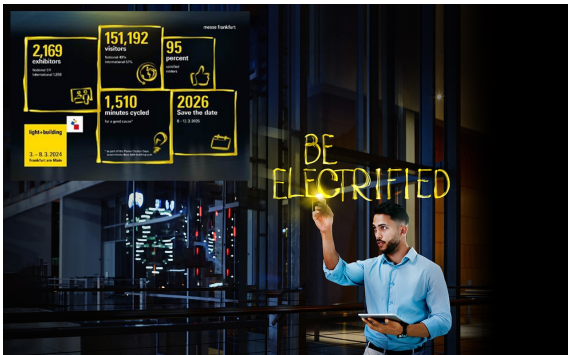
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light+building

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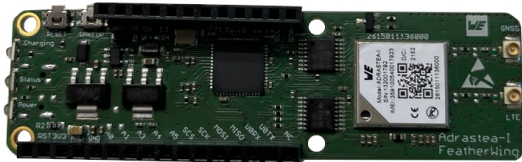
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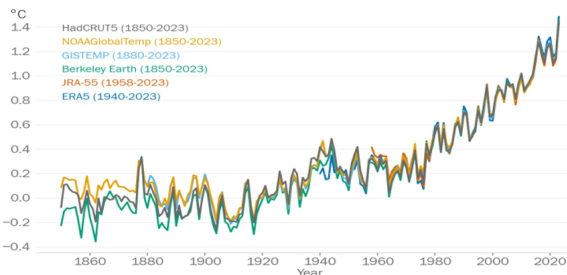
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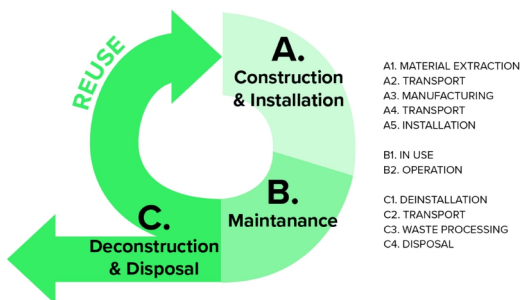
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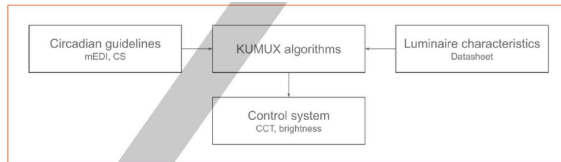
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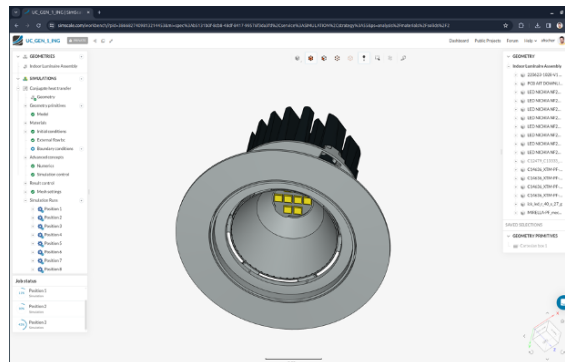
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Dr. Anne BERENDS

Dr. Anne Berends is Program Director of Life Science at Seaborough. Initially focused on developing luminescent materials for LEDs, her interest evolved to exploring light's biological effects. Currently, she delves into near-infrared light's impact on health and well-being, aiming to integrate these proven health benefits into consumer products. As Program Director, Anne drives both the scientific research and business strategy, while actively contributing to product development and marketing activities. Her journey from materials scientist to visionary leader showcases her ability to bridge academic research with real-world applications, exemplified by her significant contributions to scientific publications and patents.

Light Enhances Our Lives

The lighting industry, historically celebrated for its contributions to reducing energy consumption, now seems hesitant as it edges towards paradigm shift. The introduction of energy-efficient lighting based on LEDs, marked a significant milestone. Yet, as we navigate through an era of increased price pressure, the industry's narrative is ripe for a new chapter—one that moves beyond mere energy efficiency for a lower price to encompass the broader, more profound impact of lighting on human health and well-being.

Enter the concept of human-centric lighting (HCL). This emerging perspective has its roots in the discovery of intrinsically photosensitive Retinal Ganglion Cells (ipRGCs). These cells, sensitive to visible light peaking at 480 nm, play a crucial role in regulating our circadian rhythms, affecting everything from our sleep patterns to our overall health. Yet, despite the considerable research advancements and large coverage of the topic within scientific conferences, HCL remains notably underrepresented in the market. At trade shows like Light + Building or LEDucation, products embodying these human centric principles are still considered niche products. Additionally, the term HCL suffered from inflation as basic dimmable or CCT tunable lamps without circadian or other health effects are labelled human centric too. These observations underscore an unfortunate disconnect between scientific research and real-world application. Moreover, the potential benefits of non-visible near-infrared light, a frontier of scientific study, are not incorporated in current product offerings.

The slow adoption of 'true' HCL and the broader integration of scientific insights into the lighting industry's mainstream offerings raise questions about the industry's agility and ability to innovate. At the same time, while many lighting designers at Light + Building seemed eager to implement the newest technological insights related to health and well-being, extensive adoption of these innovations lags behind. The challenge isn't solely technological but

also conceptual—shifting the industry's value proposition and the public's perception from the traditional metrics of energy efficiency to the nuanced, yet impactful, domain of light quality and its effects on human health and well-being.

"The challenge isn't solely technological."

DR. ANNE BERENDS

Several factors contribute to this inertia. Firstly, the lighting industry's established value proposition—energy savings—remains a compelling sell, especially in an era of environmental awareness and sustainability goals. Secondly, the benefits of HCL, while significant, are harder to quantify and communicate to a lay audience, unlike the straightforward metrics of energy consumption and cost savings. Lastly, the regulatory and standards landscape has yet to fully catch up with these advances, leaving a gap between innovation and implementation.

Despite these challenges, the potential of human-centric lighting in the broadest sense, as a driver of health, well-being, and even productivity is too significant to ignore. The industry must therefore pivot, championing education and awareness to bridge the gap between scientific discovery and commercial application. Lighting manufacturers, along with lighting designers, academia and regulatory bodies, must embark on a joint effort to educate the public about the profound benefits of healthy lighting. Manufacturers need to innovate boldly, integrating the latest scientific insights into their products, while policymakers and standards organizations should facilitate this transition through supportive regulations and guidelines. Together, we can illuminate a path forward that prioritizes human health and well-being, redefining the value of light in our lives: Light enhances our lives. ■

A.B.

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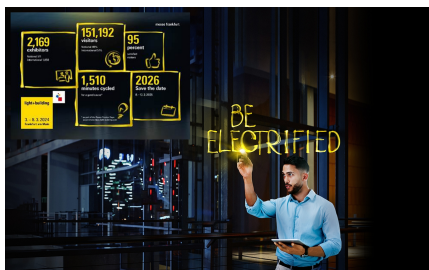
light+building

FAIR & PRODUCT HIGHLIGHTS

Light + Building

www.light-building.messefrankfurt.com

The modern building is intelligent, connected, and as a result saves energy. In combination with alternative energy sources and efficient lighting solutions, emissions in the building sector can be drastically reduced. This makes a significant contribution to achieving climate targets. 2,169 exhibitors presented the latest developments in building technology and trends in innovative lighting design at Light + Building in Frankfurt am Main from 3 to 8 March 2024. Over 151,000 visitors travelled to the world's leading trade fair for lighting and building-services technology.



“The atmosphere at the exhibitors’ booths, in the halls and throughout the exhibition grounds was simply fantastic. We are extremely pleased that so many exhibitors and visitors, as well as our long-standing partners, have continued the success story of the world’s leading trade fair for lighting and building-services technology in 2024,” summarizes Wolfgang Marzin, President and Chief Executive Officer of Messe Frankfurt. He added: “With the switch to renewable energy sources, greater efficiency and sustainability in buildings, the industry has key goals on its agenda. That’s why they used the platform intensively, especially in the first few days, to present and discover innovations and drive forward key topics. After all, if we want to achieve the climate protection goals, the building sector is an essential milestone. It is unfortunate that the rail and air transport strikes affected Messe Frankfurt’s third leading international event since the beginning of the year.”

Buildings of tomorrow and inspiring lighting solutions: Key topics were the electrification and digitalization of homes and buildings in order to reduce emissions and reuse raw materials. At Light + Building, the industry presented the digital and electrotechnical infrastructure for this and, on this basis, showcased solutions for dynamic power control, energy storage systems and applications for connected security. One

growing area is the range of e-mobility and charging infrastructure as well as innovations and products for decentralized energy supply systems and components.

Light plays an important role in the architecture of tomorrow. At Light + Building 2024, 65 per cent of exhibitors belonged to this sector. They presented high-quality lighting solutions for indoor and outdoor areas as well as dynamic room concepts. Modern LED installations ensure contemporary efficiency and either blend harmoniously into the architecture or emphasize the design elements. Lighting is to provide maximum visual comfort in all living and working environments. Thanks to the materials used, Acoustic Lighting combines a pleasant lighting atmosphere with sound-absorbing functions. Sustainability plays an essential role in both the materials used and the manufacturing processes. Many manufacturers design luminaires in a way that the raw materials used can be recycled at the end of their useful life.

“151,192 visitors from 146 countries.”

Light + Building 2024 in figures: The high-quality, extensive and international portfolio of lighting and building-services technology impressed the visitors. 95 per cent of them were extremely satisfied with what was on display and stated that they had achieved 93 per cent of their trade fair attendance targets. The most came to the innovation meeting point from Germany, China, Italy, the Netherlands, France, Switzerland, Belgium, Austria, the UK, Spain and Poland. They came from a total of 146 countries including, for example, India, the USA, the United Arab Emirates, Australia, Brazil and Singapore. The degree of internationality was thus 51 per cent. The level of internationality among the 2,169 exhibitors was also high at 76 per cent.

Meeting place for the social media community: The social media community also found its home at Light + Building. On 3 and 4 March, the leading content creators in the lighting and building-services technology sector gathered for the Power Creator Days. In addition to live podcasts, expert talks and case studies, visitors had the chance to pedal for a good cause and work together towards a high energy target. A total of 1,510 minutes were cycled on the six fitness bikes. The sponsors will convert the result into a cash donation for the Leberecht Foundation, which Messe Frankfurt will double. The exact amount will be announced on social media further to Light + Building.

The next Light + Building will take place from 8 to 13 March 2026 in Frankfurt am Main. ■

LightingEurope

www.lightingeurope.org

The event ‘From the EU Green Deal to the LightingEurope Strategy 2030’ took place at the Light + Building fair in Frankfurt. One hundred people attended and there was an intense discussion on the enforcement of sustainability rules specifically applicable to lighting products.



LightingEurope meeting at Light + Building.

Despite the very high level of non-compliant lighting products on the EU market (see <https://bit.ly/49ITzJq> the results of the mystery shopping exercise), the speakers said that there are possible ways to change the current situation.

Speakers: Holger Dickert (Hessen State), Ronald Piers de Raveschoot (DG ENER), Tanguy Griffon (Sonepar), Sylvia Maurer (BEUC - The European Consumer Organization), Marieke Hoffmann (Deutsche Umwelthilfe), Marc Guiraud (EucoLight), Kevan Shaw (International Association of Lighting Designers (IALD), Teresa Selvaggio and Alfredo Menghini (both from LightingEurope). All presentations are available on our website <https://bit.ly/3v4AeU0>

Conclusions and Highlights:

- Online platforms are obliged to check that companies selling on their platform are registered for #WEEE and have a representative in an EU country (following the German WEEE law)
- Making online platforms liable for non-compliant products if there is no liable actor (based on French law)
- Visibility of seriously non-compliant products on public websites (name & shame), encouraging citizens and companies to inform #msasafety about suspected non-compliant products
- To raise public and political concern, highlight that non-compliant products can also be dangerous or fail to contribute to climate and environmental objectives, thus harming the overall efforts of all actors -> higher contributions to CO2 objectives should instead be rewarded
- Greater cooperation is needed between surveillance and customs authorities, sharing data and coordinating sanctions
- Continue efforts in educating the market via FAQs and Guidelines.

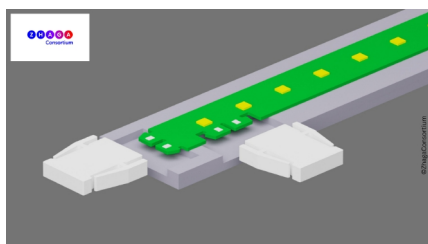
Do you want to help LightingEurope raise awareness on the topic of lack of enforcement and support us in finding the right solutions?

Get in touch with our Secretary General: Elena Scaroni. ■

Zhaga

www.zhagastandard.org

Light+Building 2024, the world's leading trade fair for lighting and building services technology, witnessed a remarkable presence from the Zhaga Consortium. Over the course of six days, the Zhaga booth experienced a constant influx of visitors, reflecting the industry's keen interest in the latest advancements in smart standards developments. One of the key attractions at the Zhaga booth was the Zhaga Book 18 focusing on the smart interface between outdoor luminaires and sensing/communication modules. Visitors experienced a demonstration of sensors and communication modules from different vendors that were placed on streetlight luminaires from different manufacturers and worked as intended, for instance, relaying the information of presence detected by a luminaire to another one.



The upcoming specification, Book 26, is centered around LED modules for linear socketable applications.

Also, the upcoming Zhaga Book 18 Edition 4, tailored to meet the needs of the decorative and heritage luminaires, garnered significant attention from attendees. Book 18 Edition 4 allows for a pole-mounted bracket assembly and addresses issues around the installation of long cables needed to connect the bracket assembly and the head of the luminaire. Book 18 Edition 4 is anticipated to be available to Zhaga members by September 2024.

On another application side, a system of an indoor sensing module and an indoor luminaire, both based on the Zhaga Book 20 “smart interface between indoor luminaires and sensing/communications modules, demonstration of a U.S. Department of Energy L-Prize prototype winner, led to interesting discussions.

Zhaga constantly develops new interfaces, addressing different needs in the lighting industry. At Light+Building, the team decided to provide a sneak peek into its upcoming

specification, Book 26, centered around LED modules for linear socketable applications. Prototypes of these modules were showcased, highlighting a cost-effective mechanical and electrical interface for toolless replacement. With a focus on repairability, on-site servicing and late-stage configuration, Book 26 paves the way for enhanced flexibility and sustainability in luminaire design.

This was an example of how circularity is a prominent theme for Zhaga, emphasizing its commitment to enabling circular economy through the adoption of global standards by the lighting industry. Beyond product development, Zhaga's Circularity Lighting framework aims to minimize waste and promote resource efficiency. This initiative resonated strongly with architects and lighting designers, who participated in guided tours titled “On the Road to a Sustainable Future.”

A highlight of Zhaga's presence at the Light+Building fair was the insightful presentation by Heinrich Thye, Secretary General of Zhaga. Thye shed light on Zhaga's forward-thinking approach to future-proofing lighting, emphasizing interoperability, connectivity, and circularity as pivotal pillars for sustainable growth in the industry. The Zhaga Consortium welcomed a diverse array of visitors, including city representatives, engineering firms, and lighting manufacturers from across the globe. Attendees hailed from regions spanning China, India, the Middle East, Europe, and North America, underscoring the global significance of Zhaga's contributions to the lighting industry. Zhaga members played a pivotal role in staffing the booth, engaging with visitors to elucidate Zhaga's objectives, the importance of certification, and the process of becoming a Consortium member. Their presence underscored Zhaga's collaborative spirit and dedication to driving innovation and sustainability in the lighting industry. With a global membership exceeding 550, Zhaga remains at the forefront of standardizing interfaces of components for LED luminaires, ensuring compatibility and efficiency across diverse lighting applications. ■

Zumtobel Group

z.lighting/

Sustainability, digitalization and innovation - these central themes shaped the Zumtobel Group's presence at the Light + Building trade fair. All Zumtobel Group brands presented themselves at the world's leading trade fair for lighting and building technology in a new location for the company, the Forum of the Messe Frankfurt. Alongside the professional range of lighting and technology solutions from Tridonic, Thorn and Zumtobel, numerous highlights lined the company's trade fair presence, including a Guinness World Record title for Zumtobel's installation of the world's

“largest continuous luminous ceiling” at the lighting specialist's exhibition space. For the first time, the new IoT product brand Keyture was introduced with the aim of accelerating the integration of digital services into the lighting infrastructure in the future.



Zumtobel Group booth at Light + Building.

As part of the trade fair, the Zumtobel Group's new IoT product brand Keyture was presented for the first time to the public. Keyture is the Zumtobel Group's new cloud-based connectivity and IoT ecosystem. Its intelligent key features support the Zumtobel Group brands Thorn and Zumtobel to optimize the use of their luminaires in professional sensor-supported lighting systems to enable their operation with maximum energy efficiency. Keyture will be available to customers starting in autumn 2024. The future focus on IoT is underscored by the Zumtobel Group's ecosystem partnership that was recently signed on 29 February 2024 with Siemens and Enlighted, a leading building technology company that is part of Siemens.

The Zumtobel Group's technology company Tridonic received one of the most prestigious international industry awards during the trade fair: the DALI Alliance Lighting Award 2024 in the “Architectural & Entertainment” category. The jury honored the Tridonic lighting control system for a major cinema complex in Dubai. Also showcased to the fair audience was one of the most significant projects in Tridonic's company history: the Milan “Hospital of the Future” Ospedale Galeazzi - Sant'Ambrogio, where 16,000 intelligent luminaires are operated with LED drivers and 6,000 sensors from Tridonic. Tridonic not only installed a sophisticated lighting management system for this exceptionally large project, but also headed the project management over a period of three years in collaboration with all companies and clients involved.

Light on a unique scale: measuring over 200 square meters, Zumtobel's CIELUMA has set a GUINNESS WORLD RECORDS title for the “largest continuously illuminated” ceiling in the world at the Light + Building 2024. Installed by Zumtobel and its long-standing manufacturing partner Typico at their exhibition space in Frankfurt am Main, the world record-holding CIELUMA illuminated ceiling was 45.029 meters long and 4.503 meters wide and was characterized by a continuous seamless luminous surface. It's the company's first GUINNESS WORLD

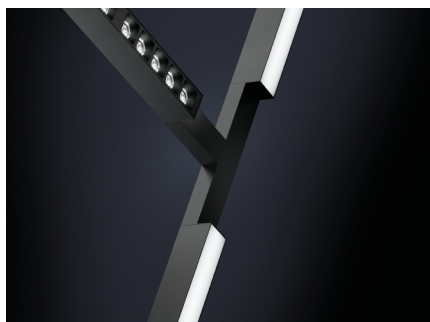
RECORDS title. In addition to its impressive size the fascination of the CIELUMA lighting installation was its perfect imitation of daylight.

Zumtobel and the Italian design studio and engineering firm Pininfarina announced their partnership at the Light + Building 2024. Both well-established companies stand for high standards of quality and design, as well as innovation and progress. Founded on their shared values and combined expertise in design, architecture, industry and technology expertise, the collaboration is focused on expanding and upgrading Zumtobel's successful continuous-row lighting system. The partnership enables meeting future lighting requirements and responding to changing customer needs in terms of flexibility, user experience and design. The launch of TECTON II was announced for the first quarter of 2025. ■

TRILUX

www.trilux.com/

This year, TRILUX opted for a holistic stand concept with a marketplace character, fostering more experiential engagement, exchange, and atmosphere rather than a traditional product presentation. Innovations were showcased in 'skyboxes', expansive cubes suspended above the stand, creating a unique experiential space for luminaires and the LIVELINK LIGHT MANAGEMENT SYSTEM. Associated information screens and hands-on areas provided product context, enabling visitors to take a closer look at the LUMINAIRES. A varied supporting program featuring keynotes and expert talks offered comprehensive insights into sustainability, digitalization and lighting quality alongside exclusive presentations on topics like New Work and pioneering architectural concepts by GRAFT Architects.



YONOS lighting system for offices.

Two new modular systems, YONOS for office applications and the E-LINE PRO for industry, were particularly noteworthy. The modular design and extensive selection of application-specific optics, luminaire modules, and functional components, offer nearly limitless possibilities for customization and adaption, making systems more flexible, secure and appealing. "Given their substantial advantages, smart and adaptable systems are

poised for long-term success," concludes Joachim Geiger.

In response to the evolving world of work, characterized by flexible models such as remote work and the principles of New Work, companies seek to illuminate office spaces to meet standards while also making them attractive and future-proof. Interest in the new YONOS modular office system, which consolidates TRILUX's expertise in functional and decorative lighting into a single system, was correspondingly high. YONOS's modular design offers tailored solutions for every office lighting task, from standard-compliant, glare-free workplace lighting and linear light for circulation zones to spotlight modules for impressive lighting accents, available as individual luminaires, continuous lines or L, T or X configurations. YONOS's versatility enables holistic lighting concepts in a consistent design language, whether classic or New Work, while simplifying planning, installation, smart functionality and maintenance.

"Smart and adaptable systems are poised for long-term success."

JOACHIM GEIGER

The new E-Line Pro also impressed with its unparalleled versatility. A new support profile with continuous current routing allows flexible positioning of optics, luminaire modules and functional components along the continuous line. For the first time, TRILUX introduced a module with an indirect component to the E-Line portfolio, expanding its applications beyond industry into sectors like education and RETAIL. Experts were equally impressed by the lightning-fast and simple installation of the E-Line Pro, which averages just 33 seconds – an improvement of 25 per cent over the E-Line Next LED.

In addition to YONOS and the E-Line Pro, TRILUX unveiled many other innovations, including the new LIVELINK ONE app for plug-and-play lighting management. "The positive feedback on our LiveLink ONE app shows how open the industry is to light management - if installation and operation are simple and safe," said Geiger. TRILUX also underlined its position as a leading supplier and industry pioneer in terms of lighting quality with the introduction of LOW CONTRAST LIGHT TECHNOLOGY, bringing exceptionally pleasant and high-quality light to outdoor spaces.

TRILUX offers the opportunity to experience innovations live and in action beyond the trade fair, at one of the 6 Germany-wide competence centers or SHOWROOMS across Europe. ■

ERCO

www.erco.com/

At the Frankfurt exhibition, ERCO unveiled a compelling vision with their motto "hands on light", inviting lighting aficionados from across the globe to engage directly with their sustainably designed Light + Building exhibition stand. The ERCOplay stations offered a hands-on experience, allowing attendees to explore sustainable lighting solutions tailored for both intimate museum display cases and expansive outdoor façades. The exhibition wasn't just about enjoyment; it delved into the crucial question of how lighting can be utilized sustainably. Through its "Greenology" sustainability programme, ERCO showcased innovative product solutions and approaches aimed at enhancing the sustainability of architectural lighting.



ERCO's booth at Light + Building.

Transforming the concept of play of brilliant to light for playing. The luminaire manufacturer's playful adaptation of Richard Kelly's lighting perception triad for the Light + Building exhibition was a creative deviation, allowing visitors at the ERCOplay stations to test their lighting knowledge across five interactive stations: At Station 1, participants turned into lighting directors on a miniature stage. Using the new Axis showcase lighting, a lighting concept based on the "3-point lighting" approach had to be realized. Moving on to Station 2, the lenses of Optec spotlights were to be changed till the light was precisely aligned with the target surfaces. At the downlight station, the objective was to solve estimation questions, including about light distribution, with a quick tap on the buzzer. Station 4 was outdoor-themed: The teams were asked to practice aligning the Beamer spotlights. The 5th station, 'hands on' Invia, encouraged participants to experiment with ERCO's linear system to create their own lighting scenes including wallwashing, ambient lighting, indirect and accent lighting.

Expertise for showcases, passion for general lighting:

ERCO designs lighting solutions that meet user needs sustainably and ensure architecture remains functional and relevant for decades. The key metrics for energy efficiency (lm/W) and effectiveness (lx/W) of lighting were showcased through the OptecNew spotlights, which represented an eco-friendly advancement of their best-selling product. By comparing the illuminance on the targeted surface with the power consumption



Cree LED upgrades XLamp® S Line horticulture LEDs for improved efficiency and sulfur resistance

Boasting up to 14% higher efficiency and the highest level of sulfur and corrosion resistance, the XLamp S Line LEDs deliver reliable performance for greenhouses. The S Line also improves system reliability through many rounds of power cycling or dimming. Enjoy longer lifetimes, lower energy costs, higher yields and a better ROI with XLamp S Line Horticulture LEDs.



www.cree-led.com

of the accent lighting fixture, it became evident whether light, and consequently energy, was being inefficiently dispersed as scattered light. The company now also offers precise lighting for sensitive artefacts behind glass: With its miniaturized Axis luminaires, ERCO sets the benchmark for lighting quality in showcases. The linear, modular Invia lighting system exemplifies versatility in application on a larger scale and stands out for its ability to provide balanced wallwashing illumination, seamlessly extending even into room corners.

At L+B, ERCO revealed its 'secret passion': Downlights. By showcasing the variety in its downlight portfolio, ERCO highlighted its broad expertise beyond just spotlights. General lighting using recessed luminaires is a crucial component of lighting designs focused on enhancing perception. Using the **Iku** and **Skim** downlights, ERCO demonstrated that luminous efficacy greater than 120lm/W combined with a zoned lighting strategy can significantly increase energy efficiency, reducing the consumption of standard-compliant office lighting to as low as 2.99W/m².

The best use of light – flexible in the office, responsible outdoors: ERCO showcased eco-friendly and standard-compliant office lighting through its track-mounted downlights as a prime example. This allows for the lighting to be flexibly adjusted to fit office layouts and adapt to changes in use. Similar to accent lighting, ambient lighting should be applied selectively, only where it is necessary. The same applies outdoors: With its Beamer series of projectors, at the L+B, ERCO showcased at the L+B precise outdoor lighting that maintains the integrity of darkness while utilizing light in a responsible manner.

An example of consistent sustainability: Sustainability comes from durability. 'Lighting Durability' is ERCO's goal which states that all newly developed luminaires are designed for a service life of 20 years. The first product to be designed in accordance with this specification is the advanced version of the Optec spotlight. Durability also served as the guiding theme for the stand design concept. In designing the stand, priority was given to selecting materials that could be repurposed following the Light + Building exhibition. For instance, a specially constructed stand floor was dispensed with and the company utilized road cases for

product presentations. These cases have been employed at local trade fairs for years and are poised for their inaugural tour. The framework used was from the 2018 Light + Building stand, and the ERCOplay stations were incorporated into a rental scaffold, which will be reused beyond the duration of the trade fair. And what will happen to the printed fabrics that were used on the stand? They will be converted into carrier bags and will soon be raffled off among visitors to the stand. It is therefore well worth subscribing to the ERCO newsletter: www.erco.com/newsletter

At the fair's conclusion, ERCO Managing Director Oliver Gabriel expressed a highly satisfied assessment: "Engaging hands-on, experimenting with light and fixtures – that's what brings excitement to a trade fair. The enthusiastic feedback from our visitors regarding ERCOplay has strengthened our commitment to making light a tangible fourth dimension of architecture. Continued discussions with planners about efficiency and lighting quality will further propel the development of durable products, enhancing the sustainability and improvement of architecture." ■

iGuzzini

www.iguzzini.com

With 65 years of experience in architectural lighting, the brand teamed up with Studio GEZA for the exhibit and Artec Studio, under the creative direction of Maurici Ginés, for the light scenography at the Frankfurt fair. Together, they crafted an immersive space showcasing iGuzzini's innovative approach to light, driven by connectivity, technology, optics research and environmental responsibility.

"Light that moves" epitomizes iGuzzini's core philosophy that summarizes the concept of connected, responsive, intrinsically sustainable and deeply human-centric lighting, which permeates each collection and resonates through the architectural and interior projects illuminated by iGuzzini. This concept will be expressed in the new brand identity, which showcases iGuzzini's innovative approach to creating light that transforms spaces, moves people, enriches cultures and ignites imagination. Cristiano Venturini, CEO of iGuzzini: "We are returning to Light + Building after six years, aware of the fair's

global significance in the lighting industry and committed to maintaining our position as a leading authority in the field. We will do this with an evolved, somewhat revolutionary image that takes into consideration the development and changes in society, presenting a unique offer in the market where iGuzzini's DNA, history and future intertwine. iGuzzini focuses on smart and intelligent lighting solutions aimed at making the lives of people better, more sustainable and fulfilling, no matter where they are. The culture of light and its roots, design, imagination, research and continuous innovation are the ingredients that allow visitors to Frankfurt to experience something different, both inside and outside the iGuzzini stand, which has been completely reinvented for the event."



Cesare AVANZI, Editorial Communications Senior Manager, showcased Filorail, a track system with just 3.6 mm opening.



Light Shed Linen units, representing a biophilic version of the Light Shed system that encapsulates the present and future of the iGuzzini brand.

In this setting, the iGuzzini light was the fifth element, enriched and diffused through a series of installations that showcased their technical, graphic and architectural capabilities. A light experience punctuated by three islands set within an ephemeral architecture, which could be viewed from both inside and outside the stand.

The entrance to the stand was marked by a

sinuous, eye-shaped structure composed of 154 Light Shed Linen units, representing a biophilic version of the Light Shed system that encapsulates the present and future of the brand. The eye that welcomed visitors not only represented iGuzzini's perspective on light but also reflected the individual, subjective viewpoints that each visitor held, regarding the objects and spaces surrounding them. The lights were designed to incorporate smart technological features within a space designed for a seamless integration of functions and a harmonious relationship with people and nature: from living to working areas, from intimate to communal spaces.

The stand's exhibit highlighted the main strategic areas of application of the iGuzzini products: Culture, Working, Hospitality & Living, Contract, Urban and Infrastructures. Inside the stand, three light installations seamlessly combined iGuzzini's humanistic and technological research with educational spaces focused on individual products and on optics designed and manufactured in-house. The collaboration with lighting designer Maurici Ginés, founder of Artec Studio, has resulted in the creation of a wonderful set design aimed at demonstrating to architects, interior designers and lighting professionals the tangible advantages the brand provides through an immersive, multi-sensory experience.

The evanescent micro-architectural components were illuminated and colored to synchronize with the rhythm of the narrative, creating a synesthetic sequence of light, sound and storytelling enclosed within the brand's three typological universes. Light for art, for indoor architecture and for outdoor architecture. Each installation embodies the concept of converting technological elements into a sensitive, human and emotionally engaging experience.

Rather than categorizing by function, the approach embraced an organic vision that encourages the open interpretation of products, free from classification and definition. The Light+Building trade fair, with its audience of lighting professionals, was an opportunity to delve into the intricacies of iGuzzini's research in Innovation & Connectivity, pivotal drivers for the company's growth. Integrated into iGuzzini's collections, these innovations have the potential to improve the quality of living spaces by providing adaptive and dynamic lighting. Additionally, they contribute to significantly reducing energy consumption and to easily access, manage and analyze usage data, promoting smart building management practices and creating a system that is easy to reconfigure and adapt over time.

Filorail is a narrow and sinuous track, the smallest ever introduced to the market, with an opening of just 3.6 millimeters. It embodies a utopian concept that envisions a future

where technology blends imperceptibly with architecture.

Newfo is the new spotlight that offers exceptional efficiency and comfort in a compact design, blending understated beauty with modernity and a timeless appeal. The new Sipario spotlight illuminates an artwork in a museum as well as an extraordinary object inside a home. They both represent a new generation of professional spotlights with superior optical performance, flexibility and efficiency.

The Iway bollard, designed for both private and public outdoor spaces, offers exceptional visual comfort. Its Retrofit feature enables flexible upgrading of the light source, improved performance and integration of smart system management tools.

Spacepad's integrated intelligence translates into energy efficiency and savings through rational use of light, allowing for flexible layouts in work settings that promote collaboration and dynamism. This lighting solution is designed to enhance working environments, making them more comfortable and adaptable to continuous evolutions. Trick EM serves as a generator of ideas and revelations. This small and compact spotlight emits light in motion and travels through spaces, gently caressing them to reveal architectural contours and details.

The Libera modular system offers new dramatic possibilities in a living room as well as the foyer of a theatre. The heart and soul of the Libera system is a bold and liberating interpretation of light, shapes and spaces. The presentation of Libera and BeTwo in a sumptuous and warm living room complements the high-tech nature of the Optidiamond optics, accentuating their qualities and the visual comfort in residential spaces. ■

Artemide

www.artemide.com

"Criosfera is not "just" a light. It is a resolution, a manifesto of our times. One that is imbued with optimism that we will, individually and collectively, defend intergenerational justice. Lights on. It's action time," says Giulia Foscari. "Criosfera, the cryosphere, encompasses all components of the Earth System that are frozen. 90% of such ice is in Antarctica. That same ice is the largest repository of data on our climate history. It is a time capsule that enables scientists to trace the climatic history of our planet, extracting from captive air bubbles trends of CO₂, greenhouse gasses and temperature from past glacial and interglacial eras. The quintessential marker of climate change is thus the Ice Core, a cylinder of stratified ice extracted from the depths of our planet's ice sheets. The ice core thus becomes the element that creates awareness and calls to action. Abandoning its frozen form, the ice core of Criosfera consists of a layering of blown recycled glass with an optic

core that learns from the refractive nature of the ice surface of the Antarctic plateau to maximize the diffusion of light, and evokes the stratification of the polar ice."



David Rommerskirchen (left) and his colleague presented SOMNIUM, a system born from the fusion of optical, structural, and production elements, brought to life through transparency. At its core there is an optical cell, engineered for maximum efficiency and optimal perception.



Criosfera, is a resolution, a manifest of our times.

Criosfera is therefore a synthesis of optical, material and scientific knowledge which translates into a manifesto of values between the present and the future. The external blown glass cylinder is the structure inside which the optoelectronic engine disappears without visible shadows. Its limits and its uniqueness are linked to the craftsmanship. Engravings are impressed into the hot glass before blowing and makes its thickness wavy and irregular. It contains the measured perfection of optical extrusion whose section diffuses the light without making the sources inside visible. This element fits into the space with three different essential structures, which refer to the scientific instruments used to extract and analyze ice cores. They are composed of surfaces made with laser cutting, a technology that optimizes the use of materials. ■

Thorn Lighting

www.thornlighting.com

Thorn Lighting welcomed visitors to its digital and immersive stand at Frankfurt's Light + Building event. The lighting brand founded in 1928 showcased elements of its extensive portfolio of indoor and outdoor solutions. Surrounding the outside of the stand were areas focused on Thorn's key outdoor applications – road and street, sports and urban and architectural. Moving into the interior space, visitors were invited to explore the indoor application areas of office and education, retail and industry.



Thorn Lighting booth at Light + Building.

Alongside physical products and prototypes, visitors to 2024's Light + Building got a first look at the City of Thorn. This 3D, interactive city has been designed to demonstrate Thorn Lighting's excellence in key application areas and was shown on large screens. In the City of Thorn, users can navigate through spaces that are all illuminated with the precision and innovation Thorn is renowned for and zoom into specific areas to examine the diverse range of products and control systems including dark-sky friendly outdoor luminaires, sustainable panels for office and education, or connected industrial solutions such as high bays. Just as great cities evolve, so too will Thorn's virtual metropolis, growing over time to incorporate a full spectrum of applications. More information to follow later this year.

Other notable innovations include HAP (High Accuracy Positioning) which was displayed in the retail and industry booths. Launching in spring, this technology can be used alongside Thorn luminaires to track people or objects, resulting in a range of benefits. Already installed at Thorn's manufacturing facility in Spennymoor (UK), visitors could view livestream data to see its real life usage. Thorn also previewed the Keyture solution, which is a new connectivity and IoT ecosystem. Launching later in the year, the luminaire compatible sensors amplify lighting control, enhancing energy and cost saving potential alongside asset tracking. Also installed in Spennymoor – the factory has seen cost savings of thousands of pounds since January.

During Light + Building, Thorn's sustainable

indoor recessed panel 'Omega Moduline' was shortlisted for Architeller's 'Sustainable Product Award'. Mark Mattimoe, Thorn's indoor Product Management Director outlined the luminaire's features (including replaceable LED modules and driver) to a jury at the fair's Design Plaza.

More success came in the form of Light + Building's first ever 'Sustainable Exhibition Stand' prize - awarded to the Zumtobel Group for the stand concepts of Thorn Lighting, Zumtobel Lighting and Tridonic.

Vice President of Thorn, Saurabh Pandhi said, "Returning to Light + Building in March exceeded all of our expectations. Visitor numbers were far greater than anticipated, and through the solutions on display and the knowledge of our teams on the stand, we have solidified Thorn's position as a strong player in the indoor and outdoor lighting market with connectivity and IoT at the core of its solutions. Over the coming months and years, we'll continue to build on our portfolios, prioritizing sustainability, efficiency and connectivity for our customers. Thank you to all who toured the Thorn stand – we look forward to continued collaboration going forward." ■

NANOTTICA, TREVOS

www.trevos.eu

Headquartered in the north of Bohemia in the Czech Republic, Trevos is a market-leading manufacturer of industrial and interior luminaires, boasting over 30 years of experience.



Michael THOR, Marketing Specialist at TREVOS. Photo: LED professional.

Trevos is also a local and global technological trendsetter when it comes to producing high-quality, innovative and affordable light fixtures. Currently exporting to over 60 countries in the world, the company has its

own R&D Department and invests heavily in innovations to satisfy market demands. In 2021, Trevos launched NANOTTICA, a family of cutting-edge light fittings that feature a nano-structure. So far, this patent-pending technology has not been used by any other manufacturer anywhere in the world.

The NANOTTICA fixture boasts a low unified glare rating with its UGR values patented nanooptics. This ensures eye comfort, high visual performance and work-place safety, which indirectly translates into higher productivity. The fitting is highly recommended for illumination of premises where workers' visual precision is of paramount importance. These include workshops where fine assembly work is performed as well as craft workshops and visual inspection areas. The fitting's standard beam angle makes it a great choice for premises with a fitting installation height of 3.5 to 8 m. In addition to indoor spaces, it is designed for agricultural buildings and other spaces with chemically aggressive environments due to ammonia fumes, lye fumes, alkali and hot water (hydrolysis). The fitting is primarily intended for large agricultural premises and industrial halls such as farms, stables, production plants and warehouses, car washes and laboratories with no explosion hazard. IP69-rated and HACCP-compliant, the fitting's design also makes it suitable for the food industry. ■

DALI+ Driver, Inventronics

www.inventronics-co.com/

Inventronics presented the first DALI+ with Thread certified wireless LED drivers at trade fair Light + Building 2024. Harnessing the advantages of the DALI-2 standard for lighting, DALI+ extends its features and benefits to the wireless realm. The DALI+ wireless network is based on the IEC 62386-104 standard and employs the same DALI language, features, and data. This will enable the seamless integration of DALI-2 wired and DALI+ wireless devices in the same installation.



Inventronics presented the first DALI+ with Thread certified wireless LED drivers.

The DALI Alliance, the global industry organization for DALI, recently launched its DALI+ certification program, ensuring cross-vendor interoperability. DALI+ represents the standardized wireless protocol of the future, aiming to defragment the

wireless landscape dominated by proprietary solutions and thereby opening new horizons for the lighting industry.

Inventronics' newly introduced wireless LED drivers mark the first DALI+ drivers certified by the DALI Alliance. This certification guarantees that the drivers seamlessly integrate and interoperate with other DALI+ products. Key features of Inventronics' wireless LED driver include enhanced connectivity, superior energy efficiency, and individualized control capabilities.

"By pioneering the first DALI+ certified wireless LED driver, we drive innovation and emphasize our dedication to promoting open standards and interoperable products," says Dr. Gernot Steinlesberger, CEO business unit Digital Systems. ■

Bluetooth® NLC Control, mwConnect

mwconnect.us

mwConnect (formerly McWong International), a leading innovator in wireless mesh technology, has achieved Bluetooth® NLC certification for its TruBlu wireless mesh control solution.



Stephen ZHOU, Executive Vice President of mwConnect at Light + Building. Photo: LED professional.

The Bluetooth Networked Lighting Control (NLC) standard, introduced in late 2023, is the first full-stack standard for wireless lighting control. Specifically designed to meet the scale, reliability, and security demands required in commercial settings, Bluetooth NLC enables multi-vendor interoperable wireless lighting control systems and unlocks the potential for mass adoption of wireless lighting control. By adding standard specifications to the individual device layer on top of the Bluetooth mesh (communication

layer) and Bluetooth Low Energy (LE) (radio layer), Bluetooth NLC standardizes performance and functionality operations for six device profiles: occupancy sensor, ambient light sensor, energy monitor, scene selector, dimming control, and lightness controller. mwConnect's new certification means the company offers the most comprehensive listing for Bluetooth NLC, with products in all six profiles. Bluetooth maintains a searchable database for qualifying products.

"We're delighted to reach this new milestone, Bluetooth NLC, for our flagship control solution."

STEPHEN ZHOU

"We're delighted to reach this new milestone for our flagship control solution," said Stephen Zhou, Executive Vice President, mwConnect. "With this new NLC standard, a project team can select from a range of product choices with the certainty that each device will operate seamlessly with every other, regardless of manufacturer. This is the next natural evolution for us in achieving true interoperability and providing the marketplace with the highest degree of flexibility." ■

W-DALI, LumenRadio

lumenradio.com

Through innovative wireless technology, W-DALI replaces the conventional DALI cable for lighting. W-DALI gives customers wireless control of large-scale lighting systems and opens up new opportunities for lighting design, energy optimization and the modernization of older buildings.

By being a completely transparent DALI solution, W-DALI eliminates the need for extensive construction work, which generates benefits including simpler project planning and reduced installation costs.



W-DALI components from LumenRadio.

"This is a game-changer for commercial interior lighting," said Niclas Norlén, Head of Product Development at LumenRadio. "With no need for any rewiring, W-DALI gives you an instant wireless lighting network which is quick

and easy to install. For our customers, this represents a great cost saving, particularly when it comes to upgrading older wired DALI lighting systems, which is the predominant lighting standard in buildings." "W-DALI is built on LumenRadio's patented wireless technology which provides unmatched reliability of performance. It doesn't interfere with or allow itself to be compromised by other wireless networks," adds Niclas. "In other words, you can use wifi, Bluetooth or the equivalent in the same area without a drop in communication quality."

An energy-efficient response to climate goals: "The potential for our wireless products and modules, which replace traditional cables, is huge," says Alexander Hellström, CEO of LumenRadio. "This is particularly true for W-DALI since the need to retrofit and modernize existing buildings, such as schools, hospitals and hotels, is growing as the EU demands greater energy efficiency within the building sector." Buildings account for over one third of CO2 emissions in the EU and of those built before 2000, 75% are deemed to have a poor energy performance. Through its revised Energy Performance of Buildings Directive (EPBD), the EU wants to increase the rate of renovation and make buildings more energy efficient. The aim is to reduce emissions and fully decarbonized building stock by 2050 in an effort to meet the EU's wider energy and climate goals.

It's DALI, just without the cable: "We've developed a solution which operates with any DALI controller," says Niclas. "Commissioning remains the same but you get a quicker and simpler alternative to running DALI cables – with all the advantages of wireless control."

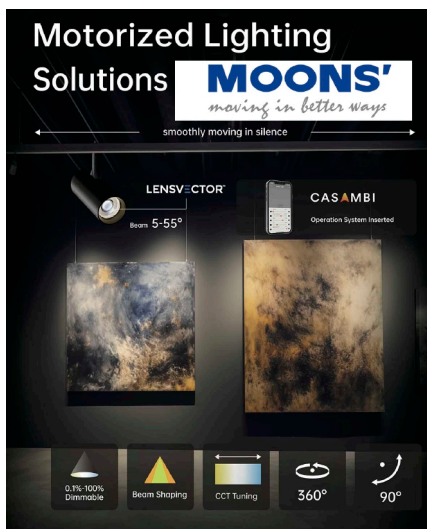
- LumenRadio has launched W-DALI – a wireless solution for indoor lighting control which removes the need to install new DALI cables.
- Uses the same language as the DALI cable protocol but communicates wirelessly.
- With no construction work required, W-DALI cuts installation costs and complexity.
- Opens the door for retrofit projects in historical buildings which cannot be altered structurally.
- Enables remote control and monitoring of lighting fixtures for more efficient energy management in buildings.

Via the wireless network, users can remotely control and monitor lighting fixtures, adjust brightness levels, set scenes, and create schedules or zones for efficient energy management. W-DALI is DALI-2 certified. As well as wireless products for DALI, LumenRadio offers wireless technology for Modbus, BACnet, M-bus and DMX. W-DALI can currently be bought in Sweden via LumenRadio's distributors, Ahlsell and Bellalite. ■

Motorized Lighting Solution, MOONS'

www.moonsindustries.com

LED circuits or LED drivers are electrical circuits that power light-emitting diodes (LEDs). LED power supplies must provide sufficient current to light the LED at the required brightness, but they must limit the current to prevent damage. Since 2005, MOONS' has been involved in the processes of designing, engineering, and manufacturing LED light drivers. In addition to traditional constant voltage and constant current LED drivers, we offer state-of-the-art, constant power to leading-edge intelligent programmable LED drivers such as 0-10V dimmable drivers, DALI dimmable drivers, and DMX dimmable drivers.



MOONS' presented the world's first fully motorized spot/track lighting solution including dimming, beam shaping, CCT tuning, and horizontal/vertical angle adjustment.

MOONS' LED drivers are used in a wide variety of applications, including roadways, tunnels, high masts, sports, landscapes, and area lighting, as well as indoor ambient, task, performance, and stage lighting. ■

InviTrack, LITE & NPC

www.npc.lighting

Leading LED lighting solutions provider LITE and Nordic Power Convertors have announced the forging of a groundbreaking partnership that is set to expand the horizons of the lighting sector. Together, the two market-leading companies are launching the revolutionary InviTrack – an invisible track driver. - to the UK market. This new technology has the capability to transform lighting design possibilities, seamlessly blending aesthetics and functionality. InviTrack drivers hide entirely in the track, allowing for new and innovative luminaire design ideas.



InviTrack Drivers are fully integrated into the track systems.

The InviTrack has been manufactured by the Danish LED lighting experts Nordic Power Convertors and will be distributed exclusively in the UK by NPC-UK (Part of Lite Group). High-end track lights are becoming increasingly important in design-led projects such as upmarket retail stores. By using the InviTrack, high-end luminaires can be fully showcased on a track system without the worry of an LED driver and track adaptor being visible or interrupting clean and flowing lines.

The hidden driver has the ability to create a high-end look and aesthetic, with a minimalist design for track lights. Adding to its appeal, as well as fitting into different track models, the driver is available in three stylish colours – white, black and grey. This allows the driver to blend into existing décor. InviTrack is certified to carry luminaires weighing up to 1.5kg per driver. This adds to its flexibility and versatility for a range of applications. InviTrack is also designed to allow luminaires to rotate near to 360° so they can be positioned where needed. Durability and longevity have also been factored into the design of InviTrack. Overheating is a risk to the lifetime of any LED driver; to combat this, InviTrack Dali has a T (case) max of 85°C, increasing the lifetime and overall reliability of the solution.

Being flicker-free is also an important factor in producing good quality light that aids in improved health and safety of those working or spending time in the surrounding environment. This is a particular benefit in retail settings, as consumers are more likely to linger and move to purchase in a welcoming and comfortable lit environment rather than one with poor light quality. NPC-UK Managing Director Paul Barnes said: "The InviTrack from Nordic Power Convertors is a revolutionary idea.

We're thrilled that LITE has become their partner of choice to promote this outstanding solution. It's a truly exciting opportunity for LITE, Nordic Power Convertors and the lighting sector." ■

Nano LED Drivers, eldoLED

www.eldoled.com

To anticipate the trend of hidden lighting and to prepare for new European building regulations (EPBD) and European cybersecurity regulations (CRA), eldoLED is introducing a new range of ECOdrive LED drivers, designed for the European market. As a leader in the design and engineering of state-of-the-art LED driver technology, eldoLED has an established tradition of creating lighting solutions that deliver Quality of Light for luminaires, elevate modern aesthetics, enhance comfort and reduce energy consumption. eldoLED builds on that tradition with the development of the new Nano family of ECOdrive LED drivers.



eldoLED's Nano family of 12W LED drivers.

The Nano family of 12W LED drivers offer programmable, digital solutions in an exceptionally small size capable of insertion within 35mm apertures for today's miniaturized downlights, spotlights, and pendant lighting designs. The Nano family from eldoLED provides cost-effective energy saving options that are compatible with analog and digital dimming protocols down to 1% as well as Casambi-enabled options for wireless control.

With the Nano family of small form factor drivers, applications such as hospitality, retail, or residential can easily achieve "quiet" ceilings without sacrificing true Quality of Light and control within the illuminated space. All Nano drivers are fully programmable with a new cloud-native programming tool, called eldoLED STUDIO, with advanced cybersecurity and full traceability.

Geert van der Meer, Product Marketing and Engineering Director Europe at eldoLED, says "We are excited to provide the next step in LED driver miniaturization with the ECOdrive Nano drivers. It is the smallest LED driver in its voltage range and is a perfect example of how eldoLED is continuing our heritage of creating quality designs that support our vision of Quality of Light and reduce energy consumption by enabling easy sensor integration in line with EPBD requirements." The ECOdrive Nano driver family is exclusively designed for Europe and scheduled for release in the summer of 2024. ■

Sensor X, TRIDONIC

www.tridonic.com

SensorX, an AI-based sensor from Tridonic detects “life” on streets and pavements so they can be reliably illuminated with minimal power consumption. SensorX can be used to dispense light on demand and thus save energy and reduce light emission. The sensor also enables road traffic to be measured and differentiated, paving the way for smart planning and control of traffic volumes and parking spaces. Instead of motion sensors, Tridonic is using machine vision for this edge device – and has found a way to make the technology not only economical and simple in its application, but also data-secure for mass use outdoors.

Modern street lighting must strike a balance between night-time safety, energy efficiency and minimal light emission. These requirements can all be met by dispensing light on demand. SensorX detects any pedestrians or vehicles in the vicinity. This results in adaptive lighting scenarios so that, for example, lighting levels on streets and pavements can be dimmed in off-peak times and brightened back up as traffic flows increase. Tridonic supports this principle with its AI-based, DALI-compatible SensorX, which makes the use of machine vision in outdoor applications both convenient and economical.

Zhaga-compliant SensorX detects and measures the presence of objects in a freely defined area. Its integrated machine learning algorithm not only detects the presence and number of objects but also distinguishes between vehicle types, pedestrians and cyclists, depending on the task it has “learned”.



Sensor X in outdoor applications.

Multiple applications in smart cities: Dosing the street lighting is just one of many application scenarios for the data that the all-rounder SensorX delivers. Users can easily define the zone and type of assets to be detected via an app. One option would be to measure traffic density – in this case, a zone could be as precise as a single lane. In the smart city of the future, experts could evaluate the data to optimize traffic flows, for example. Traffic planners could use traffic metering, including differentiation by road user, to adapt traffic light phases to current traffic volumes or to release additional lanes, avoiding congestion and unnecessary CO2 emissions.

SensorX can also make parking management much easier. The traditional sensors used for this purpose are often installed underground, and construction teams have to dig them up, relocate and rewire them if, for example, a car park is repurposed. Errors can occur with these sensors if they are covered in snow. SensorX, on the other hand, can be quickly and easily installed on Zhaga-compatible street lights and put into operation via an app. Because SensorX is so easy to retrofit it can take into account the dynamics of urban outdoor areas and help to make them more sustainable.

Edge computing for energy efficiency and data security:

As an easy-to-install edge device, SensorX processes all the information in the device itself and does not send images or videos to any external infrastructure. The sensor communicates via DALI, sending only its interpretation of the algorithm, not the input material. SensorX does not have any memory of its own. This architecture not only guarantees data protection, but also provides more bandwidth for transferring large image or video files. SensorX consumes just 1W per node. Compliance with the ZD4i standard together with DALI-based communication ensures interoperability with a wide range of systems, making it easy to use many different applications.

In April 2023, the innovative SensorX concept was a winner in the “Mobility” category of the Zhaga Smart City Sensors Awards. SensorX will be available in limited quantities from April 2024. ■

EuroLED/SunLED, Seaborough

www.seaborough.com

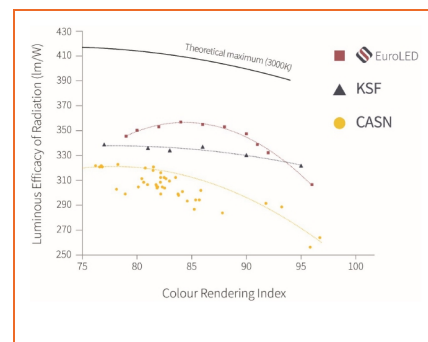
Seaborough's presence at the booth of Luminus Devices, one of SunLED's qualified component suppliers, was a testament to innovation as they demonstrated SunLED, a near-infrared light-based technology that operates beyond the visible spectrum. With a wavelength of 850nm, SunLED stands out not just for its illumination capabilities, but for its scientifically proven health benefits.

Dr. Anne Berends' presentation on Monday at the exhibitor's stage in Hall 5.0 highlighted the intersection of lighting and well-being, drawing attention from industry professionals and many fair visitors, both luminaire manufacturers and lighting designers. SunLED's potential to decrease resting heart rate, enhance mental health, and reduce inflammatory indicators was met with keen interest. The adaptability of SunLED was demonstrated in an office floor lamps and USB powered accessory, ideal for office or home study areas. The elderly care sector

also recognized the value of SunLED, envisioning reading lamps that offer therapeutic benefits alongside illumination.



Dr. Anne BERENDS explained the mechanism of Near-Infrared light.



Comparison of different LED/Phosphor technologies.

EuroLED is a new narrow-band emitter technology, based on Eu^{3+} . Eu^{3+} well known for its ultra-narrow band emission in the red spectral regio and would largely increase the efficiency of LEDs, as it radiates a much larger fraction of the light at a wavelength that could be well observed by the human eye, while also offering the possibility for a high color rendering index (CRI). The reason why Eu^{3+} is that Eu^{3+} ions do conventionally not absorb the blue light. EuroLED offers a solution to this problem and enables for the first time the use of Eu^{3+} -doped materials for solid state lighting applications. EuroLED has the potential to boost the efficiency of white LEDs by 15-20%.

EuroLED works via a nanoscale sensitization mechanism, which allows for an almost independent tuning of the absorption and emission properties. EuroLED is based on a fundamentally new nanotechnology, which allows for an almost independent tuning of the emission and excitation characteristics of luminescent materials. Conventionally, these characteristics are closely connected as they are set by the host material and active ion specie(s) doped in the host material. EuroLED separates the absorption and emission events by using two different materials, thereby opening up an entirely new range of possibilities to design these characteristics independently. ■

Bender + Wirth

www.bender-wirth.com

Bender + Wirth Celebrates 125th Anniversary!

“The only constant is change,” a maxim that holds true for the 125-year history of Bender + Wirth.



Manuela and Martin Bender in front of their company logo from 1899 at Light + Building in Frankfurt 2024.

The harnessing of duroplastics and thermoplastics, the introduction of fluorescent tubes, the invention of gas discharge lamps, low-voltage lamps, compact fluorescent tubes, and indeed, the adoption of LEDs for lighting purposes are just a few of the partly disruptive changes in the lighting industry that have occurred during the company's history.

This year, Manuela and Martin Bender, along with their team, celebrate the 125th anniversary of Bender + Wirth and the 25th anniversary of their US branch, looking forward to a future that continues to evolve. ■

Makrolon® TC, Covestro

www.covestro.com

At the Light + Building trade fair, Covestro presented a wide-ranging program of innovative material developments for the lighting and building industry, including the current trends of “electrification” and “smart connectivity”. Covestro also supports customers from conception through product and design development to commercialization.

In line with the increasing demand for more sustainable products, the company offers Makrolon® R polycarbonates made from mechanically recycled plastic waste as well as ISCC PLUS-certified, mass-balanced grades from the Makrolon® RE range using biowaste



Innovative polycarbonates for lighting technology.

and bio-residues. This range is part of Covestro's CQ portfolio of products and technologies with a minimum of 25% alternative raw materials. A current example of these products are switches and sockets from the SAGA™ series from ABB.

As an alternative to metal heat sinks, the Makrolon® TC series offers a maximum of thermal conductivity. These materials not only enable weight reduction, but also design flexibility and more energy-efficient production than with the conventional material aluminum. ■

GL OPTICAM 4.0 and GL SPECTIS 4.0, GL Optic

gloptic.com

GL Optic presents the GL OPTICAM 4.0 M SC, a luminance and color measuring device with sequential imaging, for demanding metrological applications in laboratories and industry. With its revolutionary technology, this spectrally corrected RGB camera avoids the shortcomings of previous devices and offers superior application characteristics. The OPTICAM 4.0 M SC is based on a modular technology that integrates a luminance meter and a spectroradiometer in a single housing. It enables the precise and fast measurement of luminance and color parameters for light sources of different sizes, such as LCD display panels or backlit electronic modules. This makes it ideal for light measurement applications in laboratories and industry as well as for regular quality control in production. Other application examples include the characterization of displays on display panels, for example, in vehicle cockpits, as well as the general evaluation of luminance and color uniformity of monochrome and color displays. Based on a spectral correction, the device provides precise x/y coordinates for each pixel. The unique sequential measurement method of the OPTICAM 4.0 M SC ensures higher signal levels and therefore better accuracy compared to conventional solutions with basic optical filters or beam splitters. Supported by the super-fast OPTICAM Soft 4.0 M software, luminance and chromaticity are analyzed at high speed - measurement results are available in less than three

seconds. Other features of the device, such as the built-in depolarizer and the 9-megapixel CMOS image sensor in 1-inch format, provide high dynamic range and ensure that the system is ideally equipped for current and future display measurement challenges.

At the forefront of precision measurement technology lies the GL SPECTIS 4.0 M spectroradiometer, designed to usher in a new era of accuracy and flexibility in optical radiation measurements. The primary objective in its design was to create a modular instrument that could be tailored to meet the unique needs of customers while maintaining laboratory-grade accuracy. Equipped with thermal stabilization directly applied to the detector, the SPECTIS 4.0 M effectively reduces noise and dark current values.

This enhancement significantly improves measurement capabilities for low-level signals, particularly in the ultraviolet range, such as LED UV-C, while ensuring independence from ambient temperature fluctuations. A hallmark feature of the SPECTIS 4.0 M is its variable optical path module, offering unparalleled flexibility in adjusting the system's optical properties. By simply changing the aperture and filters, users can quickly adapt the instrument to suit specific measurement needs, eliminating the necessity for dedicated probes for each application. Moreover, calibration parameters are maintained across all optical path configurations.

The SPECTIS 4.0 M is equipped with the latest optical solutions, ensuring precise light quality control across a variety of applications. Its inclusion of a Peltier module reduces measurement uncertainty by minimizing signal noise and dark current levels, making it ideal for demanding measurement tasks in both laboratory and production environments. With its universal modular design, the SPECTIS 4.0 M offers unmatched flexibility for every industry.

The SPECTIS 4.0 M stands as a testament to GL Optics' dedication to innovation and excellence. With its unmatched precision, flexibility, and reliability, it empowers users across industries to conduct high-precision light source testing with confidence and accuracy. ■

IQ System, NANOPTIQS

www.nanoptiqs.com

IQS NANOPTIQS has launched IQ System, the first nanotechnology lighting optics to be delivered as a modular kit. IQ System means lighting manufacturers and designers can now design and produce luminaires that are much slimmer, save material and energy, and provide precisely controlled light distribution for a wide variety of applications. They thus better meet the requirements for sustainable,

low-energy lighting projects while creating a more comfortable environment for users.



Presentation of the IQ System at the Design Plaza.

A luminaire built with IQ System, for instance, weighs less than 135 g per meter yet delivers over 20 lumens per gram of luminaire weight, setting a new industry standard.

IQ System consists of three components, each with a specific function:

- A reflector for primary light shaping and control.
- An antiglare cover for enhanced visual comfort and a low UGR rating.
- Nanofilm at its core enabling it to achieve supreme optical precision and desired light distribution.

Luminaire manufacturers can thus combine their own creativity with fundamentally new technological possibilities to develop their own unique solutions for galleries, showrooms, corridors, warehouses, large halls, building reception areas, and anywhere else where both visual comfort and material and energy efficiency are important.

IQ System differs from existing optical modular systems in that it is based on optical nanotechnology. The component surfaces have a structure created using mathematical algorithms on the same scale as the wavelength of light. IQS Group companies design, develop and produce these sophisticated nano and micro structures with precise architecture, using them in a range of fields from anti-counterfeiting through medicine to material engineering. Lighting technologies can thus benefit from expertise in other fields.

The IQ System solution was presented at the Light + Building 2024 trade fair in Frankfurt am Main (Germany), where it attracted great attention. IQS NANOPTIQS also introduced their innovative optics system at the fair's Architekt presentation format, earning praise for its sustainable nano-optic technology from architects and exhibitors alike. This recognition underscores IQ System's innovative approach to meeting modern design and environmental standards.

Marek Škereň, Research and Development Director at NANOPTIQS, said: "This innovation represents years of dedicated effort and marks a significant advancement in lighting technology. Our journey involved a

rigorous process of testing, refinement, and solving complex technical challenges. Through collaboration with our partners, we refined our technology to make it practically applicable and effective. The development process was both challenging and rewarding, leading us to make a notable breakthrough in lighting."

IQS NANOPTIQS is a member of IQS Group. ■

NOMUS, LEDCity

ledcity.io

Lighting accounts for up to 30% of energy costs in commercial buildings. With LEDCity's plug-and-play lighting system, you can reduce costs in no time, thanks to retrofitting. Leave the automatic regulation of light intensity and duration to the NOMUS lighting solution and save between 60% and 80% compared to modern LED lighting systems—without any loss of comfort.



LEDCity at the Light + Building 2024.

At the Light and Building event, NOMUS, their most advanced lighting system built as an all-in-one solution for entire buildings was showcased. NOMUS utilizes 'True Swarm Intelligence': employing intelligent algorithms and integrated 'computers', their luminaires communicate wirelessly with each other. Information is utilized in real-time to automatically and proactively regulate light intensity and duration, allowing the light to envelop a person's every step like a swarm. True swarm intelligence combines highly efficient lighting with an equally high level of comfort, safety, flexible settings, and customized functions. Additional features like daylight control ensure that energy savings are maximized, and thanks to the IoT-based system, over-the-air updates, remote configuration, and even remote maintenance are possible: The condition of all light sources is checked daily. This means that faults are detected automatically, rendering tedious inspection rounds a thing of the past.

The comprehensive sensor data collected from the lighting can be analyzed in real-time via remote access, and the energy consumption data is sent frequently, simplifying ESG reporting and laying the groundwork for further optimization. Sensor data can also be made available to partner companies through their interface (API) to

automate and optimize other areas of building technology—thus extending beyond lighting.

They also showcased that their lighting system is plug-and-play: Thanks to their modular approach with a manufacturer-independent standard, their intelligent light sources can be easily installed in existing lamp holders. This is not only simple but also cost-effective. By integrating all components into each light source, outdated lighting can be quickly converted to the latest technology with a simple retrofit.

A final highlight includes their OEM solution, the NOMUS Sensor Node DALI. Containing all sensor and control components, the Sensor Node DALI seamlessly integrates into various luminaires with its industry-standard compatibility. Design-wise appealing and with a high level of intelligence, their technology meets the highest comfort requirements while simultaneously combining energy efficiency and convenience. ■

Low Blue Light Street Lights, EDISON OPTO

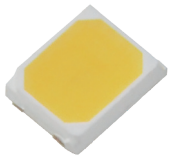
<https://www.edison-opto.com>

Harnessing the Power of Color Temperature for Environmental Protection: Low blue light technology directly addresses biological rhythms by minimizing the blue light component in LED lamps. This adjustment helps regulate the natural sleep-wake cycles (circadian rhythms) of humans, animals, and plants. Excessive exposure to high-energy blue wavelengths, particularly at night, disrupts these routines. Light sources rich in blue light can stimulate the visual system, hindering melatonin production and negatively impacting sleep quality, potentially leading to sleep disorders. EDISON OPTO leverages its expertise in LED 5050 research and development, along with innovative optical lighting module solutions, to implement low-blue light technology. This approach effectively reduces the blue light ratio in LED fixtures, minimizing the negative effects of artificial lighting on humans, animals, and plants. Ultimately, EDISON OPTO's healthy lighting solutions promote natural biological rhythms, fostering healthy sleep patterns and contributing to a better quality of life for all.

The Growing Stringency of Blue Light Regulations for Environmental Protection: Major regions worldwide are taking action to combat light pollution and protect the environment. This includes stricter regulations on light sources. For instance, the European Union (EU) has established standards, while the American National Standards Institute (ANSI) (formerly the IES) in the United States and the Japanese government all mandate the use of low-blue light technology in architectural lighting. Furthermore, the Chilean

Beyond Illumination, Better Living

EDISON OPTO LED steps into an evolution of light quality and transforms illumination for a healthier living space.



- Full Spectrum CRI95, Ra>97
- Low Blue Light Hazard RG0
- 490nm Circadian Light
- MDER equivalent to sunlight

www.edison-opto.com
service-eng@edison-opto.com.tw



“Ocean Lamp” project exemplifies the global commitment to environmental well-being. This initiative aims to redesign street lights along beaches and coastlines with the intention of safeguarding coastal ecosystems. Traditional high-pressure sodium (HPS) street lights contribute to light pollution and generate excessive heat, both of which have detrimental effects on marine organisms and coastal life. The Ocean Lamp project seeks to replace these outdated fixtures with new LED street lights and incorporate low-blue light LED lighting solutions. This approach will significantly reduce light pollution and mitigate rising ambient temperatures, ultimately protecting the delicate balance of the marine environment.



EDISON OPTO leverages its expertise in LED 5050 research and development, along with innovative optical lighting module solutions, to implement low-blue light technology.

EDISON OPTO Pioneering Low Blue Light Innovations:

EDISON OPTO is dedicated to advancing low blue light technology. To achieve its target of less than 1% blue light, the company has developed a range of optional LED lighting solutions (A, B, and C) catering to the specific needs of various application markets.

- Option A: Prioritizes a prominent PC Amber color, closely resembling traditional sodium lamps. This option achieves a low color temperature (CCT < 1800K), ideal for applications seeking a familiar replacement.
- Option B: Emphasizes high color rendering (CRI ≥ 70Ra), ensuring road safety requirements are met in conventional street lighting projects.
- Option C: Focuses on maximizing efficiency while maintaining a specific color temperature. This option boasts superior performance of 130Lm/W with a glass lamp cover.

Success Story: Heľpa, Slovakia:

The picturesque town of Heľpa, nestled in Slovakia’s Brezno District, is renowned for its stunning natural landscapes. Committed to protecting this ecological treasure, the local government opted for EDISON OPTO’s professional SG Street Light Series. These street lights are ZHAGA D4i compliant, enabling smart control functions. This intelligent system automatically adjusts brightness based on traffic flow and operating

hours, optimizing energy savings. EDISON OPTO’s 5050 high-efficiency LEDs deliver energy savings exceeding 30% compared to conventional LED street lights, even during installation. Additionally, the SG Street Lights boast a DARKSKY design that minimizes upward light intrusion. This thoughtful feature creates a tranquil and comfortable nighttime environment for residents while fostering harmonious coexistence with nocturnal creatures.

Heľpa village has become a potential forerunner in Europe, implementing a comprehensive low-blue light street lamp replacement program. EDISON OPTO’s solution offers several advantages for road lighting projects, including tool-free maintenance, a variety of optional optical lenses, and high lumen output. These features, along with the low blue light technology, have garnered high praise from Heľpa village in Slovakia.

The town of Heľpa, located in the Brezno District in north-central Slovakia, is famous for its rich natural landscapes. In order to protect the ecological environment, the local government selected the EDISON OPTO professional SG Street Light Series. This street light complies with ZHAGA D4i, the smart control function which can automatically adjust the brightness of the street light according to traffic flow and operating hours to achieve energy saving. ■

Lighting the Way: Groundbreaking Trends and Technologies from Light + Building

Interviewed and Edited by LED professional

In the bustling halls of the Light + Building 2024 event in Frankfurt, the future of lighting and building technologies was not just displayed but vividly brought to life through the insights and innovations of industry leaders. This article compiles exclusive statements from pioneers at the forefront of the sector, offering a unique window into the advancements and trends shaping our environments. From the grandeur of the world's leading trade fair for lighting and building services technology, we've gathered firsthand accounts detailing each company's showcase in Frankfurt, their latest innovations on display, and their observations of overarching trends in the lighting field. These leaders, through their interviews, provide a comprehensive overview of the direction in which lighting design, technology and applications are moving; highlighting the integral role of sustainability, digitalization, and human-centric design in the evolution of our built environments. Join us as we delve into the minds and motivations behind some of the most influential companies and people in the lighting industry today, as seen at Light + Building 2024.

Alfred FELDER, Zumtobel Group
z.lighting



Dr. Alfred FELDER, CEO of Zumtobel Group.
Photo credits: Zumtobel Group, Studio Fasching.

"This year, all Zumtobel Group brands were presented in the Forum of the Messe Frankfurt, at the world's leading trade fair for lighting and building technology; a new location for the company. We were able to showcase pioneering lighting and technology solutions, shining a light on digitalization as well as reflecting the Zumtobel Group's corporate philosophy in terms of sustainability: The concept of our exhibition space combined aspects of sustainability with "lightness" in architecture. The emissions from the production of the exhibited luminaires, interior and architectural elements were documented transparently. The possibility of reuse or the use of already recycled materials applied to 85% of the exhibition space, which significantly reduced its CO₂ footprint. In this respect, we are delighted that our sustainably designed concept was awarded the first ever "Sustainable Exhibition Stand" prize by the independent jury of the Designplus Awards by Light + Building."

"There can be no innovation without considering sustainability and efficiency, always taking into account the needs of peo-

ple and nature. Light quality, an energy-efficient lighting infrastructure and of course a product design based on the Circular Design Rules – which are an integral part of our product development – for longevity are key factors for new designs. There is a clear demand for circular design and recyclable materials or products that are easy to refurbish. Another trend is acoustic lighting, which combines lighting technology with sound-absorbing qualities to reduce noise pollution, especially in open space offices. A future focus will also be on wireless IoT solutions."

"A future focus will also be on wireless IoT solutions."

ALFRED FELDER

"Another emerging trend that I have just touched on, in parallel with sustainability, is smart lighting control, which allows for a reduction in energy consumption. As part of the trade fair, the Zumtobel Group's new IoT product brand Keyture was presented for the first time to the public. Keyture is our new cloud-based connectivity and IoT ecosystem. Its intelligent key features support the Thorn and Zumtobel brands to optimize the use of their luminaires in professional sensor-supported lighting systems to enable their operation with maximum energy efficiency. We see a great future in this new IoT system that can help make an important contribution to the decarbonization of buildings. Furthermore, there is an increased desire for more flexible and modular systems, user-friendly and intuitive products, individual design and extra durability. The next generation of our successful TECTON continuous-row lighting system, announced for the first quarter of 2025 and Zumtobel bringing prestigious design firm Pininfarina on board as a partner to help, will meet these future user needs."

Hubertus VOLMERT, TRILUX

www.trilux.com



Hubertus VOLMERT, CEO of TRILUX. Photo credits: Trilux.

“We consciously chose a very open stand concept because we aim to be transparent with our customers and visitors. It’s meant to be inviting and highly structured, so our visitors can easily discern the main focuses of our work and developments. This is what we have implemented, allowing anyone at our stand to quickly see four primary areas of focus. These include the office area with our new YONOS office modular system, then our significantly advanced digital solutions: Live Link, our light management system, and TRILUX ONE, followed by the innovations for exterior lighting in the outdoor area, and the fourth focus on industry and industrial logistics.”

“In the office area, our YONOS office modular system has been completely rethought from an application point of view. We’ve deeply considered how the office world is changing. Our goal is to create living and working spaces that are so attractive that employees feel comfortable. We’ve pondered over what light needs to look like to achieve this and have captured this with the highly flexible YONOS system, which can illuminate both traditional and new office worlds and adapt seamlessly to a changing work environment.”

“The highly flexible YONOS system can illuminate both traditional and new office worlds.”

HUBERTUS VOLMERT

“E-Line Pro represents an evolution of the well-known E-Line that has been available on the market for many years. The new mounting rail features numerous technical refinements with the aim of enabling even faster installations, thus saving work time on-site and offering more flexibility in light placement. Now, a lighting fixture, a spot-light, or an IoT system can be placed at virtually any point along this mounting rail.”



Zumtobel has set the world record title for largest continuous ceiling light, measuring more than 200 m².



E-Line Pro – TRILUX has taken the highly successful European-wide continuous line to the next level.

Benjamin HEINE, ERCOwww.erco.com

Dipl.-Ing. (FH) Benjamin HEINE, Marketing & Product Management - Group Manager Content at ERCO. Photo: LED professional.

“From our perspective, it’s all about durability — utilizing products in a building for as long as possible. However, applying this concept to a trade fair booth is challenging due to its temporary nature. Therefore, we’ve explored how to translate durability into sustainability at a fair. This involves considering what we can forego, such as omitting secondary flooring and designing a booth that is reusable in its structure and internals. We utilize road cases, where products are installed, which have been and will continue to be on the road, and transport boxes from the factory, repurposing them as seating. Furthermore, the fabrics from the stand will be transformed into bags. Essentially, it’s about reusing materials of the trade fair booth.”

“We see significant sustainability benefits in using light precisely.”

BENJAMIN HEINE

“We see significant sustainability benefits in using light precisely — illuminating only where human perception requires it. This involves focusing on precision optics, emphasizing lux per watt for accent lighting over lumens per watt, and reducing watts per square meter for general lighting with a zonal approach. For general lighting the epitome of efficiency is achieved by combining the efficacy and visual comfort of downlights with the flexibility of positioning illumination only where it’s needed. This reduces energy consumption and matches the flexibility required in modern offices. Changes in layout can be easily accommodated by adjusting the lighting accordingly.”

“When asked about key trends in lighting, sustainability is the first word that comes

to mind. We need to make sure it’s not just a trend, but a permanent change. It’s exciting to see many different approaches — whether it’s product design, production methods, or application strategies. Durable products, recyclable materials and carbon-neutral production are examples that show that there are many ways to achieve sustainability. What matters is to act, not to hesitate.”

Filippo BETTINZOLI, PROLICHTwww.prolicht.at

Filippo BETTINZOLI, Head of Marketing & Product Management at PROLICHT. Photo: LED professional.

“At this year’s Light and Building 2024, amidst a spectrum of innovations, two standout developments underscore our commitment to advancing the forefront of lighting technology. The first notable innovation is the introduction of the Lullaby product family, a collaborative creation with the renowned French-Italian designer Mark Sadler. This acoustic lighting family, aptly named Lullaby, is designed to enhance office spaces with its technical prowess and high performance, while also catering to larger spaces with a cloud configuration available as a standard product.”

“The second pivotal advancement we’re excited to present is the full compatibility of our comprehensive product portfolio with the Matter control system. This integration signifies a monumental leap towards the future of lighting control, enabling users to seamlessly manage and interact with our entire catalogue through Matter. Our exhibition space features an extensive setup for visitors to experience this innovation first-hand, using iPads to control and manipulate lighting scenarios. This move towards Matter compatibility isn’t just a glimpse into the future—it’s a present reality for us, embodying our vision for the integration of smart technology in lighting.”

“A clear trend that has emerged, and one that we’re embracing wholeheartedly, is miniaturization. Our launch of the Just Black system heralds a new era for lighting solutions, featuring incredibly sleek, integrated low voltage tracks that are merely five millimeters wide. This innovation opens up a myriad of lighting possibilities, allowing

for a variety of inserts and configurations to suit any space. The move towards smaller, more discreet lighting fixtures reflects the industry’s shift towards blending efficiency with aesthetic appeal, made possible by advances in electronics and new technologies.”

“This move towards MATTER is our vision for the integration of smart technologies.”

FILIPPO BETTINZOLI

“These innovations represent the direction we believe the industry is headed, with a strong emphasis on smart control technologies. Our embrace of the Matter control system is indicative of our belief in the future of lighting—a future where ease of use, integration, and smart functionality are paramount. These trends, highlighted at Light and Building 2024, are not just about anticipating what our clients will demand but are also a testament to our dedication to leading the charge in the evolution of lighting technology.”

Clemens MÜLLER, ams OSRAMams-osram.com

Dr.-Ing. Clemens MÜLLER, Sr. Director Application Marketing Industrial & Medical at ams OSRAM Group. Photo credits: ams OSRAM.

“I think it fundamentally involves making lighting efficient and intelligent. So it’s not enough, just optimizing the LEDs on their own. Exploring the forefront of lighting innovation, we delve into the realms where complex systems and dynamic projectors from the automotive space illuminate our environments in transformative ways. These innovations offer not just aesthetic appeal but functional advantages like dynamic escape route guidance, leveraging a blend of light incentives for diverse applications including smart horticulture. Here, advanced LED solutions like the high-efficiency OSLO Square Batwing, augmented with spectral sensing, optimize growth conditions in response to natural light variability. This technology ensures that only those luminaires in shadow activate, enhancing energy efficiency and ad-

dressing the pressing challenges of rising energy costs and water scarcity affecting industrialized nations globally.”

“Central to this innovation is the decentralization of control, allowing for precise, situational lighting adjustments. This approach, powered by sensors integrated into each luminaire or driver, promises not only enhanced system responsiveness but also significant cost-effectiveness. Such decentralized systems are particularly relevant in controlled horticultural environments, aiming for maximal yield through tailored lighting, thus replacing the need for a central control unit with more adaptive, localized management.”

“This narrative extends to product highlights like the OSLON Square or Batwing LEDs, which boast unique optics eliminating the need for secondary lenses and significantly boosting efficiency. Additionally, technological collaborations have led to the development of cutting-edge sensors, such as those enabling new ways to interact with devices through optical force sensing. These innovations represent the synergy between lighting control and sensor technology, showcasing the combined strengths of companies in enhancing product offerings.”

“Innovations represent the synergy between lighting control and sensor technology.”

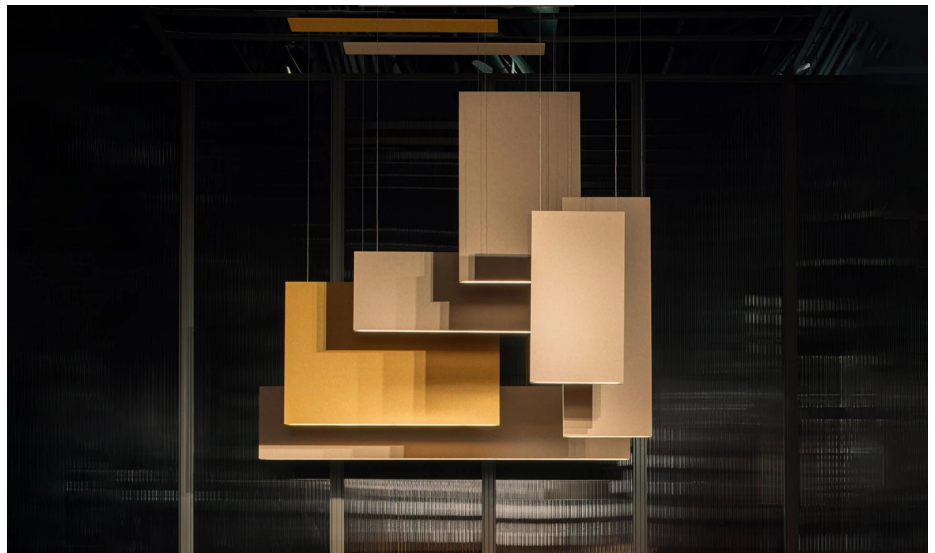
CLEMENS MÜLLER

“Moreover, the integration of components like the Mira050 CMOS Image Sensor in thermal cameras illustrates the leap in efficiency and versatility in lighting applications, from general illumination to specialized fields like horticulture and medical devices. This reflects a strategic focus on component-level innovations, smart integrations, and partnerships that foster advancements in automotive lighting, medical applications, and beyond, including wearable technologies for vital sign monitoring.”

“The transition of technologies like vital sign monitoring from consumer wearables to medical-grade devices exemplifies the crossover potential and the transformative impact of these innovations on healthcare, offering more discreet, efficient, and user-friendly solutions for continuous health monitoring. This exciting journey into the future of lighting and sensor technology underscores a commitment to smarter, more sustainable, and adaptable solutions that meet the evolving needs of a wide array of applications.”



With Axis, ERCO sets new standards in terms of lighting quality for display case lighting. It reproduces colors without distortion, highlights special details and sets impressive accents. Axis shines the light on precious exhibits: Big magic on a small stage.



LULLABY is a pendant luminaire designed by Marc Sadler. Thanks to PROLICHT’s technologies and materials, LULLABY is a masterpiece that combines sound absorption and lighting.



2D/3D camera systems based on the advanced sensor and emitter components from ams OSRAM in combination with the SoM product range from Teknique.

Kei HARAGUCHI and Takashi ONISHI, NICHIA

www.nichia.co.jp/en/



Kei HARAGUCHI, Deputy General Manager at Nichia Corporation. Photo credits: Nichia.



Takashi ONISHI, Vice President of Nichia Europe. Photo credits: Nichia.

“At Nichia, we are dedicating our time at this showcase to unveil the latest leaps in lighting technology, with a keen focus on enhancing both the efficiency and the quality of light. Our team has been hard at work to present innovations that redefine the standards of lighting, specifically targeting three key areas: efficacy of light, quality of light and space of light.”

“One of our most notable advancements is the development of LEDs that no longer force a compromise between high Color Rendering Index (CRI) and energy efficiency. Traditionally, opting for a higher CRI meant accepting a reduction in efficacy, but thanks to our innovative H6 series, this is no longer the case. These LEDs are optimized to deliver an impressive high CRI of $R_a \geq 90$, $R_9 \geq 50$, and $R_{15} \geq 85$, matching the efficacy of 80 CRI LEDs, thus eliminating the need for compromise.”

“Furthermore, Nichia is pioneering in the field of circadian rhythm lighting. We recognize the industry’s shift towards supporting human circadian rhythms through

light exposure that mimics natural sunlight. Our latest LEDs include the crucial 480 nanometer spectrum, essential for activating the circadian system, something that standard LEDs lack. This feature is especially beneficial in the morning to help stimulate wakefulness.”

“Nichia’s H6 series LEDs offer high CRI and energy efficiency without compromise.”

KEI HARAGUCHI

“In addition to supporting general well-being, Nichia has developed the Clear White LED, a lighting solution tailored to the needs of the elderly. Our research has led to the creation of LEDs that cater to the aging eye, which tends to yellow over time, requiring light with a specific spectrum for clearer vision. Our in-depth testing has shown that elderly individuals overwhelmingly prefer the lighting conditions created by our specialized LEDs, noting improvements in activities such as reading and dining.”

“Nichia is also leading the way in integrating these advanced lighting solutions into architectural designs. We’re not just focusing on the light itself but also on how it’s delivered. Our innovations allow for more flexible and less intrusive installation methods, significantly reducing the weight of lighting fixtures and overall installation costs. Our new Cube Direct Mountable Chip and Nichia Light Cluster Type L represent eco-friendly LED technology that allows for the creation of smaller, more efficient luminaires. This boosts design flexibility and reduces material use.”

“Our approach to lighting extends beyond lm/W.”

TAKASHI ONISHI

“Our approach to lighting extends beyond lumens per watt. At Nichia, we advocate for a more holistic consideration of lighting—emphasizing the right shade and intensity of light to enhance overall efficiency and the environmental compatibility of our installations. This perspective is crucial as the industry moves towards more sustainable practices, reducing energy consumption and minimizing waste.”

“Nichia’s commitment to innovation is evident in our comprehensive approach to lighting. From enhancing visual comfort for the elderly to pioneering circadian rhythm support and sustainable installation tech-

niques, we’re setting new industry standards. Looking forward, Nichia envisions a future where lighting solutions are not just more efficient but also more attuned to human needs and environmental sustainability, marking a new era of lighting technology that promises to transform our experience of light.”

Daniel HAN, YUJILEDS

www.yujiintl.com



Daniel HAN, VP & Co-founder of YUJILEDS (right). Photo credits: Yuji Group.

“Our aim is to manifest our philosophy and the concept of wellness through innovative lighting technologies. Utilizing diverse approaches within each technology, such as the FlameWarm, Well24, and the SunWave, we strive to craft lighting experiences tailored for relaxation, pre-sleep preparation, focus, and daily use across both residential and commercial settings. The core objective is to articulate our unique perspective on wellness lighting.”

“FlameWarm™ offers an M/P ratio of 0.099; significantly lower than a candle.”

DANIEL HAN

“Addressing the inquiry regarding key trends in lighting from a broader perspective, I am of the view that future advancements should increasingly center on the well-being of the human body. Historically, the emphasis has largely been placed on efficiency and energy savings – aspects undeniably critical. However, as we transition into a new era of lighting technology, it becomes imperative to prioritize the health implications of lighting on the human body more significantly. We are witnessing a surge in smart lighting and control systems designed to enhance human wellness. Therefore, it is my belief that focusing on the intersection of lighting technology and human health will emerge as a dominant trend in the foreseeable future. Indeed, this direction holds great promise for the future of lighting.”

Martin HUBER, Amrax

amrax.ai



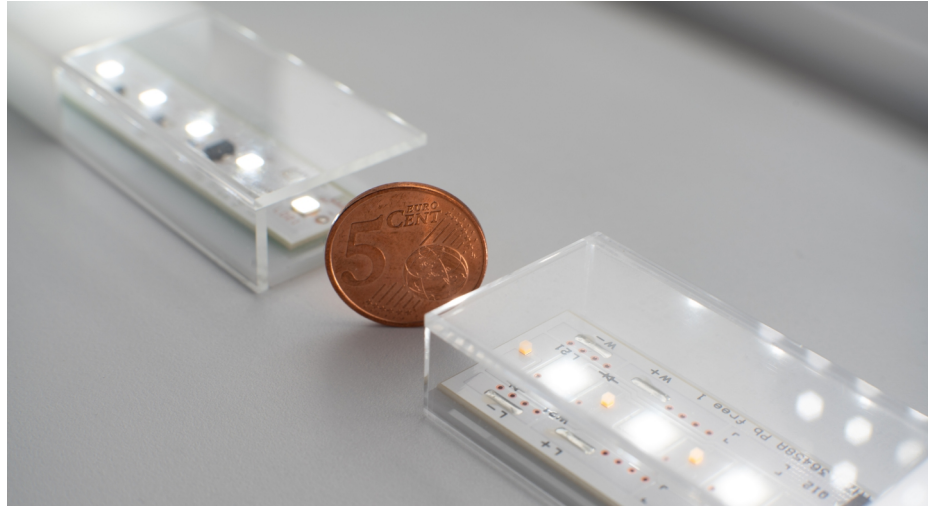
Martin HUBER, CEO und Co-Founder of Amrax. Photo credits: Amrax.

“The Light & Building event in Frankfurt is an amazing opportunity to see the breadth of innovation taking place in the lighting industry. For Amrax, we were able to showcase how our app can enable users to fully optimize their lighting plans to create designs that are not only much more cost effective and sustainable but also innovative and aesthetically pleasing. Following our recent partnership with Relux, designers can now export 3D scan data from Amrax’s Metaroom Studio open directly to Relux’s light planning software. This enables a fast creation of precise and detailed light and sensor plans for each room. Users can seamlessly integrate true-to-scale 3D models of rooms or entire buildings, including detailed information on measurements, dominant colors and furniture into Relux’s light planning software. Hundreds of people visited our stand to experience this solution and we saw an unprecedented surge in downloads from across the world.”

“Now, designers can export 3D scan data from Amrax’s Metaroom Studio directly to Relux’s light planning software.”

MARTIN HUBER

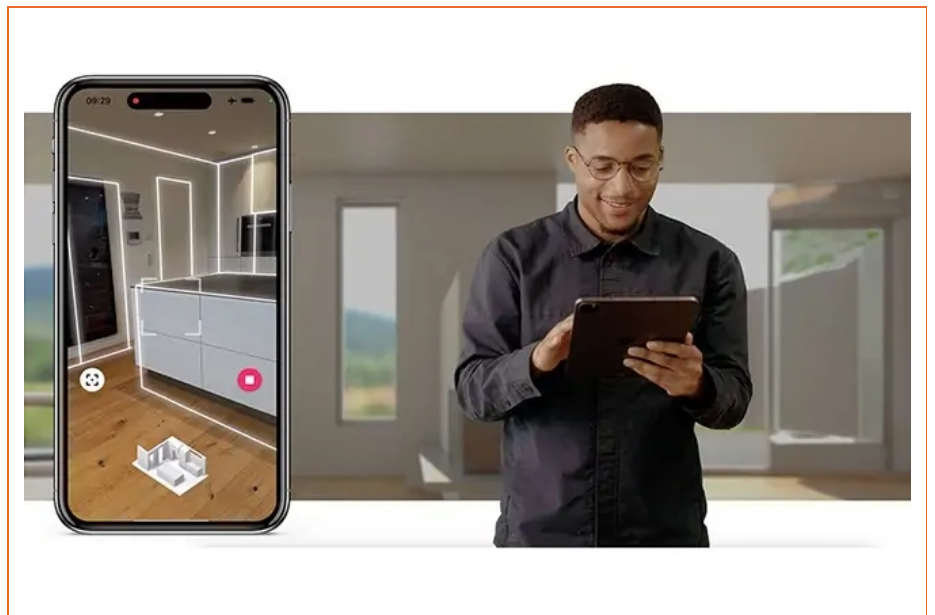
“With more than 2,000 exhibitors and 150,000 visitors, the Light & Building event provided a huge amount of insight into major trends that will transform the lighting industry over the next few years. It isn’t a surprise to learn that AI was top on the minds of people - it’s already being used in a range of solutions from 3D mapping to smart lighting - but there was plenty of debate on what might be next - particularly regarding real time monitoring and



Nichia’s Cube Direct Mountable Chip (shown right), compared to a conventional LED (shown left), is characterized by its ultra-wide light distribution.



YUJILED'S SERENITY Lamp – Designed with well-being in mind, the lamp promotes relaxation, focus, and better sleep, effortlessly. Based on the FlameWarm LED Technology from YUJILED'S.



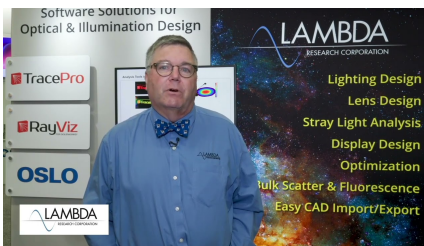
METAROOM by Amrax. The world’s first multi-room scanning. Ideal for AEC industry, BIM, facility management and WiFi Network planning. It enhances accuracy and productivity in your spatial planning projects.

coordination of the internal environment of buildings.”

“What was very encouraging to see is that sustainability and energy efficiency was one of the major themes. There were reusable and recycled solutions and most exhibitors talked about how their products prioritized enhancing energy efficiency. One of the most notable innovations on show was the thinner components used in lighting hardware. This opens the door to even more design options and clever lighting solutions. If you put all of these major trends together - AI, 3D design software, smaller devices, and the sustainability drive, you can see how we experience lighting in buildings is going to change. For example, we will move from most offices dominated by troffer lighting to a host of different systems that interconnect and take into account in real time how a space is being used to maximize efficiency.”

Dave JACOBSEN, LAMBDA RESEARCH

lambdares.com



Dave JACOBSEN, Director of Sales and Application Engineering at Lambda Research. Photo credits: Lambda Research.

“We are witnessing an increasing interest in the exploration of diffractive surfaces for illumination applications. Innovations such as holographic optical elements, computer-generated holograms, zero-order diffractive phase surfaces, and now, metallic surfaces, are being considered for their potential. The aspiration behind these advancements is to afford lighting designers and optical engineers enhanced control over light distribution. The goal is to achieve this through optics that are not only smaller and more adaptable but also more economically feasible to produce. This direction aims to broaden the scope of possibilities while streamlining design processes to achieve compactness and efficiency.”

“Lighting designers seek enhanced control over light distribution.”

DAVE JACOBSEN

“Looking forward, we anticipate this trend to significantly shape the future of lighting and optical design. Accordingly, we are directing our software development efforts to support and enhance these innovative features, aiming to meet the evolving needs of the industry.”

Jessica van HECK, PHABULOUS

phabulous.eu



Jessica van HECK, COO of PHABULOUS Photo credits: Phabulous.

“PHABULOUS specializes in producing free-form micro-optical components to enhance light forming efficiency and optimize compactness. The benefits of free-form micro-optics in lighting technology include improved efficiency, color mixing, customizable light direction, and global lighting uniformity—all while prioritizing compactness. We are thrilled to be present at Light and Building, showcasing our demonstrators that utilize freeform micro optics in both luxury automotive and general lighting applications. It’s highly encouraging to receive feedback and observe the growing interest among companies in adopting micro optics as an innovative solution. This technology enables the creation of distinctive features and specialized light direction for luxury applications. We are eagerly anticipating a more active engagement in this market.”

“The benefits of free-form micro-optics in lighting technology include improved efficiency, color mixing, customizable light direction.”

JESSICA VAN HECK

“The PHABULOUS Pilot Line made its debut at Light and Building, and we were pleasantly surprised by the warm reception of our services. Throughout the week, the standout attraction at our booth was undoubtedly the sparkling and beautiful demonstrator from Swarovski. Free-form micro-optics have various applications, and we received requests from a range of companies, including producers of light

signs for retail and manufacturers of down-light LEDs seeking optics smaller than 10 mm (which is even large for us!) or reading lights for aerospace environments. Now, we need to study if our technology can meet their requirements.”

Summary

At the Light + Building show in Frankfurt 2024, industry leaders from across the globe came together to showcase a series of innovations that signify a significant shift towards sustainability, digitalization, and human-centric design in the lighting and building technology sectors. The event was a melting pot of ideas, with a clear emphasis on the integration of smart technologies, the advancement of sustainable materials and practices, and the enhancement of light quality and control for both efficiency and user well-being.

A central theme was the pioneering use of sustainable and circular design principles, evidenced by award-winning exhibition concepts that combined architectural lightness with environmental responsibility. These concepts were not only about reducing the carbon footprint but also about showcasing the potential for reuse and recycling in the construction of exhibition spaces. Innovations in LED technology, which no longer force a compromise between high Color Rendering Index (CRI) and energy efficiency, were highlighted, marking a significant advancement in lighting design that meets both aesthetic and environmental standards.

The introduction of acoustic lighting solutions reflected a growing trend towards creating more comfortable and productive environments, particularly in open office spaces. This, coupled with the debut of new IoT brands and systems, underscored a significant push towards optimizing lighting systems for energy efficiency through smart, sensor-supported solutions. The discussion around IoT and cloud-based connectivity further indicated a move towards more integrated, intelligent building management systems capable of contributing to the decarbonization of buildings.

Moreover, the event spotlighted the importance of flexible, modular lighting systems that cater to changing work environments, with designs that prioritize user friendliness, individual customization, and durability. The commitment to sustainability was also evident in discussions on precision optics and the use of light to support human cir-

adian rhythms, with innovations designed to enhance well-being and visual comfort across various age groups.

The show was not just about presenting new products but also about envisaging the future of lighting and building environments. The drive towards miniaturization, evident in the development of sleek, low-voltage lighting solutions, and the integration of advanced control systems like Matter, showcased a future where lighting is not only more efficient and discreet but also more responsive to human needs and environmental imperatives.

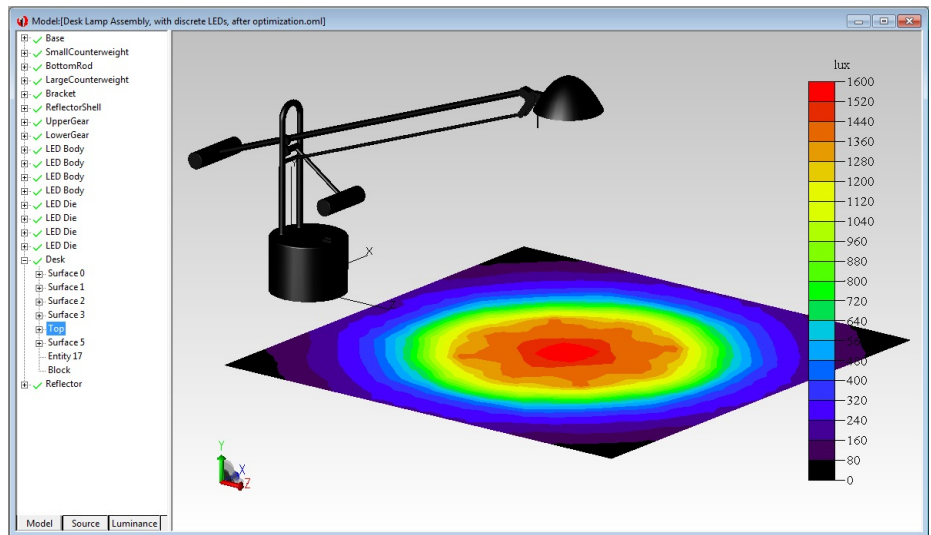
In essence, the Light + Building show in Frankfurt 2024 painted a picture of an industry at the forefront of technological and sustainable innovation. It showcased a collective vision for a future where lighting and building technologies not only enhance the quality of human life but do so with an acute awareness of their environmental impact, paving the way for a more sustainable, efficient, and human-centered approach to lighting and building design.

“A special thank you to all the companies and their representatives for their valuable time and insightful interviews.”

LED PROFESSIONAL

Zumtobel Group and Dr. Alfred Felder, CEO; TRILUX and Hubertus Volmert, CEO; ERCO and Dipl.-Ing. (FH) Benjamin Heine, Marketing & Product Management - Group Manager Content; PROLICHT and Filippo Bettinzoli, Head of Marketing & Product Management; ams OSRAM and Dr.-Ing. Clemens Müller, Sr. Director Application Marketing Industrial & Medical; NICHIA with Kei Haraguchi, Senior Lighting Consultant and Deputy General Manager, and Takashi Onishi, Vice President of Nichia Europe; YUJILEDS and Daniel Han, VP & Co-founder; Amrax and Martin Huber, CEO and Co-Founder; Lambda Research and Dave Jacobsen, Director of Sales and Application Engineering; PHABULOU S and Jessica van Heck, COO.

Their expertise and innovations are driving the future of our built environments towards more sustainable, efficient, and human-centric designs. Thank you for sharing your visions and advancements with the community. ■



Trace Pro from Lambda Research combines Monte Carlo ray tracing, analysis, CAD import/export, and optimization methods with a complete and robust macro language to solve a wide variety of problems in illumination design and optical analysis.



Throughout the week, the standout attraction at the PHABOLOuS booth was undoubtedly the sparkling and beautiful demonstrator from Swarovski.



From Alarming Figures on Lighting Non-compliance to Constructive Solutions

LightingEurope, Elena SCARONI

LightingEurope returned to Light + Building in 2024, hosting an event titled 'From the EU Green Deal to the LightingEurope Strategy 2030' at the fair in Frankfurt on March 5th. The main focus of the event, with approximately 100 attendees, was the enforcement of sustainability regulations relevant to lighting products. It also marked the first public unveiling of LightingEurope's new 2030 Strategy and its recommendations for the upcoming EU Institutions' mandate from 2024 to 2029.



Elena SCARONI, Secretary General of LightingEurope.

LightingEurope's Strategy Towards 2030

In its new Strategy 2030, finalized at the end of 2023 and published in early February on our website [1], LightingEurope is to become the platform where the whole lighting industry can speak with one voice, cooperate, and advocate the value of sustainable and better lighting across the whole value chain and with end-users.

LightingEurope has agreed on four key objectives to implement its new vision and mission. The new objectives will make sure that in 2030 lighting is a key element in new and renovation construction projects, that the lighting industry can be supported by good rules that are well implemented.

In its new mission, LightingEurope will integrate its traditional role supporting policy makers in shaping rules and policies on lighting with the new key objectives.

LightingEurope's Political Manifesto

2024 is the year of the European elections, with new political decision-makers and a new political program to be put in place by the new European Commission, a new European Parliament, and new leadership from the Member States at the European Council level. This is why LightingEurope is publishing a Political Manifesto [2] containing our demands to political decision-makers.

The Enforcement of EU Rules

The event showcased the findings of the EEPLIANT 3 project, the latest EU-wide effort on market surveillance. Ronald Piers de Raveschoot, Policy Officer at the European Commission explained that EEPLIANT 3 employs a risk-based strategy, conducting various checks on products like lighting to enforce EU energy labelling and ecodesign regulations.

The results for lighting products are concerning, with high rates of non-compliance across different checks: 98% (187 out of 191) of the targeted models failed the documentary check, 96% of the models (239 out of 249) checked in 83 online shops were missing information requirements (label, PIS...) and 68% of the models (54 out of 80) failed the product tests.

LightingEurope also conducted compliance monitoring. In the latest edition of our Mystery Shopper Exercise [3], both the GLS lamps and the desktop luminaires performed poorly. 71% of products checked online were not compliant and 95% of products delivered and physically checked were not compliant.

These findings highlight the ease of purchasing non-compliant lighting online, underscoring the need for EU-wide enforcement mechanisms to ensure product compliance. EU legislation must ensure that there is always a liable economic operator in the EU for product compliance. In our manifesto for the upcoming mandate 2024-2029, LightingEurope is asking for the re-opening of the Digital Services Act to address this issue.

[1] [LightingEurope's Strategy 2023](#)



[2] [LightingEurope's Political Manifesto](#)



[3] [Mystery Shopper Exercise](#)



In a panel debate, LightingEurope asked a panel of experts how to better enforce rules on sustainable products.

Our panel was made up of Holger Dickert (Responsible for Market Surveillance of ecodesign products in the Hessen State in Germany), Ronald Piers de Raveschoot (Officer at the European Commission – Dg Energy), Tanguy Griffon (Vice President in charge of Sustainability at Sonepar), Sylvia Maurer (BEUC - The European Consumer Organisation), Marieke Hoffmann (Deutsche Umwelthilfe, a German Environmental NGO), Marc Guiraud (EucoLight), Kevan Shaw (International Association of Lighting Designers (IALD)), Teresa Selvaggio and Alfredo Menghini (from LightingEurope).

Both short-term and long-term solutions have been proposed, for example:

- To require online platforms to check that companies selling on their platform are registered for WEEE and have a representative in an EU country (following the German WEEE law).
- To make online platforms liable for non-compliant products if there is no liable actor (based on existing French law).
- To raise public and political concern, highlighting that non-compliant products can also be dangerous or fail to contribute to climate and environmental objectives, thus harming the overall efforts of all actors. Higher contributions to CO₂ objectives should instead be rewarded.
- To continue efforts in educating the market via FAQs and Guidelines following the work being done by the European Commission and by LightingEurope.
- To ensure a greater cooperation between surveillance and customs authorities, sharing data and coordinating sanctions.

Smart Lighting Systems

Paolo Bertoldi from the European Commission's Joint Research Centre offered insights into ongoing research on smart lighting systems. He estimated a substantial rise in demand for lighting services over the next 15 years, leading to a significant expansion of the smart lighting market. Bertoldi underscored the imperative of transitioning to smart lighting applications to effectively reduce energy consumption and associated greenhouse gas emissions in the lighting sector. Key drivers of this transition include the necessity for energy-efficient lighting solutions and the growing adoption of human-centric lighting. Smart

lighting is poised to play a central role in the integration of IoT technologies and the development of smart cities and buildings.

The Engagement of LightingEurope in the Harmonization of PSR Rules for Lighting Products

The event at Light and Building was the opportunity to inform the industry of the engagement of LightingEurope towards harmonization of Product Specific Rules for lighting products.

A further significant step towards strengthening the environmental profile of the lighting industry was taken with the successful revision of the Product Specific Rules

(PSR) for Luminaires. LightingEurope and its members played a crucial part in driving this revision that not only responds to the increasing demand for quantifiable and comparable environmental performance of lighting products, but also responds to the nature and market circumstances of the lighting industry. The next step will be the transposition of these rules into international standards which will further support the comprehensive and transparent delivery of information on the lifecycle of luminaires benefiting manufacturers, regulators, and customers. ■



Results of the second mystery shopper exercise performed in 2023.



LightingEurope event titled 'From EU Green Deal to the Lighting Europe Strategy 2020' at Light + Building 2024 in Frankfurt.

Zumtobel and Pininfarina: Lighting Technology Pioneer Partners up with Design Expert to Shape the Future of Lighting

Zumtobel

Light + Building 2024 was a great success for Zumtobel: Not only did the lighting specialist achieve a Guinness World Records title for the largest continuous illuminated ceiling, but the company also announced a partnership with Pininfarina, a brand recognized all over the world for their design expertise. Together, the integrated lighting solutions provider and the Italian design studio will expand the portfolio of Zumtobel's successful TECTON continuous-row lighting system, with the launch of TECTON II announced for the first quarter of 2025.

Zumtobel and Pininfarina are both well-established companies synonymous with high standards of quality and design, as well as innovation and progress. Founded on shared values and combined expertise in design, architecture, industry and technology, the collaboration is focused on expanding and upgrading the TECTON continuous-row lighting system, helping the partners to meet future lighting requirements and to respond to changing customer needs in terms of flexibility, user experience and design.

TECTON – A Benchmark for More than Two Decades

For over 20 years, the modular TECTON [1] product family has been making buildings of all kinds shine in top-quality light. The universal trunking system incorporates lighting, controls and emergency/safety lighting. Tool-free installation is also a key factor in the TECTON system's success. Eleven ports allow for connecting a range of different luminaire types, emergency lighting, sensors, and other IoT components. Zumtobel's innovative concept and accompanying digital services serve as the foundation of a smart building structure and offer huge potential for digital applications in the future.

The Next Evolution of TECTON

While the first generation of the TECTON continuous-row lighting system was developed more than 20 years ago, it features state-of-the-art technology today. Over the last two decades, Zumtobel has continu-

ally modernized TECTON and equipped it with the latest technologies. Now the new generation of TECTON is ready to go, with Zumtobel bringing prestigious design firm Pininfarina on board.

"As we launch the next generation of TECTON, we want to continue offering planners, architects, installers, retailers and end customers industry-leading lighting solutions that are perfectly equipped to meet the requirements of the future," explains Andreas Fussenegger, Director of Product Management at Zumtobel. TECTON II considers users' need and increased desire for more flexible, user-friendly, and intuitive products, individual customization, modern design, improved sustainability and increased durability. Fussenegger adds: "All the lighting components of the new generation will be backward-compatible. The TECTON projects are and will always be future-proof. Our expanded range can be used to upgrade existing lighting solutions with the latest technology at any time."

Zumtobel and Pininfarina: A Luminous Match

To find a suitable partner for the development of TECTON II, Zumtobel adhered to clearly defined criteria. For the expansion of the TECTON portfolio, Zumtobel was looking for a partner who shares their brand values of innovation leadership, quality, and design requirements. The company also needed to cover different specialist disciplines, approach the project from a neutral outside-in perspective, and to demonstrate ways and means of optimizing the user experience.

“In Pininfarina, we have gained a partner who fulfills all of these requirements perfectly. The prestigious design firm impressed us across the board, particularly with its forward-looking approach to user experience,” says Alfred Felder, CEO of the Zumtobel Group. “Our collaboration with Pininfarina aligns extremely well with the values and long-term vision of the Zumtobel brand.” A major advantage of the collaboration is that Pininfarina has an extensive, diverse pool of experienced architects and product design specialists at its disposal.

“Develop the best into something better.”

SILVIO ANGORI, CEO OF PININFARINA GROUP

Pininfarina is a brand name that evokes emotion, especially in car enthusiasts since the company initially made a name for itself in the automotive industry thanks to clear design language with high levels of brand recognition. “We are now bringing our ideas and concepts to lighting and architecture. Partnering with Zumtobel allows us to help shape the future of lighting, generate innovation and develop the best into something better,” says Silvio Angori, CEO of Pininfarina Group. “We look forward to continuing our collaboration with Zumtobel, which has gotten off to a constructive and smooth start.”

One thing Pininfarina and Zumtobel definitely agree on: the lighting products must be sophisticated and timeless – and remain discreetly in the background. “We want lighting that doesn’t polarize opinion, isn’t a fad and won’t lose its impact, even after five years,” says Andreas Fussenegger. ■



Thomas Ölz, VP Brand & Application at Zumtobel; Silvio Angori, CEO Pininfarina Group; Alfred Felder, CEO Zumtobel Group at Light + Building 2024, announcing the partnership between Zumtobel and Pininfarina (left to right). Photo credits: Andrzej Siegmund.



Thomas Ölz, VP Brand & Application at Zumtobel; Silvio Angori, CEO Pininfarina Group; Alfred Felder, CEO Zumtobel Group (left to right). Photo credits: Andrzej Siegmund.



References

[1] TECTON. <https://z.lighting/de/zumtobel/produkte/tecton>.



To celebrate the partnership, Pininfarina exhibited their hydrogen-fueled racing car Pininfarina H2 Speed. Photo credits: Andrzej Siegmund.





This photo, as well as the cover of this issue feature the Gallery Xavier Hufkens, in Brussels. Photos: Thomas Mayer, Neuss/Germany. ERCO products: Eclipse inTrack, Jilly. (c) ERCO GmbH. www.erco.com

Free-form Micro-Optics in Automotive Applications

Dr. Daniela KARTHAUS, Lighting Technology & Optics Expert at FORVIA HELLA

The automotive industry is constantly evolving, and new developments in light sources have sparked a number of trends that are changing the look and feel of vehicles. From narrow bands of light to homogeneous luminous surfaces, automakers now have a range of styling options available to give their vehicles an elegant and sophisticated aesthetic. In this article, we will look at one optical technology for realizing such trends in automotive lighting technology: free-form micro-optics.

Current Standard: Free-form Macro-optics in Automotive Lighting Systems

Classic free-form macro-optics have been used in automotive lighting for many years. In addition to free-form reflectors, typical applications include total internal reflection (TIR) optics and imaging optics used in headlamp systems, as shown in **Figure 1**. Regardless of the field of application or the specific shape of the optics, free-form macro-optics have the advantage that they can be manufactured with typical process standards for automotive optics manufacturing, i.e., injection molding. But they also have a decisive disadvantage in that they are macro. In terms of styling, this means that the optical elements themselves as well as the free-form macro-structures on surfaces are visible even from a great distance. This is no longer compatible with current styling trends, which focus on the visual integration of optical systems into the vehicle body or completely hiding them from view.

Potential Fields of Application for Free-form Micro-optics in Automotive Applications

The advantage of micro-optics is that they not only offer the possibility of reducing the dimensions of the optics, but they can also optimize the optically effective surfaces with regard to the visibility of curvatures or structures. Free-form micro-optics thus combine the design freedom of free-form optics and the advantages of micro-optics, and the resulting potential for various application fields is enormous.

As regards automotive, a top field of application for free-form micro-optics is their use as diffuser optics to create homogeneous luminous surfaces and in recent years, FORVIA HELLA has developed their FlatLight family of technologies to realize

such luminous surfaces with particularly low installation space (**Figure 2**).

The FlatLight family includes the FlatLight μ MX consisting of a light guide with multiple optical layers. These optical layers use different freeform micro-optics and diffuser optics to realize an impressive homogeneity in combination with great efficiency. With this approach the required installation space is reduced by up to 90%, to just 5 mm and compared to conventional LED taillights FlatLight μ MX requires up to 80% less energy while maintaining the same performance and homogeneity. For this impressive technology, FORVIA HELLA recently received the CES 2024 Innovation Award in the category "Vehicle Tech & Advanced Mobility". But there are many other applications in which free-form micro-optics can enable new developments, such as sensors, displays, beam shaping, compensation of color aberration and projection optics. The reason why free-form micro-optics are not already widely used in automobiles is due to the various requirements placed on optical components in the automotive environment. These include high optical surface quality; cost effective mastering and series production comparable to injection molding; and the need for automotive certified materials that can withstand automotive environmental conditions. Additionally, 2D, 2.5D and 3D curved substrates are required to enable visual integration of optics into the car body as well as the fabrication of large-scale optics, e.g., tail or car body lamps. Finally, there is the issue of data handling of large-scale optics to simulate the entire lamp system, e.g., for stray light analysis and the interface for design and simulation tools to avoid data errors due to long tool chains.

While not all requirements have to be fulfilled for every application, a combination of at least four of them are always considered when integrating free-form micro-optics into an automotive lighting system. The problem here is that although there are enough companies specialized in one or

more of the requirements, the challenge is to find these companies, and then link their competences to a process chain that works for series production. These challenges lie outside the scope of individual companies, and this is where the PHABULO μ S pilot-line comes into play.

PHABULO μ S Pilot Line

PHABULO μ S was set up in 2020 by the EU with the aim of creating Europe's first pilot line for the manufacture of free-form micro-optical components by UV replication technologies (wafer-scale, roll-to-plate, and roll-to-roll) with a clear roadmap for high volume production at competitive cost.

From the outset, FORVIA HELLA has been one of the use-case partners and works together with the pilot-line partners on the development of a new freeform micro-optics system for headlamp applications. FORVIA HELLA's idea is to use the light input side of the component as primary optics and the light output side as secondary optics to shape the light distribution. Both high and low beam distributions have been investigated with different optical structures

as part of the project. In initial testing, a micro-Fresnel lens was used on the first surface and a free-form facet structure was used on the second surface. **Figure 3** shows an example of a facet structure for generating a low beam distribution.

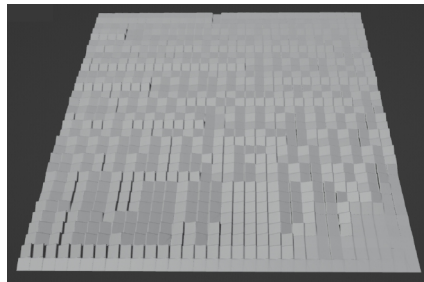


Figure 3: Example of a first state free-form micro-optic with a facet structure to generate a low beam distribution.

For the first fabrication step, the mastering, different partners of the pilot-line analyzed the structures regarding their origination capabilities. The mastering of the facet structure was a challenging task due to the steep edges and the different orientations of the 300 μ m large facets in combination with the required surface quality. FORVIA HELLA's partners for the replication are SUSS MicroOptics and Nanocomp, who both proved that their processes meet the

requirements. **Figure 4** shows a replica from Nanocomp, which is no larger than a one cent coin, and in the case of using the R2R process, even thinner!

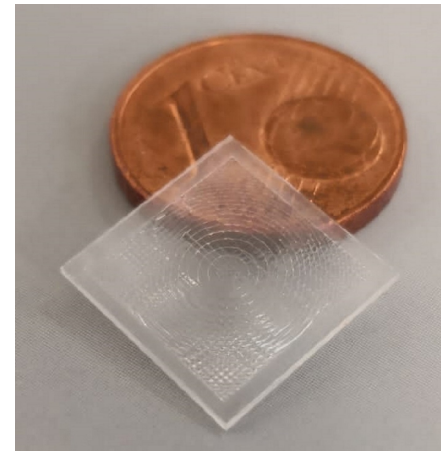


Figure 4: Example of a double-sided free-form micro-optic replicated by Nanocomp - as small as or even thinner than a one cent coin.

Even though the replicas are convincing in terms of their optical quality, the light distributions generated by different tested components have not yet reached the standards for automotive products. This is due to a combination of available algorithms for calculating the free-from micro-structures

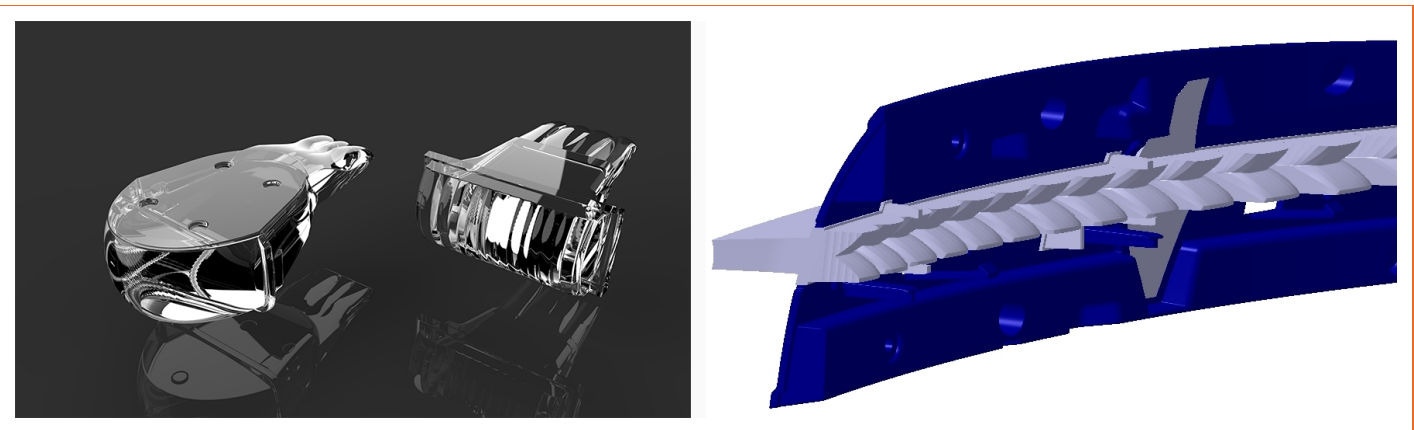


Figure 1: Examples of free-form macro-optics in headlamp (left) and rear lamp (right) applications.

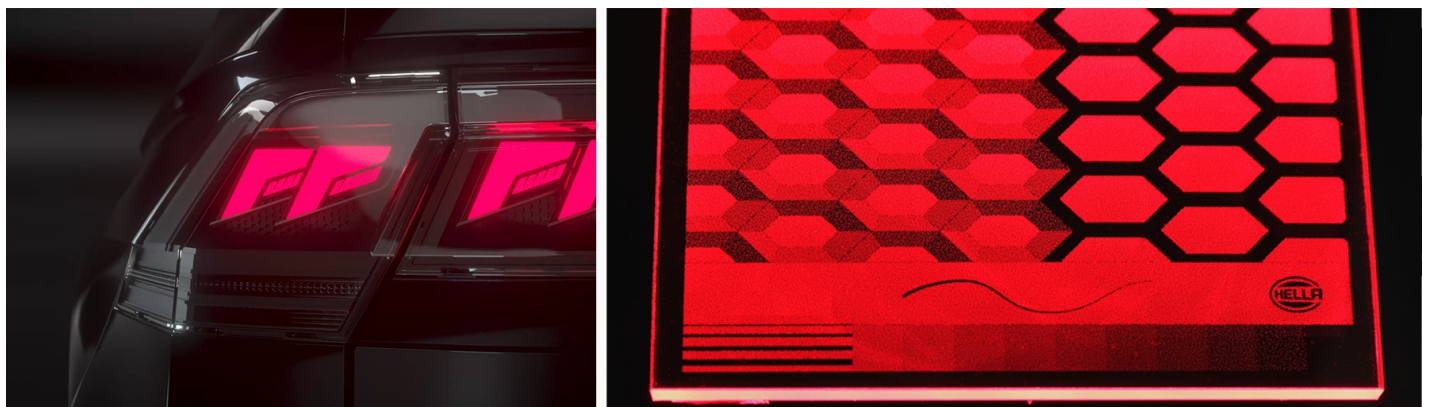


Figure 2: Images of the HELLA FlatLight| μ DO (right) and FlatLight| μ MX (left) variants, both of which use free-form micro-structures.

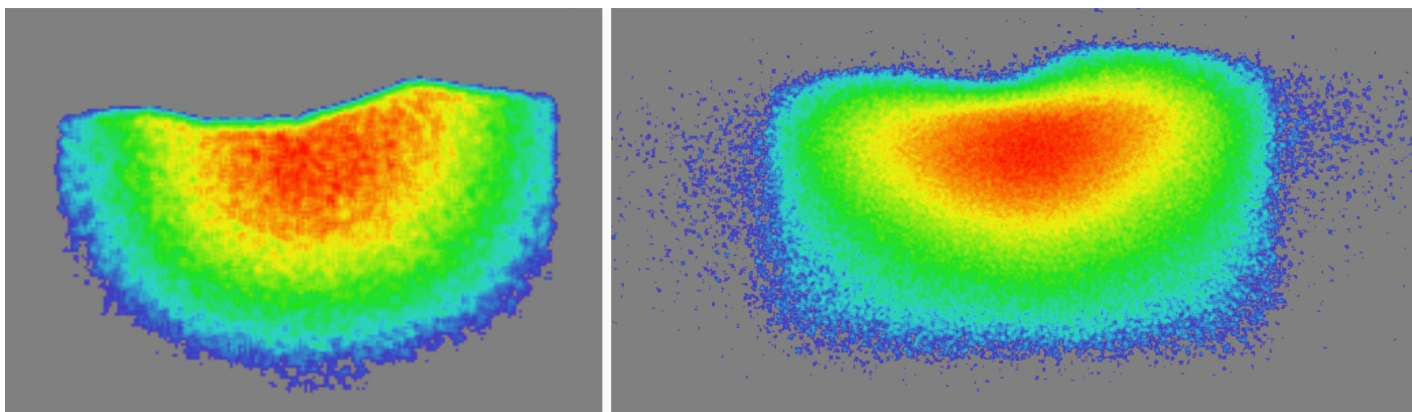


Figure 5: Simulated light distributions of a free-form structure to generate a low beam distribution. Left: ideal illumination, right: illumination with a standard automotive LED + classic primary optics.

and the approximations of the incoming light. But these are general problems as they have already been observed for other micro- and nano-optics and so the challenges will need to be addressed independently from the PHABULO μ S project.

Although FORVIA HELLA's use case for the PHABULO μ S project is particularly challenging for automotive lighting, other applications with less demanding requirements that do not need hard cut-offs could be easily implemented with this technology. Even though the headlamp use case still needs further developments, the potentials proofed by simulations and FORVIA HELLA's results with their FlatLight technology should be enough to encourage everyone working with lighting technology to embrace free-form micro-optics as the technology for the future. ■



Dr. Daniela KARTHAUS
Lighting Expert, FORVIA HELLA

Daniela KARTHAUS works in the Innovations department at FORVIA HELLA and is an expert in lighting technology and optics. She evaluates new technologies for automotive lighting applications, has several years of experience in micro- and diffractive optics and did research on holography for her PhD. Since January 2020, she has coordinated FORVIA HELLA's activities in the PHABULO μ S projects.

About FORVIA HELLA

FORVIA HELLA is a listed, international automotive supplier. We are a company of the FORVIA Group, the world's seventh largest supplier of automotive technologies. As a global market leader in high-growth areas, FORVIA employs over 150,000 people worldwide. FORVIA HELLA therein stands for high-performance lighting technology and automotive electronics. At the same time, we cover a broad service and product portfolio for the spare parts and workshop business as well as for manufacturers of special vehicles with our Business Group Lifecycle Solutions.

About PHABULO μ S

PHABULO μ S is the one-stop-shop for free-form micro-optics, taking designs and prototypes to large-scale manufacturing. They have launched an open call to support the industry with the implementation and integration of free-form micro-optics, to bring your product to volume markets. This open call aims to support Europe's early adopters of our pilot line services to move towards volume production of free-form micro-optical components. Do you have a design and/or prototype and are looking to move your development into pilot or large-scale production?

The PHABULO μ S value chain consists of Europe's leading Companies and Research & Technology Organizations allowing for seamless development from early phase proof-of-concept to regulated pilot production. Depending on the phase of the development and market application, a technical team and prime contractor are selected, who will help the companies to verify the technical requirements and support the company by making a design and/or prototype suited for large scale manufacturing.

Up to 3M€ of funding is available to support a minimum of 20 pilot cases / early

adopters. They will be selected within the project to implement free-form micro-optical components and integrate that into their product developments with the aim to go towards large-scale production. The exact amount of subsidies per applicant will be decided based upon the type of company and the three main selection criteria. For each pilot case, an in-kind contribution from applicant is also expected.

For more information about FORVIA HELLA and PHABULO μ S please visit:



<https://www.hella.com/en>



<https://phabulous.eu/>





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Horticulture LEDs to Boost Vertical Farming Efficiency

Alexander GERFER, Adithya MADANAHALLI, and Johann WALDHERR from Würth Elektronik eiSos

With the growing world population and global warming, arable land and fresh water are becoming increasingly scarce [1]. Many new approaches will be needed in agriculture. One of these is Controlled Environmental Agriculture (CEA). Würth Elektronik offers Horticulture LEDs and promotes the use of plant- and growth-specific light recipes. Engineers at the company have thought about how the control of a CEA could be realized as an IoT application.

One of the Controlled Environmental Agriculture solutions is indoor vertical farming. In "vertical farms", fresh, nutritious food can be grown locally for people, e.g., in urban areas. This method of growing is also possible in regions of the world where conventional agriculture would not work. It supports traditional agriculture and does not compete with it. Vertical farms are multi-level digitized greenhouses that can only be successful if several key technologies like lighting, control and monitoring are mastered. Würth Elektronik offers a wide range of "horticulture LEDs" [2] whose color spectrum is ideally matched to plant requirements. It also conducts its own research in this area to further establish suitable dynamic lighting recipes for the market [3]. A sample kit with horticulture LEDs and wireless connection exists to create optimal lighting conditions and keep energy consumption low with intelligent lighting control and optimized power supply [4,5]. More about horticulture LEDs and their application can also be found in [6] to [11]. Besides optimal light conditions, other environmental factors are also important for plant growth including temperature, humidity or even the soil moisture. These parameters must be monitored, controlled, and dynamically optimized.

An IoT Controlled Vertical Farm Prototype

A network of sensors and actuators that are needed for the Internet of Things for complex automation, such as the smart factory of Industry 4.0, smart buildings, or even new agricultural concepts. The following shows how the use of horticulture LEDs and the implementation of remote monitoring and control for plant growth in vertical farms can be realized quickly and cost-effectively using rapid prototyping tools. **Figure 1** shows the prototype of an indoor farming box.



Figure 1: Prototype of an indoor farming box.
Source: Würth Elektronik eiSos.

All critical components of the prototyping solution are available from a single source, from Würth Elektronik. The core task of any IoT solution is to transfer data from the field to the cloud, where it is analyzed to generate the desired added value for the application. An open-source hardware and software ecosystem was used and a complete IoT solution was created for this application. To this end, Würth Elektronik has combined Adafruit's Feather M0 Express board with its own FeatherWings, i.e., the Feather form-factor development boards with various sensors, radio and power modules, LEDs and LED drivers and components (**Figure 2**). Here the basic idea is to create a digital system that

optimizes growth, on the one hand, and electricity and water consumption, on the other.

Water and Light

The vertical farming prototype is based on a soil substrate combined with a 4-channel LED driver and a horticulture LED design kit that makes it easy to mix the required light spectra to promote plant growth under different lighting situations. The drip irrigation system and water tank use recycled water whose pH and electrical conductivity (EC) (salinity) are measured, controlled, and transmitted to the cloud through wireless connectivity modules from Würth Elektronik. A soil moisture sensor monitors soil moisture and a small pump supplies water to the system, if required. The excess water is collected, filtered, and returned to the tank. The heart of the system is Adafruit's Feather M0 Express board with relays used as switches. Data is sent to the cloud, where the information is processed, analyzed, and used to control the farm.

LED Panel

The lighting system (**Figure 3**) consists of a horticulture LED panel with four separate channels including special single-color horticulture LEDs, and the MagI³C multi-color LED driver. Both are included in the Lighting Development Kit from Würth Elektronik [2]. The LED driver with the MagI³C series step-down power module allows individual adjustment of the intensity and color of each of the four LED strands to meet the application requirements and match the light recipes to the plant profile. The horticulture panel consists of six hyper-red (660 nm), four far-red (730 nm), two deep blue (450 nm) and four white ceramic LEDs. The system can be controlled via Bluetooth, Wi-Fi or a cell-phone connection.

Watering

The very accurate MEMS piezoresistive WSEN-PDUS differential pressure sensor measures the water tank filling level (**Figure 4**).

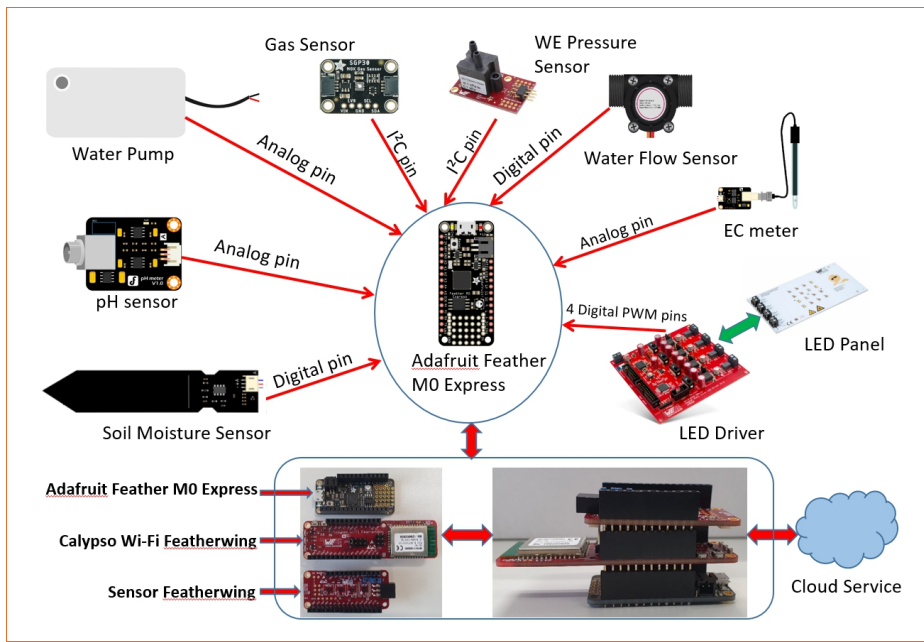


Figure 2: IoT system prototype for vertical farming based on the Feather form factor. (Source: Würth Elektronik eiSos).

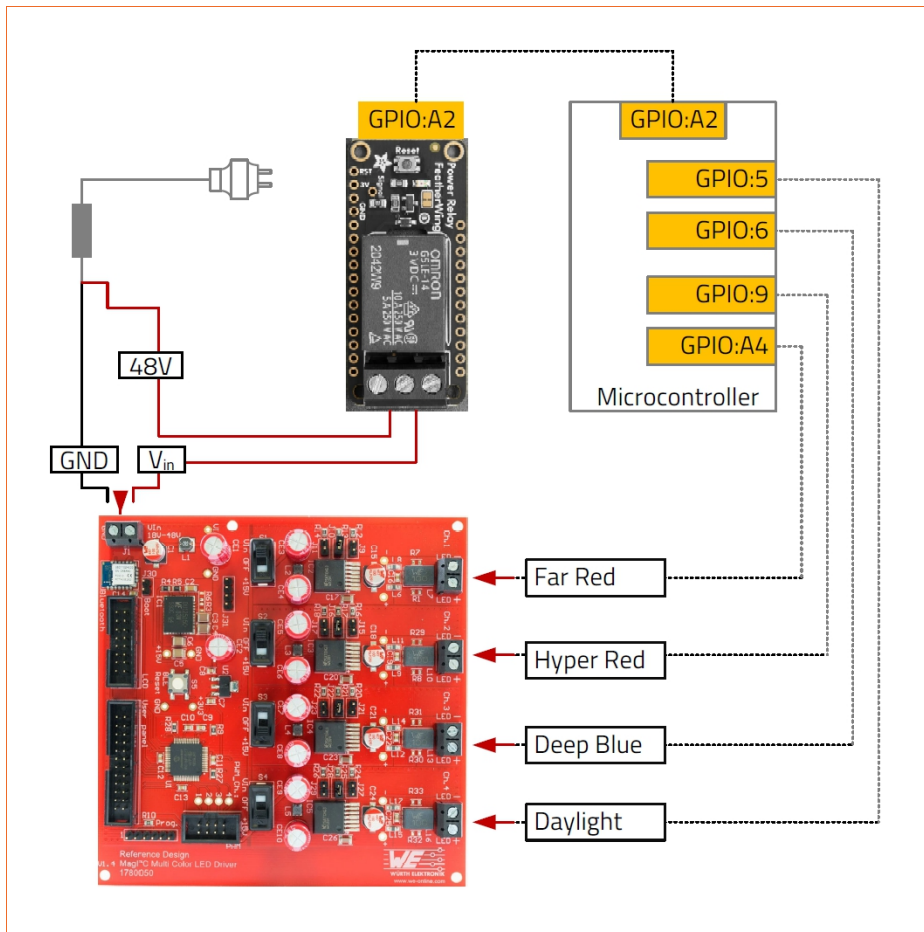


Figure 3: The lighting system for plant cultivation consists of an array of single-color LEDs and an LED driver. (Source: Würth Elektronik eiSos).

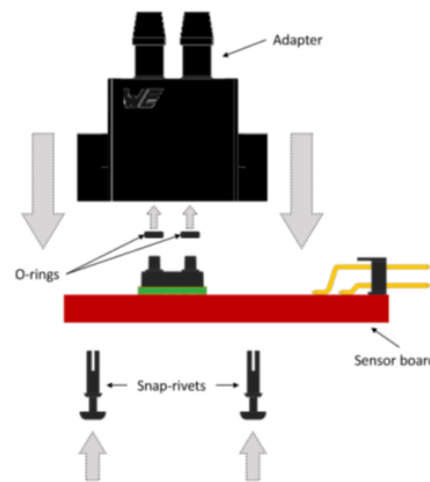


Figure 4: The WSEN-PDUS differential pressure sensor is a very accurate MEMS piezoresistive sensor. Source: Würth Elektronik eiSos.

In addition, a 12 V pump moves the nutrient-rich water into the drip tray via a flow sensor. Water quality is monitored with the DFR-05874 (pH) and DFR-0300 (EC) meters from the DFRobot Gravity series. Most natural bodies of water have a pH value between 5 and 8. The generally accepted pH for irrigation water is between 5.5 and 7.5, but the best results were achieved with pH values between 5.5 and 7. Water in this pH range maintains its nutrient balance, provides effective chemical disinfection, and prevents calcification in irrigation systems [12].

“Fertigation” is a blend word of fertilization and irrigation. As a result of the small substrate surface area, growing in substrates requires good irrigation and a lot of fertilizer, which is added to the irrigation water. An EC meter is used to detect an undersupply or oversupply of fertilizers in the irrigation water. Electrical conductivity (EC) is a measure of the concentration of ions in water and serves to measure the ability of water to conduct electricity. The purer the water, the lower the conductivity. The capacitive STEMMA soil sensor from Adafruit was used to measure soil moisture. Capacitive measurements use only one probe; there is no exposed metal that can oxidize, and no DC current is passed into plants. The pump is controlled automatically and directly via the cloud. Its operating time is calculated based on the number of plants, required soil moisture, and the pump flow rate (Figure 5).

Feeding Plants

Carbon dioxide is required in large quantities for enrichment and extraction processes. These processes accelerate the growth of plants and CO₂ serves as a fumigant. In enrichment, a CO₂ content of 800–1500 ppm is usually set to accelerate growth by 20 to 30%. Increasing over-

all metabolic rate helps plants withstand the effects of heat. Larger, healthier and more robust plants tolerate extreme environmental influences better. An increased plant metabolic rate means additional requirements, however. The plants not only need more water and nutrients, but also additional ventilation. The CO₂ content of the system was measured and monitored online using the Adafruit SPG30 air quality sensor connected to the Würth Elektronik sensor FeatherWing. It should be kept in mind that the sensor measures the equivalent CO₂ content. This eCO₂ value is calculated based on the H₂ concentration, so it is not a “real” CO₂ sensor for laboratory use. A plant requires different light and heat conditions at each stage of growth. Most plants tolerate normal temperature fluctuations, and the optimal thermal conditions for plant growth can vary, not only between the respective phases, but also throughout the day. Optimization can be achieved by measuring the temperature and optimizing the daily cycles. When the light is switched off, the temperature should be a few degrees lower. Humidity is specified as relative humidity. Different plant stages require different levels of humidity. An overly humid environment can raise the potential for spreading disease. Both humidity and temperature are monitored with the WE sensor FeatherWing.

Connections to the IoT

How to connect to the digital world. Today, there are many standardized and proprietary wireless solutions, whose selection is determined by several factors such as transmission range, throughput, frequency bandwidth, local regulatory requirements and energy budget. The prototype's communication is implemented using two different approaches, firstly with a Calypso Wi-Fi FeatherWing (Figure 6) for environments where Wi-Fi is available, and secondly with an Adrastea-I FeatherWing (Figure 7) for environments without Wi-Fi. Both boards are connected to the rest of the system via the Adafruit Feather M0 Express board. The Calypso board is a compact Wi-Fi radio module based on the IEEE 802.11 b/g/n (2.4 GHz) Wi-Fi standard. It has an integrated TCP/IP stack and an out-of-the-box MQTT (Message Queue Telemetry Transport) protocol. The Adrastea-I module is a compact LTE-M/NB-IoT mobile module with integrated GNSS and an Arm Cortex-M4 processor suitable for every IoT application. Both modules are suitable for simple and secure connection to the cloud. In this case, the choice was made for Microsoft IoT Central, a Platform as a Service (PaaS), because of its simplicity and ease of use. IoT Central has a ready-to-use user interface and API for connecting, managing and operating

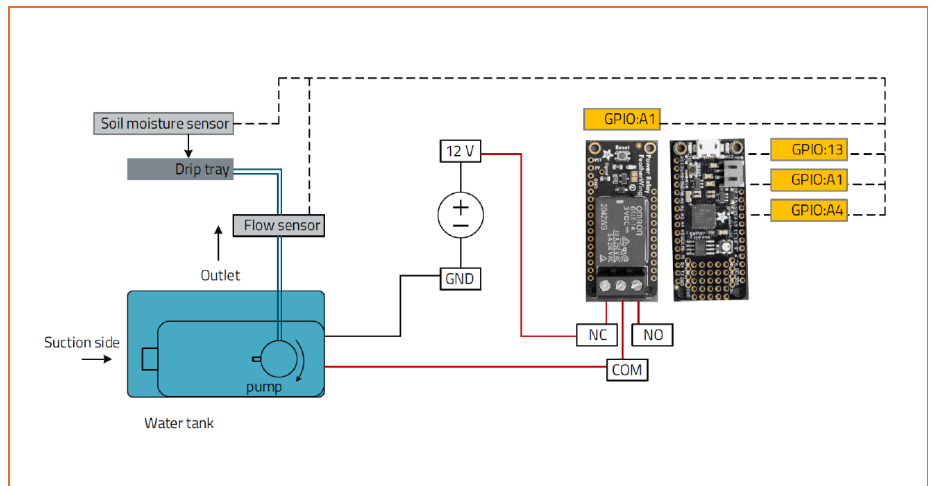


Figure 5: Irrigation system with sensors, water tank, pump and control boards. Source: Würth Elektronik eiSos.

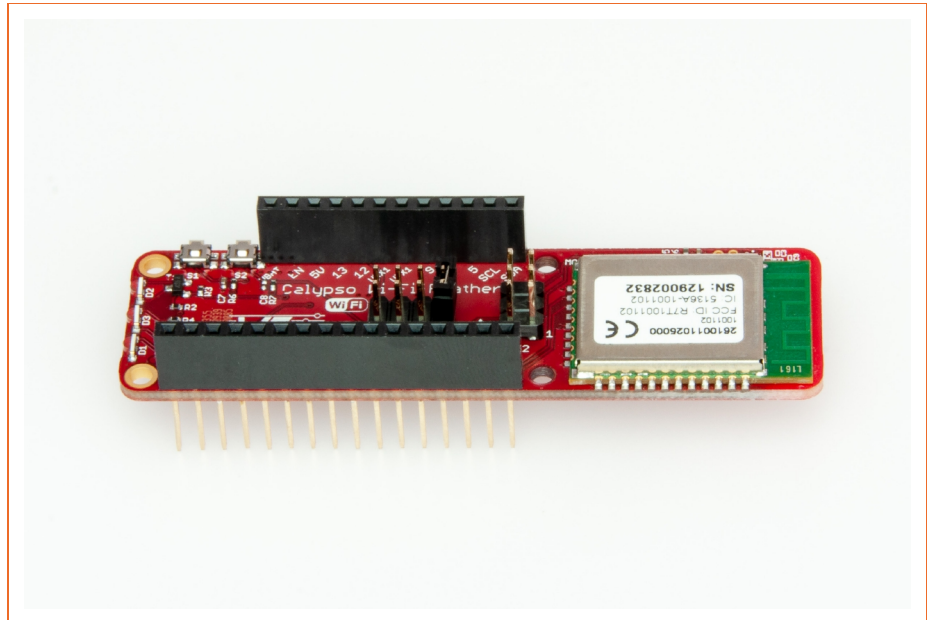


Figure 6: The Calypso FeatherWing provides connectivity in environments where a WiFi network is available. Source: Würth Elektronik eiSos.

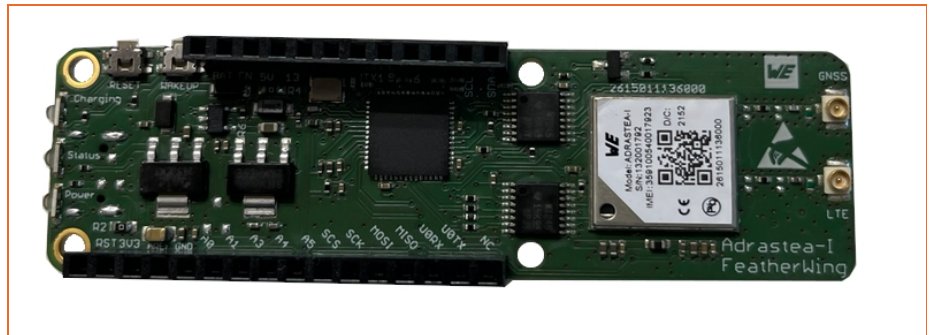


Figure 7: The Adrastea-I module is a compact LTE-M/NB-IoT mobile module with integrated GNSS and an ARM Cortex-M4 processor. Source: Würth Elektronik eiSos.

IoT devices. With its telemetry, features and commands, it has been used to monitor and control all aspects of the vertical growing system.

Summary

How does the IoT connected vertical farming work? The prototype shows it on a small scale and is in itself an application: A similar cabinet produces fresh herbs in the Würth Elektronik canteen. The electronic components of the prototype, from software for microcontroller control, communication with the cloud, to the power supply and LEDs, all come from a single source, Würth Elektronik. ■

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Alexander GERFER, Managing Director and Chief Technology Officer at Würth Elektronik eiSos

Alexander GERFER is Managing Director and Chief Technology Officer of one of Europe's largest manufacturers of electronic and electromechanical components. The graduate engineer (University of Applied Sciences) in Electrical Engineering and trained radio and television technician has been with Würth Elektronik since 1997 and started his career classically as a technical sales representative. The starting point for today's eiSos Group product range was his knowledge of the many unanswered questions surrounding inductive components, as well as his practical experience in power management, and the need for standardized power inductors and suppressor ferrites. He is instrumental in building the company's research and development as well as product, quality and supply chain management. Alexander Gerfer is a textbook author, lecturer and in-demand keynote speaker. With his experience and credo, he has helped shape the development and orientation of Würth Elektronik eiSos as a service-oriented manufacturer and promoter of technology.



Adithya MADANAHALLI, IoT Solution Architect at Würth Elektronik eiSos

Adithya MADANAHALLI graduated from the Technical University of Munich with an MSc in Communications Engineering. He went on to work for several years as a

software engineer in the field of wireless connectivity and sensors. Since 2017, Adithya Madanahalli has been working as an IoT engineer at Würth Elektronik eiSos in the Wireless Connectivity and Sensors business unit. Here he is specialized in the design and development of IoT solutions with a focus on hardware, embedded software and end-to-end security.



Johann WALDHERR, Business Development Manager for Horticulture LEDs at Würth Elektronik eiSos

Johann WALDHERR graduated from the Technical University in Munich and Humboldt University in Berlin with a MSc. in Horticulture Science. He then worked for several years as a plant researcher, with a focus on how different wavelengths of the light influence different quality parameters of the plant. Since 2017, Johann has been a Business Development Manager for Horticulture LEDs at Würth Elektronik eiSos in the business unit eiPal Optoelectronic. There he specializes on the biological, optical and electrical parameters in the field of Vertical Farming and Horticulture Lighting. He supports the development of light concepts in the area of plant lighting.



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Solid-State Lighting Report – The Impact of LEDs on Electricity Consumption and Global Warming

Dr. J. Norman BARDSELY, Chief Analyst at International Solid-State Lighting Alliance

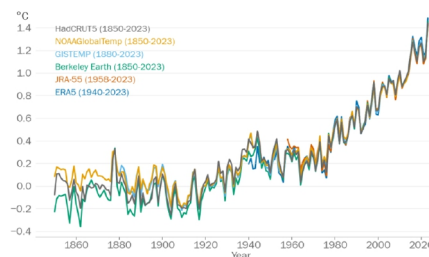


Dr. J. Norman BARDSELY, Founder and SSL Analyst, Bardsley Consulting

Dr. J. Norman Bardsley, a distinguished Professor of Physics, has earned international acclaim as an expert in solid-state lighting (SSL) through his advisory roles with the Department of Energy (DoE) and the International SSL Alliance (ISA). Renowned for his extensive and nuanced understanding of OLED technology, Dr. Bardsley possesses a comprehensive grasp of its manufacturing processes, cost structures, and ongoing research endeavors.

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Through the adoption of LEDs, the lighting industry has made a substantial contribution to the mitigation of global warming. But stocktaking made in 2023 by the United Nations Environmental Program (UNEP) showed that the total global effort to reduce emissions of greenhouse gases (GHG) is falling far short of what is needed to achieve the targets set in the Paris Agreement of 2015. The World Meteorological Organization (WMO) has judged that 2023 was the hottest year on record and there seems to be no slowing in the rate of increase in the global mean temperature. The purpose of this report is to assess the contribution of lighting in reaching these goals and to urge the industry to maintain its concern about this important issue.



Global Mean Temperature Difference (°C) compared to 1850-1900 average. Global temperature rise persists (Source: WMO).

Introduction

Spreading the availability of artificial light across the globe at an affordable cost has been one of the major achievements of the LED era. As noted in the last issue of LpR, global light production has risen to 230 petalumen hours (Plmh), up from

135 Plmh in 2005, and is expected to reach 350 Plmh by 2040. Much of the increase has come from China, where the per-capita production has risen from 10 megalumen hours (Mlmh) to 60 Mlmh and now exceeds that of Europe. This has been achieved with only a small increase in electricity consumption, from 2650 terawatt hours (TWh) in 2005 to 2900 TWh in 2023. The share of lighting in the global use of electricity has dropped from 17% to 11%. This reduction was made possible by an increase in the average efficacy of lighting systems from about 48 lm/W to around 80 lm/W.

The International Solid-State Lighting Alliance (ISA) believes that much more can be done in reducing the environmental impact of lighting. Raising the average efficacy of the global installed base to 150 lm/W would enable further access to high-quality lighting across the globe while reducing the electricity use to below pre-LED levels.

Pressures on Electricity Supply

The substitution of renewable energy sources for fossil fuels does not solve all the environmental issues. Daily use patterns for lighting are not well matched to solar power generation, especially in winter when the peak demand for electricity is in the evening hours. Substantial increases in battery production are needed. The manufacture of batteries requires significant energy consumption and the disposal procedures bring challenging issues [1] (IER 2023).

In North America and Europe, transportation has become the major source of GHG

emissions. The resulting pressure to replace internal combustion by electric vehicles is adding to the demand for batteries as well as more generation of electricity.

The major challenge comes in regions that are still reliant on fossil fuels. Closing down the coal industry in countries like India and Indonesia will have a major impact on the income of workers and on tax revenues. Building replacement energy supply systems and employment opportunities will take many years.

Electricity Use by Lighting

In 2006, the International Energy Agency (IEA) published “Light’s Labour’s Lost” (LLL), a thorough analysis of the global impact of lighting and the potential for progress through LED adoption [2]. According to this report, global electricity use for lighting in 2005 was 2650 TWh, with 1500 TWh from OECD countries and 1150 TWh from developing economies. In most developing countries, the increase in the consumption of electricity for lighting correlates well with the growth in GDP, expressed in constant dollars. This table shows the estimates made by ISA for the five members of the BRICS working group.

Country	2010	2020	Ratio
Brazil	72.7	65	0.89
China	550	1000	1.82
India	114	128	1.12
Russia	115	133	1.15
South Africa	24.7	34.5	1.4

Country	2010	2020	Ratio
Brazil	10710	8921	0.83
China	4428	9771	2.21
India	1475	2016	1.37
Russia	10442	11289	1.08
South Africa	7279	6340	0.87

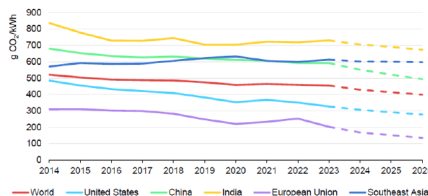
Greenhouse Gas Emissions

It is generally accepted that the higher emission of greenhouse gases is the major cause of global warming. Total global GHG emissions rose from 47 gigatons (Gt) in 2005 to 57 Gt in 2022, with about two-thirds coming from energy production. According to UNEP, the total emissions need to be reduced to below 40 Gt by 2030 to meet the minimal goal of restricting mean temperature rise to less than 2% [3].

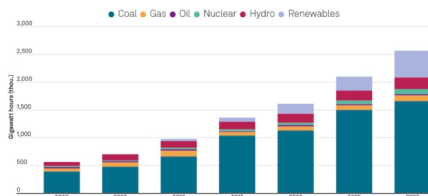
The key to meeting the goals seems to be to increase the role of electricity in

power generation and to reduce the burning of fossil fuels in electricity production. Through greater reliance on renewable energy sources, the electricity generation industry in North America and Europe has achieved substantial reduction in GHG emissions. However, these gains have been offset by greater emissions in many countries within Asia.

The adoption of renewable sources of energy has led to a reduction in the average global emission of GHG for each kWh of electricity to less than 500 grams of CO₂. However, the value remains high for most developing countries, especially in Asia [4].



Coal-fired power remains the major source of supply in the Asia-Pacific region, accounting for 57% of electricity generation in 2023. This leads to other environmental concerns, in addition to global warming. The figure shows that the consumption of coal in India is expected to rise significantly in the next decade.



Lighting Contribution to GHG Emissions

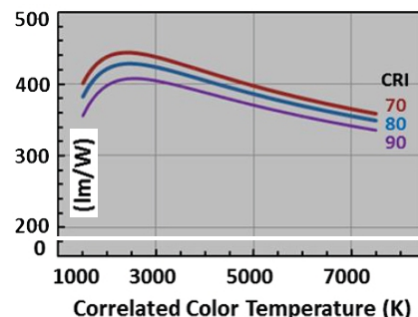
According to LLL, the contribution of lighting to greenhouse gas emissions in 2005 was about 1900 megatons (Mt) of CO₂ per year. The ISA estimates that this contribution is now around 1350 Mt, with 250 Mt in OECD, 600 Mt from China and 500 Mt from other developing economies. The reduction has been enabled by the adoption of LEDs but has been achieved mainly by the greater use of renewable sources in electricity generation.

The data from the WMO shows that radical actions are needed to constrain the rise in mean global temperature to less than 2°C. The lighting industry can continue to

provide leadership by reducing electricity consumption to well below the 2005 level of 2650 TWh. The remainder of this article summarizes some of the ways that this can be done.

LED Efficacy

Although LEDs now offer efficiency far superior to that of traditional sources, much more can be achieved. The theoretical limit for the production of white light is around 400 lm/W for a wide range of Color Rendering Index (CRI) and Correlated Color Temperature (CCT). Some losses are unavoidable and the target of the US DOE for 2050 is 320 lm/W. Reaching this goal will require the mixing of LEDs of different colors, rather than phosphor-converted blue LEDs.



Maximum luminous efficacy of radiation in lm/W for white light. Source: Jeff Tsao.

Smart Lighting

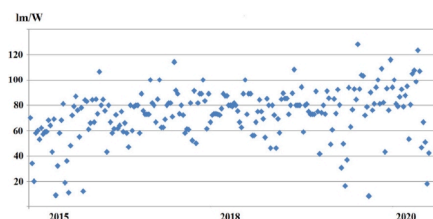
Smart lighting has become a mantra for many in the lighting community and needs little elaboration in this article. There are many ways to improve the efficiency with which the light produced by LEDs is delivered. Greater control over light distribution can enable the desired illumination levels to be met with less total light. This is especially true for outdoor lighting. Schemes to adapt to daylighting, room occupancy, circadian rhythms and personal preferences have been promoted for years, but successful implementation has proved to be challenging. This is especially true for connected lighting and networked controls.

A survey by the Design Lights Consortium (DSL) and the Northwest Energy Efficiency Alliance showed average energy savings of 49% from networked lighting controls [5]. However, in 2019 the US DOE estimated that less than 1% of luminaires in the US were connected in this way. They attributed the low adoption rate to their complex configuration, high cost, limited interoperability, and the availability of people who know how to efficiently design, install, commission, and operate them.

Signify is proud to announce that their systems have connected more than 100M light points, but this is far less than 1% of the global base.

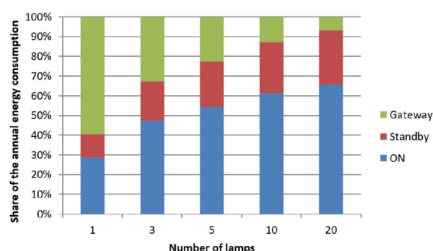
The need for improvement in so-called smart lighting systems was documented in the 2022 report by the IEA 4E SSL Annex [6]. Among the disturbing findings from a study of 224 smart lamps and luminaires were:

- The average efficacy was only 73 lm/W, which was 10 lm/W less than that for non-smart lamps in the US Energy Star data base in the same period.



Measured efficacy for 224 smart lighting products in the SSL Annex database.

- In networked systems, the gateway and the stand-by power contributed between 33% and 70% of the total energy consumption.



Division of total energy consumption in networked smart systems. Source: IEA SSL Annex.

- In one-quarter of the tested products, dimming to 25% of full power led to a reduction of efficacy by as much as 74%.

Lamp Manufacturing and Distribution

In order to reduce costs, most lamps on the market today use LEDs that are far from the best available. For example, recent data from the European Product Registry for Energy Labelling (EPREL) shows that around two-thirds of the General Service Lamps (GSL) now on sale have efficacy less than 110 lm/W.

Although the bans on fluorescent lamps will eliminate many inefficient lights, the industry is missing an opportunity to enable a significant rise in the average efficacy of the installed base. The EPREL data confirms

that LED tubes are available with efficacy greater than 160 lm/W and the on-line vendor 1000 Bulbs shows that these can be purchased in the U.S. at prices less than \$2 per klm. But 65% of the LED tubes listed in the EPREL database in March 2024 and almost all tubes offered by major hardware stores in the US have efficacy less than 135 lm/W. Most of these products have operating lifetimes of 35,000 hours or more and so may remain in operation for decades.

Innovative manufacturing methods are needed to reduce the cost of producing good quality lamps and lighting systems. In addition, distributors and retailers need to pay more attention to the efficacy of the products they offer and to promoting the benefits of lower energy consumption for both the user and the environment.

Incentives and Regulations

A wide range of means have been devised across the globe to encourage the use of more efficient lights. For example, the DLC provides guidelines and a product database for U. S. utilities that offer rebates for purchases that will help to reduce electricity demand. The EPREL labelling system clearly induced manufacturers to introduce products that meet the highest standards, although some of these products are relatively expensive. The overall effect of the EPREL program is illustrated in the table below. The distribution (%) between the seven efficiency classes is shown for products on the market in April 2022 and February 2024. The last column shows those added since October 2023. Although the recent entries show a substantial increase in the top three classes, most products on the market are still in the bottom two.

Class	Mains Efficacy lm/W	Product Distribution (%)		
		April 2022	February 2024	Last 5 months
A	over 210	0.07	0.6	2.4
B	185–210	0.51	1.4	4
C	160–185	3.2	5.9	8.3
D	135–160	8.9	13.1	13.2
E	110–135	23.1	23.6	26.4
F	85–110	43.2	35.6	30.4
G	below 85	19.7	19.5	15.7

There is an urgent need for a comprehensive labelling system for the efficiency of lights in the US. Certification by the Energy Star program is almost meaningless, since more than 93% of the approved lamps have efficacy below 110 lm/W and so would fall in the lowest two classes of the EPREL scale. The program is not used for suppliers of LED tubes and specification

of the electricity consumption or the light output is missing from some packages on store shelves.

LED Adoption in Developing Countries

Valuable support for the adoption of LEDs in developing countries has been provided by international organizations such as CLASP, the IEA 4E SSL Annex, UNEP and the ISA. This support should be continued, perhaps together with additional help from the Global Lighting Alliance and the IEEE Smart Lighting initiative. However, much of the responsibility lies with the national and local governments, who could follow the example of the authorities in China.

Much of the early adoption has been enabled by the availability of affordable LED products from China, which have been heavily subsidized by the Chinese governments. However, countries such as India, Indonesia and Thailand are building the facilities and infrastructure needed for substantial local manufacturing. For example, India has launched a production-linked incentive (PLI) initiative to boost the contribution of domestic manufacturing to the cost of lighting products based upon imported chips and packages from 25% to 85% by 2028.

Summary

The contribution of lighting to global warming has been mitigated over the past twenty years through the combined efforts of the lighting and electricity generation industries. However, more drastic actions are needed, and the lighting community has the opportunity to show even more leadership in this critical endeavor. ■

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Eco-Innovation in Lighting: LCA-CALC Leads the Way in Sustainable Lighting Solutions

Tiphaine TREINS, Founder and Head of Temeloy

LCA-CALC was born out of Tiphaine Treins's, founder and CEO of the innovative eco-lighting studio Temeloy, frustrations with the inability to obtain reliable, scientific, and usable eco-design metrics at a reasonable cost, combined with her desire to innovate and move the lighting industry markedly closer towards a more environmentally conscious future.

Ms Treins partnered with the International Reference Center for Life Cycle Assessment and Sustainable Transition (CIRAIG) to build LCA-CALC. CIRAIG is a cutting-edge life cycle assessment research center that develops metrics necessary for a transition to an eco-friendly society and is affiliated with Polytechnique Montreal. This made the partnership an obvious and fruitful fit. Using CIRAIG's expertise, Treins created the first online, accessible and affordable tool to calculate the environmental footprint of all LED lighting fittings (exterior, interior, decorative fittings) using life cycle assessment (LCA).

LCA=CALC
SMART ECO-LIGHTING METRICS



<https://lca-calc.com/>

LCA is governed by the ISO 14040-44 standards. The general methodology of LCA is first the quantification of all the exchanges with the environment (resource inputs and emissions to air, water and soil) of all the activities related to the use of a product, covering all its life cycle stages: the initial extraction and transformation of natural resources, the manufacturing of the product, its distribution, use and end-of-life **Figure 1**. The quantified exchanges are then converted into relevant environmental indicator results, such as the *climate change* indicator in kg of CO₂ equivalents.

There are four phases to an LCA study:

1. The goal and scope definition, where the recipe, i.e., the what and the how, for the study is specified;
2. The life cycle inventory (LCI) analysis, where data about the environmental exchanges of the considered activities are collected and related to a reference unit;
3. The life cycle impact assessment (LCIA), where the quantified environmental exchanges are converted into the relevant environmental indicator units; and
4. The interpretation of the results, where their environmental significance is assessed and recommendations and conclusions are drawn.

Two modes are available in LCA-CALC, the first is more focused on eco-design and identifying the main activities/components/materials contributing to a lighting fitting environmental footprint and thus guiding efforts to improve it, the second is aimed at producing an environmental product declaration (EPD) for a lighting fitting. An EPD is a communication tool used to provide the environmental footprint, i.e., a series of relevant environmental indicator results calculated through LCA, of a product to a target audience. EPD can then be used to compare the environmental performance of similar products.

As multiple methodological choices have to be made during an LCA, e.g., the systems boundaries (specifying the considered activities), the calculation reference unit, the set of environmental indicators, for EPD to be comparable the LCA methodology needs to be consistently applied to each product, i.e., the LCA recipe and the elements presented in the EPD need to be the same. Product category rules (PCR) are used to specify the recipe for the LCA serving as the basis for the EPD of products in a same category. EPD and PCR are governed by the ISO 14025 standard, which requires EPD program operators to manage the publication of PCR and EPD. A PCR for lighting fittings is available through the French PEP Ecopassport EPD program operator, the PSR0014, whose second edition was published in 2023 and is followed by the EPD mode in LCA-CALC. As of now, no PCR is available for the North American market but a think tank is working of developing one in the near future.

Several LCIA methods are available to LCA practitioners, LCA-CALC includes two of the most recently developed ones: Environmental Footprint (version 3.1) and IMPACT World+ (v2.01). The American TRACI (v4.2) method will be added in the near future. Each method differs in the set of environmental indicators it provides, and the environmental models used to calculate their results. The EF v3.1 method, specified in the PSR0014 ed. 2, provides a set of 16 of what are commonly called midpoint indicators which focus on specific issues like *climate change*, stratospheric ozone layer depletion or freshwater eutrophication; results are generally expressed in units of reference substance equivalents (kg CO₂ eq. for the *climate change* indicator). IMPACT World+ v2.0.1 provides three levels of indicators: midpoints, damages and areas of protection (AoP). The included midpoint indicators are very similar to and provide the same level of environmental coverage as the ones in EF v3.1. Those are, however, translated

into damages on the areas of protection (AoP) *Human health and Ecosystem quality*. The AoP indicators aggregate several relevant midpoints, thus reducing the number of indicators to be considered in the assessment and facilitating the interpretation of the environmental footprint. The first accounts for the potential impacts on human health from greenhouse gases, toxic substances (carcinogenic and non-carcinogenic), those that lead to respiratory problems, that generate ionizing radiations or photochemical oxidant (smog) and that deplete the stratospheric ozone layer and water availability and is expressed in DALY

(*disability-adjusted life years*). The second accounts for the potential impacts on ecosystem quality, or biodiversity, from *climate change*, acidification, eutrophication, freshwater ecotoxicity, land use and water availability and is expressed as the fraction of species that will potentially disappear (potentially disappeared fraction – PDF) in a given area and over a certain time period (PDF*m²*year). LCA-CALC provides results for the *Human health and Ecosystem quality* AoP and the Fossil and nuclear energy use and Mineral resources use midpoint indicators.

In order to model the life cycle of the lighting fittings, the user enters data into the online platform. Required data includes the list of materials and their respective amounts, manufacturing, distribution, use and end-of-life information. Light output, driver power, fitting and components lifetime and electricity consumption during use and stand-by data are also required. All activities directly related to the lighting fitting make up the foreground system, essentially the manufacturing, distribution and use life cycle stages, while all other activities make up the background system: materials and components production, energy (electricity) production, transports and waste treatment. As specific data cannot be collected for all background activities due to time and cost constraints, those are modeled using generic datasets taken from life cycle inventory (LCI) databases. LCA-CALC makes use of datasets included in the widely used and annually updated LCI database ecoinvent, version 3.9.1 (2023) using the *Cut-off* system model. This database provides global coverage for the included activities while presenting regionally differentiated datasets for several activities. The global average context was considered in LCA-CALC but for the electricity generation during the use stage for which several regional and national grid-mixes are available. A generic dataset is available for the production of LED but the user can also adapt it to better represent its own LED design when they have the information.

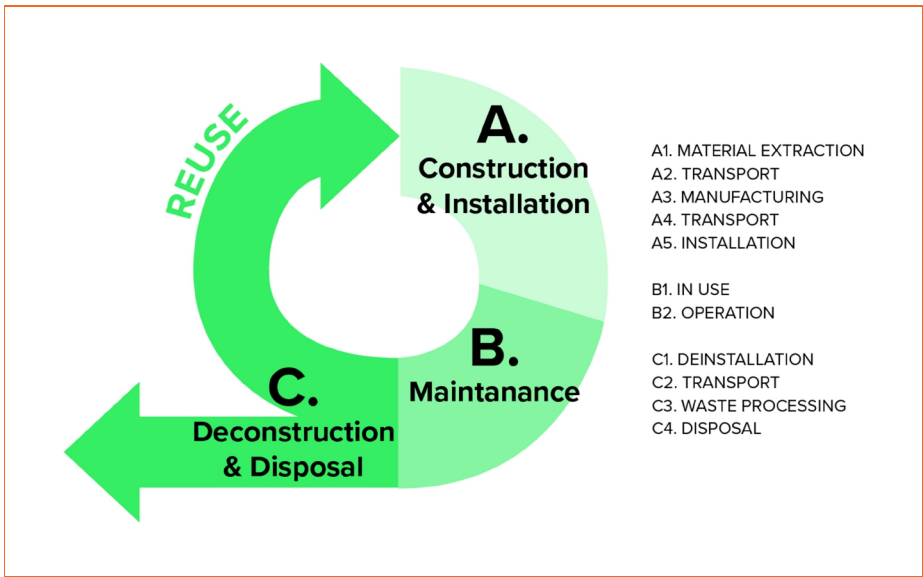


Figure 1: Life Cycle Assessment (LCA) methodology is a comprehensive approach used to assess all the environmental impacts associated with all the stages of a product's life from its beginning to its end.

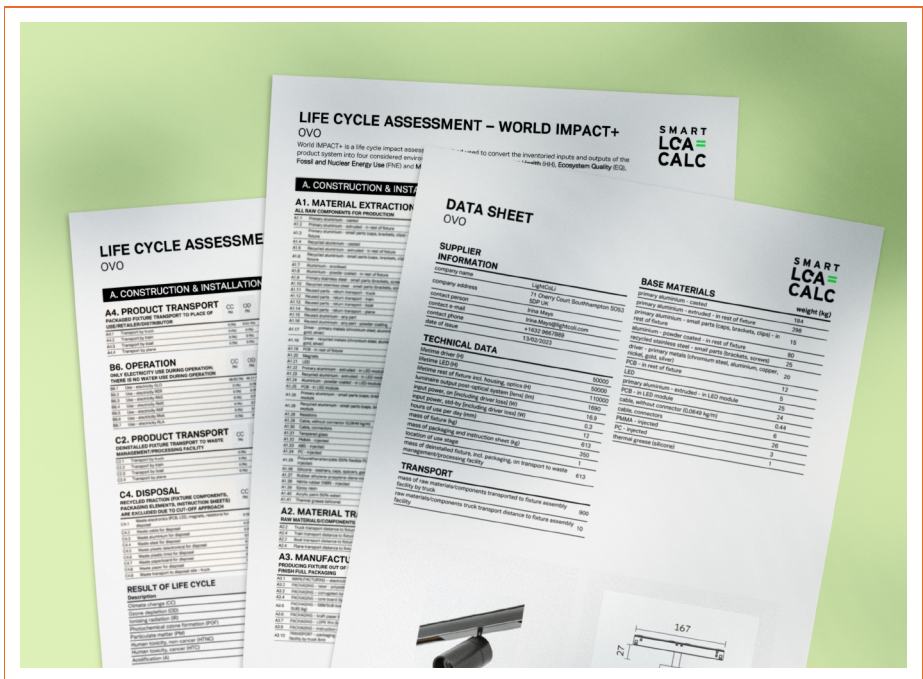


Figure 2: LCA report calculated from the calculator helps understand and evaluate the severity and significance of the potential environmental impacts.

LCA-CALC can also model lighting fittings designed with a circular economy model. The tool can consider the reuse of components, by including the transport and treatment of the previous used fitting, and includes datasets on recycled materials. For the latter, the approach used is consistent with the ecoinvent *Cut-off* system model, which considers that all burdens associated with the collection, sorting and recycling of the pre-recycling material, i.e., waste material, are allocated to the recycled material and the life cycle which uses it.

Once the lighting fitting life cycle is modeled by entering all required data for each life cycle stage, LCA-CALC relates all the entered data to the calculation reference unit ("providing 1000 lumens for 35000 hours" or "providing the lumen output of the lighting fitting over its lifetime") and provides the absolute and relative results for the set of indicators of either included LCIA methods (EF 3.1 and IMPACT World+ 2.0.1). The first includes the generally accepted indicator for carbon footprints in kg CO₂ eq. (split into fossil, non-fossil and

land transformation sub-indicators). The tool also generates pre-filled LCA report and EPD templates that will facilitate their preparation for their submittal to the verification process leading to the publication of the EPD by a program operator recognizing the PSR0014 ed. 2 PCR for lighting fittings.

As was previously mentioned, EPD of lighting fittings can only be compared if they not only follow the same recipe, i.e., PCR, but if the same choices are made concerning the few elements for which PCR leave some flexibility to the practitioner conducting the underlying LCA, e.g., use stage electricity grid-mix, LCI database used to model the background activities. Moreover, several characteristics of lighting fittings are not considered in the available PCR for this product category, e.g., CCT, CRI, typology, which could affect the environmental performance of those products. More generally, the environmental footprint of a lighting fitting should not be the only criteria used to judge its overall quality: design and technical criteria should also be considered. The Lighting for Good initiative, another brainchild of Ms Tiphaine Treins, aims to create a market benchmark for lighting fittings that would account for all those aspects. In 2024, it will launch the first eco-lighting awards based on life cycle assessment (<https://lightingforgood.org/awards/>).



LCA-CALC is the first tool of its kind for the lighting industry. Other attempts, such as the Chartered Institution of Building Services Engineers (CIBSE) Technical Memorandum 66 (TM66), have been made to create environmental metrics for lighting. Whereas TM66 only provides recommendations for design and manufacture of circular products, LCA-CALC is a widely applicable and in-depth life cycle quantitative assessment tool for all LED lighting fittings, new and reused, circular or not.

LCA-CALC is user-friendly, flexible, accessible and affordable for lighting manufacturers and designers who wish to prioritize transparent and eco-friendly manufacturing and design. ■

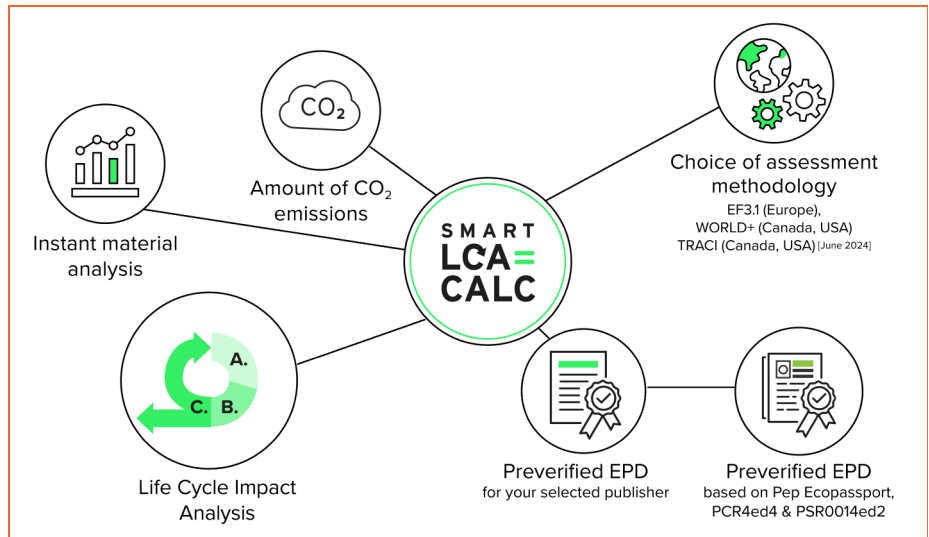


Figure 3: LCA-CALC encompasses an extensive array of eco-lighting metrics. After filling in the Life Cycle Inventory (LCI) in the calculator, users can extract a diverse range of information and reports. They have the option to concentrate on CO₂ emissions, utilise the calculations to refine and minimise the design of their luminaires or generate pre-verified Environmental Product Declarations (EPDs) that include the LCA report.

Tiphaine Treins, founder and principal of Temeloy Eco-lighting Innovator, is a leading -edge lighting designer who integrates state-of-the art technology with innovation, beauty, creativity and sustainability. Treins, a French national, is currently based in London. Her unique lighting signature can be found on homes, luxury boutiques, superyachts, parks, museums, exhibitions and events all around Europe.



Tiphaine TREINS.

Treins founded Temeloy Lighting in 2009 and has since been involved with a roster of diverse clients and demanding projects. At Temeloy, Treins focuses on improving, evolving and innovating lighting design. Temeloy endeavours to create excitement with original lighting concepts that elicit an emotional and visceral response. To that end, Treins has developed a platform of “augmented architecture”. In short, she ensures architecture and lighting solutions interact with their surroundings. Once that occurs, any given space will, no doubt, create a richer experience to the passer by. A good example is the Grande Epicerie’s living façade in Paris where the plants evolve and grow with the seasons. Treins also implemented augmented architecture at the 2012 “Renault Car Show” and with the exceptional dome at the Elephant Paname Art Center. Treins feels all big picture ideas require a holistic approach. Key to this is the ability to listen, and communicate, before implementing your ideas. Treins also feels it is of paramount importance to develop strong relationships, respect and trust with the people with whom you are working.

In 2018, together with Nicolas Martin, LVMH lighting manager and director of environment, Treins created a “think tank” and a program called Lighting for Good with the object of establishing an “eco gold standard” for suppliers of lighting fixtures. Eco-design, eco-lighting, and sustainability is something that Treins not only encourages but also strives for with all of her work.

LCA-CALC represents a significant step forward in her path of eco-innovator, demonstrating a commitment that has demanded patience, resilience, and determination.

Treins is committed to creating and delivering outstanding results to each and every project that she manages. Her passion and dedication are evident in her work. She puts her all into creating something extraordinary. And for Treins, Eco-lighting innovation brings research and intelligence to the process of designing with light.

The first Life Cycle Assessment calculator for the lighting industry

LCA=CALC

SMART ECO-LIGHTING METRICS

Reducing costs and complexity on your path to sustainability



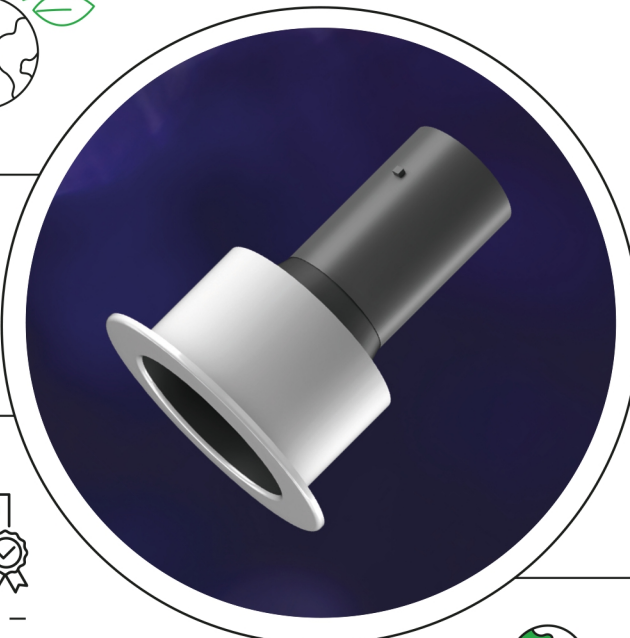
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based on **PEP Ecopassport**
PCR4ed4 & PSR0014ed2



Assess life cycle impact analysis (**LCA**) of your luminaire



Calculate the **CO₂ emissions** of your luminaire



Choose your assessment methodology

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Connecting Lighting Design and Circadian Research with AI

Dr. Adrià HUGUET-FERRAN, Founder & CTO of KUMUX

The benefits of dynamic lighting, aligned with circadian rhythms, have been demonstrated by numerous scientific studies. However, when attempting to introduce this lighting solution to clients, such as office owners, there are practical challenges in its application. These include discrepancies among scientific studies and the difficulty in applying specific circadian metrics, like Melanopic Equivalent Daylight Illuminance (mEDI) and Circadian Stimulus (CS), versus more familiar colorimetric parameters like Correlated Color Temperature (CCT) and Color Rendering Index (CRI).

The potential circadian impact cannot be predicted by CCT alone [1], complicating appropriate luminaire selection without knowing their Spectral Power Distribution (SPD). Additionally, circadian scientific guidelines are based on the spatial conditions of an environment, complicating the assurance that recommendations are fulfilled without detailed knowledge of the SPD or the specific circadian attributes of the lighting fixture.

KUMUX has developed advanced machine learning (ML) algorithms that predict the values of circadian metrics from colorimetric parameters, addressing the issue of critical data scarcity in lighting projects. An Application Programming Interface (API) has been developed and has been implemented inside a software platform to facilitate the integration of these algorithms into major existing lighting control systems. This enables the adjustment of the CCT and brightness of luminaires in accordance with circadian scientific guidelines. This system acts as a bridge between scientific theory and practice, enabling the optimization of lighting control systems with application of scientific knowledge to a project through AI (Figure 1).

Developing the Model

Spectral data from 1,719 white LEDs of various brands have been collected, with CCTs ranging from 2000 K to 7000 K, including those that emit in the short-wave spectrum (380–450 nm). Key parameters such as CCT, CRI (CIE Ra), the Melanopic Daylight Efficacy Ratio (mDER), and CS (v2) at 100 lx have been calculated. These parameters, both circadian (mDER, CS) and colorimetric (CCT, CRI), can be displayed in two comparative charts, illustrating the relationship between them.

As observed in Figure 2, it is concluded that, for a white LED, determining the mDER or the CS based exclusively on the CCT is not possible, as previously mentioned. However, looking at the color of the

charts, related to the CRI, it is possible to see that there is a significant correlation. Specifically, white LEDs with a higher CRI tend to have higher circadian values for the same CCT.

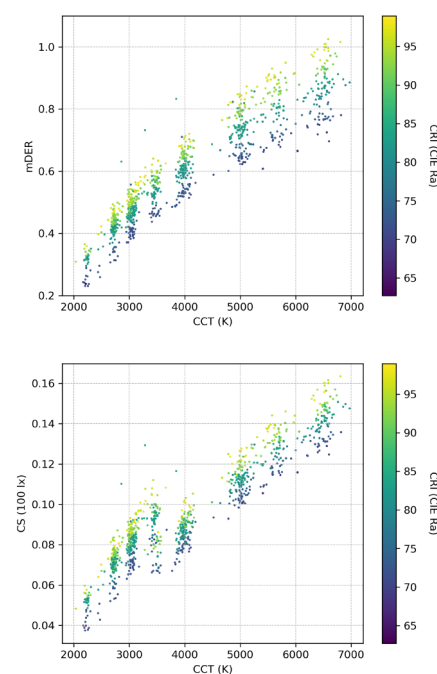


Figure 2: mDER as a function of CCT (top). CS at 100 lx as a function of CCT (bottom). In both cases the CRI (CIE Ra) is represented by the color.

Although not directly, there is a non-linear relationship between colorimetric and circadian parameters in commercial white LEDs. In this way, the following hypothesis can be proposed: is it possible to identify a general model that enables the prediction of circadian values (mDER and CS at 100 lx) based only on the CCT and CRI of a commercial white LED? To achieve this, the benefits of Random Forest regression models have been utilized, which are capable of identifying relationships ranging from classical linear to more complex non-linear ones.

For this purpose, the set of 1,719 LEDs has been divided into two subsets:

- Training subset: dataset used to teach the ML model to identify patterns and make predictions.
- Test subset: dataset used to evaluate the ability of the ML model to generalize to new examples not seen during training, since it is independent of the training subset.

A validation subset has been discarded because the model itself already has mechanisms to avoid overfitting, the process by which a ML model learns the details and noise of the training dataset to such a degree that it impairs its performance on new and unseen data. Thus, the training subset consists of 1,375 LEDs while the test subset consists of 344, randomly chosen.

After training the model with the 1,375 LEDs in the training subset, calculations were performed for the 344 LEDs in the test subset, which were not previously seen by the model.

Results of the Model

In this section the predictive model development and error analysis for the mDER parameter is shown, although the same procedure, with very similar results, can be applied to the CS parameter (at 100 lx).

The predictions of the mDER parameter as a function of the real mDER values of the test subset can be seen in **Figure 4**.

To evaluate the effectiveness of the model, some relevant statistical parameters have been calculated, such as the coefficient of determination R^2 . The R^2 is a statistical measure that reflects the proportion of the variation in the dependent variable (mDER) that can be explained by the independent variables (CCT and CRI) in a regression model. In simpler terms, R^2

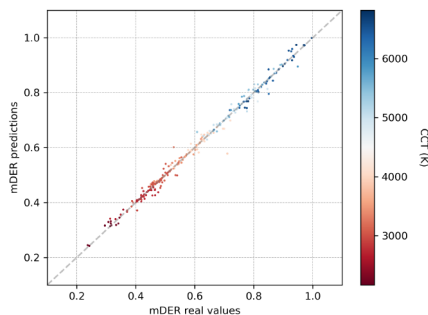


Figure 4: Predicted mDER as a function of real mDER with the CCT plotted in color for the 344 white LEDs of the test subset.

shows how well the observed values fit the modeled or predicted values. An R^2 of 1 means that the model explains all the variability in the data, while an R^2 of 0 indicates that the model explains none of the variability. In this case, the R^2 obtained was 0.988, which implies that the model can explain 98.8% of the mDER variability from the CCT and CRI. This suggests that the model has a very good fit and that the CCT and CRI values are able to predict the mDER values in commercial white LEDs.

Now, the relative error analysis of the 344 LEDs in the test subset is shown in **Figure 5**.

In **Figure 5** it is possible to see that the relative errors are, in the vast majority of cases, negligible. 95% of the predicted values have a relative error of less than 5%.

In the case of CS, very good effectiveness values are also obtained. In this case, R^2 is 0.982. The small downward difference is explained by the fact that the calculation of the real CS value is not linear, since it contains two different functions for the

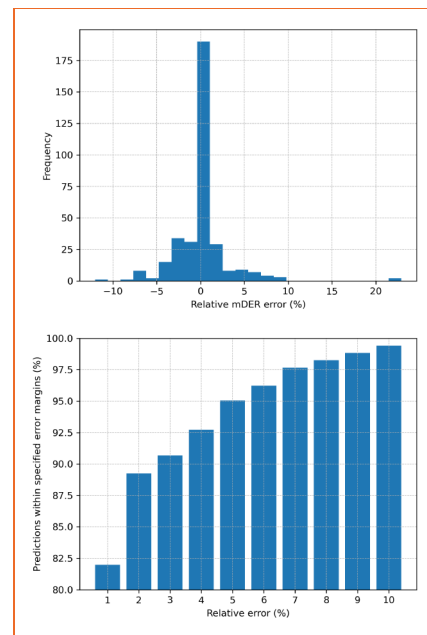


Figure 5: Histogram of relative error in mDER prediction (top). Percentage of predictions for the mDER parameter that are within a given relative error margin (bottom).

Relative Spectral Contribution of the Circadian Response [2]. The discontinuity can be clearly visualized around 3500 K in **Figure 2** (bottom). Although the ML model is able to incorporate this discontinuity, this causes the fit to lose linearity and gain complexity. Relative errors also remain practically negligible in the vast majority of cases. 94% of the predictions are below 5% error.

Limitations of the Model

ML models are characterized by learning by identifying patterns in the datasets. Since the training subset only contains data from commercial white LEDs of different types, the model developed is only valid for commercial white LEDs. In this case, the CCT is limited between 2000 K and 7000 K, since most of the white lighting is within this range. This limitation allows us to isolate extreme cases and improve the results in this area of interest.

It's crucial to understand that while a model can be developed to predict the mDER (or mEDI), when considering the illuminance value and CS values at 100 lux with high accuracy, based solely on the CCT and CRI, these predictions cannot be universally applied to any SPD. In special multi-channel LEDs or multichannel luminaires (beyond tunable white), where very different SPDs can be observed, the model will probably fail considerably in its predictions. The relationship shown in **Figure 2** between circadian metrics and colorimetric parameters is not applicable in these cases.

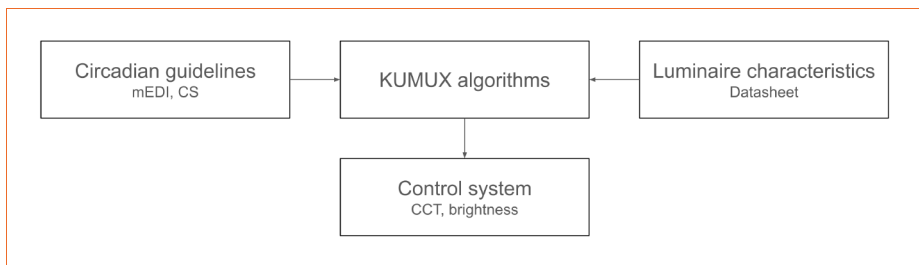


Figure 1: Schematic of KUMUX position in a circadian lighting project.

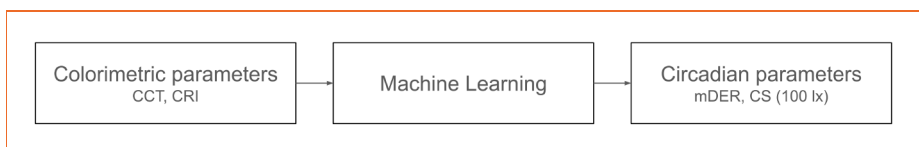


Figure 3: Scheme of transformation from colorimetric to circadian parameters.

Conclusions of the Developed Model

Generalizing, CCT and CRI cannot explain the value of mEDI or CS at a given illuminance, since the SPD can potentially have very diverse shapes. Nevertheless, the developed model is able to predict very accurately the value of the mentioned circadian metrics by knowing the CCT and CRI of a commercial white LED. This fact allows working more accurately in a circadian lighting project when it is not possible to know the SPD of the luminaires used, but common parameters such as CCT or CRI can be known.

Compliance with Circadian Guidelines

Another crucial aspect of a circadian lighting project is determining the appropriate values of CCT and brightness to schedule throughout the day. Despite using versatile luminaires and understanding the characteristics of the space, including accurate calculations of illuminances, it is essential to specify the values that the luminaires will deliver at different times. Circadian lighting goes far beyond having tunable white luminaires capable of providing very warm or very cold lighting. It is necessary to take into account scientific studies, sometimes depending on the environment or users studied, to apply the appropriate light from a circadian point of view.

Thus, once the potential circadian impact of the luminaires is calculated, it is time to choose which guideline to follow. Numerous published studies and guidelines can be found, such as those of the Lighting Research Center (LRC) [3], Underwriters Laboratory (UL) [4] or the WELL Building Standard [5], as well as scientific publications that do not depend directly on an organization [6]. Each has its advantages or disadvantages, which depend on the case study.

When it comes to control systems, standard protocols such as DALI2 and proprietary systems offered by companies like Casambi typically allow for the manipulation of only two parameters: the CCT and brightness of a luminaire. This limitation poses a challenge for executing circadian lighting projects, which rely on specific metrics such as mEDI or CS, as indicated by research and guidelines in the field. Consequently, to effectively implement circadian lighting strategies, it becomes necessary to map the adjustable parameters of CCT and brightness with the desired values of circadian metrics.

To simplify this process, KUMUX has developed an algorithm that performs all these calculations in a simulated way. In addition to the investigations concerning the circadian impact at the light level, design constraints, such as Kruthof limits, have also been taken into account.

Delivering the Results in Real Projects

In order to apply the developed algorithms to the lighting control systems, a software platform has been developed. Having the CCT and the CRIs of the LEDs of the luminaire, the average horizontal illuminance and the ratio between vertical and horizontal illuminance, the platform delivers the lighting settings in terms of CCT and brightness (or illuminance) that the control system should set throughout the day, depending on geolocation and type of building. In addition, the calculations can be customized by setting limits to the CCT range or limiting the brightness to a minimum, among others.

To facilitate the integration process, the platform allows applying the results and its automation in numerous control systems, such as Casambi, Pharos Architectural Controls, Lutron, OSRAM (now Inventronics) or the KNX ecosystem.

An example of the data obtained can be seen in **Figure 6**.

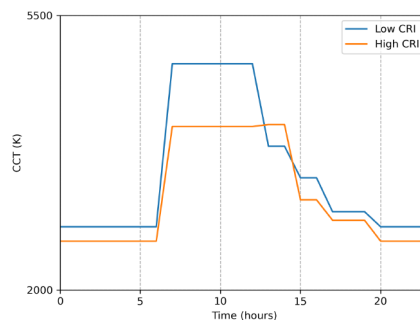


Figure 6: CCT data for one day for two luminaires with LEDs with different CRIs for the same project, having a horizontal illuminance of 700 lx.

Case Study – BeAble Office Project

Recently, a project was carried out in an office located in Madrid, Spain. In this case, the algorithms described above were utilized to integrate the circadian schedules defined by the LRC and the WELL Building Standard.

Once the new system has been implemented, spectral measurements have been taken in the vertical plane, 1.2 meters above the ground, to verify the results of the project. In this case, the results provided by KUMUX compliance with the of-

fice guideline published by the LRC (green area), as can be seen in **Figure 7**.

Conclusions

In conclusion, this article has demonstrated the effectiveness of ML algorithms in predicting circadian metrics from colorimetric parameters, thereby addressing a significant gap in lighting project planning. The potential impact of this technology on future lighting standards and health guidelines is substantial, as it promises to enhance the alignment of artificial lighting with human circadian rhythms, potentially improving sleep quality, mood, and productivity. The development and adoption of this model and platform are encouraged, as they represent a significant step forward in the integration of scientific knowledge into practical lighting solutions. Further research and widespread implementation could lead to more personalized, health-supportive lighting environments. ■

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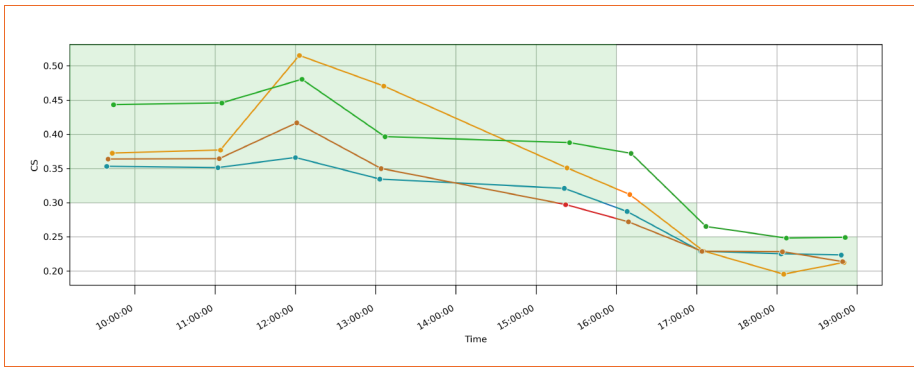


Figure 7: Measured CS values in the vertical plane as a function of time of day in different rooms.



Adrià Huguet-Ferran is a physicist and holds a PhD in Applied Sciences. His area of expertise is the development of algorithms for lighting applications and spectral engineering. In 2017, he founded KUMUX, a spin-off from the University of Barcelona, where he holds the position of CTO. In parallel, Adrià has maintained connections with the academic world, making numerous contributions and serving as a university master's level professor for 7 years. In 2020, he won the LpS Digital Conference Best Paper - LED professional Scientific Award 2020 for the work "Facing the Challenges of Spectral Engineering with a New Software Tool".

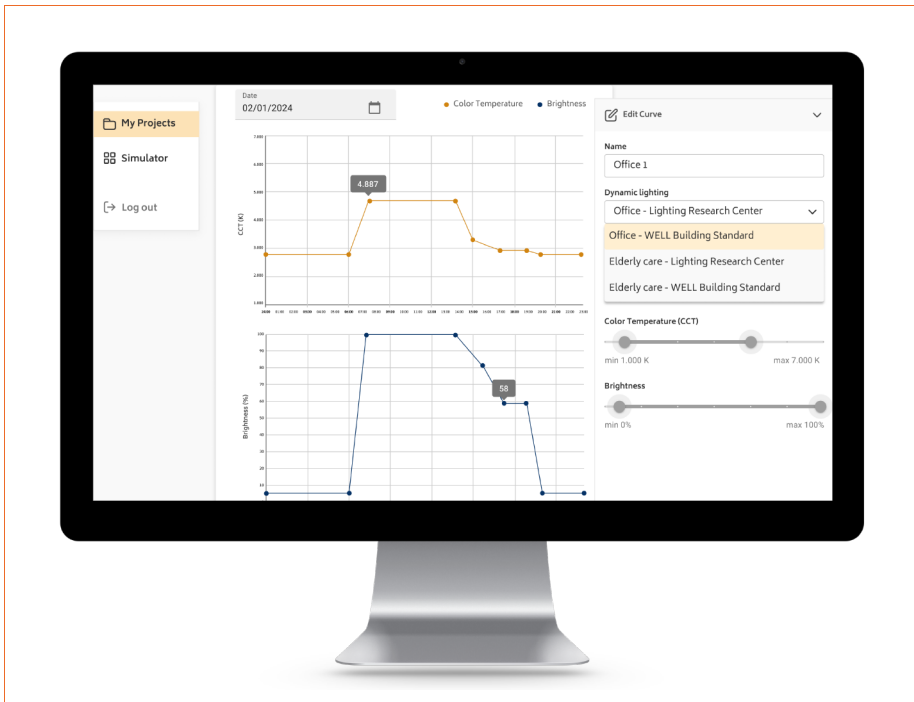


Figure 8: KUMUX platform showing some data resulting from applying the algorithms described above.

KUMUX KUMUX is focused on transferring the properties of natural light into artificial light, to bring the benefits of sunlight indoors and enhance people's health and well-being. From its origins at the University of Barcelona, their team has the light and innovation knowledge to create software that uses existing lighting and control systems in buildings to simulate daylight. KUMUX Phone: +34 934 48 73 82

<https://kumux.io> | hello@kumux.io



Figure 9: KUMUX API lighting settings on a spring evening in a nursing home.

Digital Twin Architecture for Lighting Infrastructure in the Context of Front-End Industry 4.0

Alex FISCHER, Product Manager at SimScale

We are moving towards a digital twin architecture for the lighting industry, as described in this paper [1] which introduces an ontology-based Digital Twin (DT) architecture for the lighting industry, integrating simulation models, data analytics, and visualization to represent luminaires. The same paper offers a comprehensive definition of a digital twin in general, but also for the lighting industry; “A DT is a virtual representation of a physical object, process, or system, encompassing the digital counterpart of its real-world counterpart. It captures the properties, behavior, and characteristics of the physical entity in real time, facilitating data exchange and interaction between the virtual and physical components. Consisting of three fundamental components—the physical entity, the virtual model, and the connection enabling data exchange—DTs serve a general purpose of providing valuable insights, enabling predictive analysis, facilitating optimization, and supporting decision-making throughout the life cycle of the physical object or system.”

A correctly defined setup and curated digital twin of a luminaire is critical considering the variety of conditions they are subjected to. We can refer to this as the User Profile and it includes:

- Environmental parameters
 - Temperature
 - Humidity
- Operating conditions
 - Voltage
 - Dimming
 - On/off cycles
- Lifetime factors
 - Critical failures in power and power quality
 - Aging effects
 - Color shifting
 - Remaining luminous flux

AI-TWILIGHT

New design workflows and integrations have been made possible by the introduction of the cloud for high performance computing. SimScale is working on calibrating digital twin thermal models for LED luminaires as part of the AI-TWILIGHT EU-funded project. Based on a fully scripted application, one can extract thermal resistance values for, e.g. SPICE-like reduced modeling without ever touching a graphical user interface, let alone simulation parameters or domain discretization (mesh). The AI-TWILIGHT project is bringing together the leading academic and industrial experts on solid-state lighting (SSL) and LED technology. “The main goal of AI-TWILIGHT is to merge the virtual and physical worlds to pave the way for innovations in fields where the European industry is likely to be competitive. Self-learning digital twins of lighting systems (LED source, driver of a lighting application) will be created and used as input for predicting the performance and lifetime of product and infrastructure design and management in an autonomous world. Tests will be carried out in selected application domains, e.g. automotive, horticulture, general and street-lighting.” (<https://ai-twilight.eu/>)



Figure 1: AI-Twilight EU project logo*.

Lighting Digital Twins Using Cloud Native Engineering Simulation

Cloud-native simulation for LEDs offers 3D parametric scenario analyses, allowing engineers to generate multiple CAD variants and study them in parallel. Advanced physics solvers and meshing algorithms reduce simulation time and focus on insight-driven design. Application programming interfaces (APIs) enable third-party CAD, analysis, optimization, and parametric design tools to collaborate, promoting ‘cooperation’ between technology firms.

The AI-TWILIGHT project aims to reduce the cost of developing and testing advanced SSL products by using simulation, statistical, and artificial intelligence models. This allows for faster and accurate analysis of thermal and structural performance of LED luminaires, allowing for the creation of digital twins and the use of cloud computing power to simulate hundreds of design candidates in parallel. The goal is to develop more efficient and reliable products.

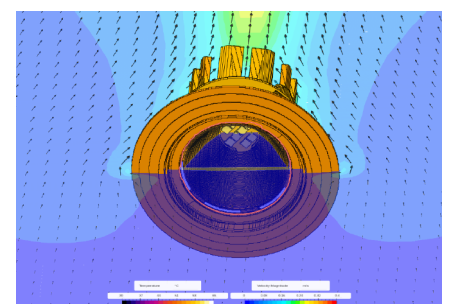


Figure 2: A 3D thermal and flow simulation of a luminaire showing velocity and temperature.

[1] <https://www.sciencedirect.com/science/article/abs/pii/S0167739X24000359>

* Note: Adapted from <https://ai-twilight.eu/> with permission. This project has received funding from the ECSEL Joint Undertaking (JU) under grant agreement No 101007319. This dissemination of content reflects only the author's view. JU is not responsible for any use that may be made of the information it contains.

The workflow developed using SimScale as part of the AI-TWILIGHT project, specifically has unique benefits including:

- Calibration of parameters for the SPICE-like compact thermal model or reduced order model can be done very fast in parallel with cloud computing
- API-driven workflow allows for
 - Integrated workflow into OEMs tool-box
 - Custom application workflow in SimScale or via a third party service provider
- No simulation expert knowledge required by SME engineers due to Cartesian based robust simulation workflow
- Potential of on-demand access to calibration without continuous and full access to simulation capabilities which is quite costly
- Access to a broad spectrum of physics for thermal, flow and structural analysis of luminaire design.

Case Study

The example below shows an indoor lighting use case from the AI TWILIGHT project based on a new spot designed by Ecc-electro and Ingélux. The aim is the calibration of a thermal model for a luminaire by extracting a thermal resistance network model from the more advanced 3D simulations.



Figure 3: Real world spot light (Ecc-electro & Ingélux) for which the digital twin model is created.

The thermal simulations are carried out using Conjugate heat transfer analysis in the SimScale platform where solid conduction, natural convection and thermal radiation are considered. All luminaire parts or a subset of the assembly can be calculated in the simulation, for example, if some thermal resistances are known from spec sheets or physical tests.

The thermal interaction between components is determined by running a parametric study, heating one power source at a time. The scalable cloud backend allows for running all required simulations in parallel, cutting down the simulation turnaround time for n simulations to the turnaround time of a single simulation (Figure 5).

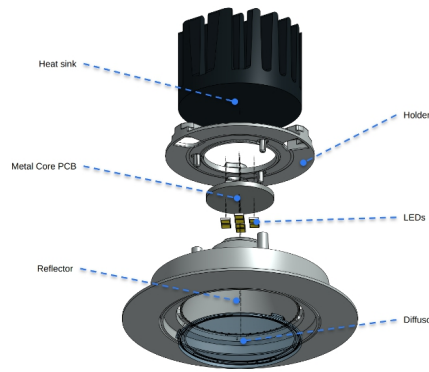


Figure 4: Indoor luminaire parts for the thermal 3D simulation.

The temperature results on the interfaces of the relevant components, for example at the solder points, are extracted using surface result controls and represent the main input for the resistance calculation. The resistance matrix gets assembled from the resistance values by dividing the temperature differences with the driving power or combining the simulated data with priority known resistances e.g. for the chips or heatsink. Lastly, some matrix sanitization steps are executed, described in detail in the Delphi4LED publications which serve as a base for the AITwilight research. All data simulation and data processing steps

can be easily executed via the SimScale API (Figure 6).

The resulting heat path and dependencies between the power sources mounted on the substrate can be nicely derived from the resistance matrix. Only components that have a positive value in their respective cross-section cell show a relevant thermal dependency. The heat path and dependencies can be nicely displayed as 2D networks from LED junction to ambient and within the substrate plane. In the end, the resistance matrix allows for the application of a power vector with one entry for each thermal node of the network and outputs a temperature delta above ambient for each position, including the most relevant LED junctions (Figure 7, Figure 8).

The thermal resistance network calculated is then used as an input to a larger network model for system level multi-physics modeling, including electrical, optical and thermal properties. This model allows the application of certain duty cycles and ambient conditions during the design phase or can be applied in the field during operation to predict the remaining lifetime. For that purpose, measurement data as well as machine learning methods can be taken into

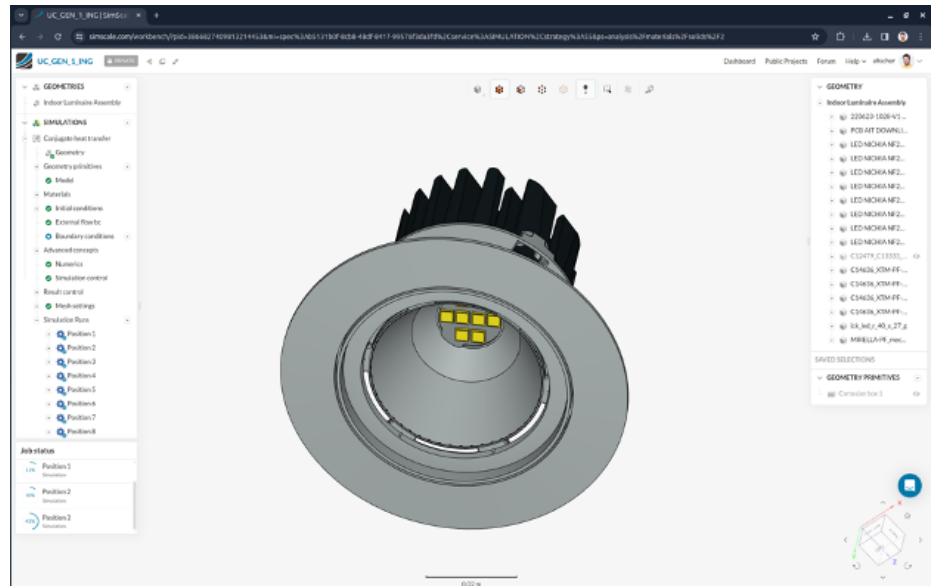


Figure 5: Eight simulations, one for each LED are run in parallel, accessed via Chrome web browser.

Combined Rth Network								
Position	Position 1	Position 2	Position 3	Position 4	Position 5	Position 6	Position 7	Position 8
Position 1	2.28	10.43	19.59	11.89	50.39			
Position 2		2.41		30.87	17.71	29.07		
Position 3			3.10	8.16			2.19	
Position 4				8.21	9.53			2.14
Position 5					3.08	9.03	27.72	
Position 6						2.18		23.14
Position 7							3.45	9.39
Position 8								2.78

Figure 6: Thermal resistance matrix of LED positions on substrate, non-zero values show dependency.

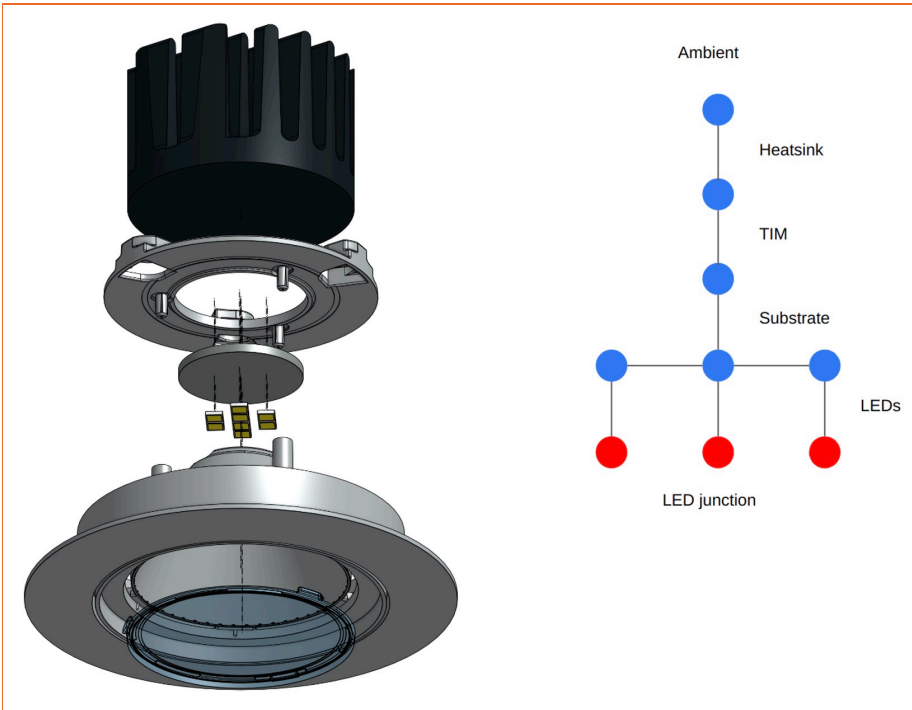


Figure 7: Compact thermal network covering the heat path from the LED junction to Ambient.

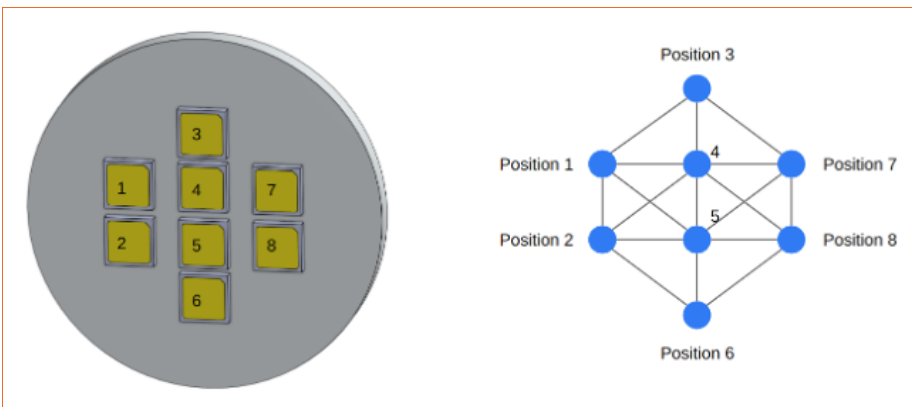


Figure 8: Thermal dependence of LED power sources on the substrate. Where positions are not linked, there is negligible influence; e.g. Position 6 and Position 7.

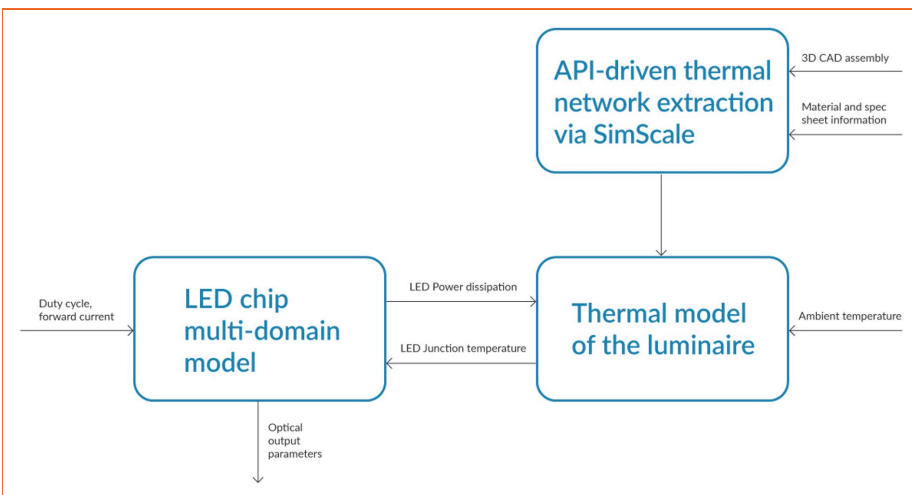


Figure 9: Multi-domain system solving with electrical and thermal in- and outputs and additional optical output characteristics.

account. Due to the seamless workflow that doesn't require any in-house or on-site computing power, it is always possible to update or recalibrate the thermal model, taking additional data from the field into account (Figure 9).

Outlook & Summary

The new design methods developed from the AI-TWILIGHT project will allow thermal simulations to create synthetic data for machine learning models, an oft-cited bottleneck to fully exploiting AI and machine learning tools. Engineers will then be able to connect operational digital twins that receive field data with SimScale to automatically update the thermal model in the cloud on-demand and make tweaks/adjustments to the designs continuously. ■



Alex Fischer: With a background in computational mechanics and control technology, Alex Fischer has worked for ten years in a range of product and engineering roles, building a fully cloud and web-based simulation platform. He is a co-founder of SimScale and leads the company's thermal management and electronics solutions.

SimScale GmbH has developed the world's first fully deployed cloud engineering simulation platform. SimScale allows engineers to test their designs against real-world physics using a powerful CFD engine accessed through a web browser. The SimScale Community Plan is accessible for engineers to begin simulating their projects for free.

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The Good Light Group is a non-profit organisation. We are a group of scientists, lighting designers, sleep experts, and lighting companies focused on improving indoor lighting for health and well-being.

For more information: info@goodlightgroup.org

Expert Talks on Light – Micro-Optics in Automotive Lighting

HELLA-FORVIA | PHABELOuS Pilot Line

PHABULOuS

PHABULOuS is the one-stop-shop for free-form micro-optics, taking designs and prototypes to large-scale manufacturing. They have launched an open call to support the industry with the implementation and integration of free-form micro-optics, to bring your product to volume markets. This open call aims to support Europe's early adopters of our pilot line services to move towards volume production of free-form micro-optical components. Do you have a design and/or prototype and are looking to move your development into pilot or large-scale production?

The PHABULOuS value chain consists of Europe's leading Companies and Research & Technology Organizations allowing for seamless development from early phase proof-of-concept to regulated pilot production. Depending on the phase of the development and market application, a technical team and prime contractor are selected, who will help the companies to verify the technical requirements and support the company by making a design and/or prototype suited for large scale manufacturing.

Up to 3M€ of funding is available to support a minimum of 20 pilot cases / early adopters. They will be selected within the project to implement free-form micro-optical component and integrate that into their product developments with the aim to go towards large-scale production. The exact amount of subsidies per applicant will be decided based upon the type of company and the three main selection criteria. For each pilot case, also an in-kind contribution from applicant is expected.

For more information: phabulous.eu/open-call.

Content of the Talk

HELLA, operating under the overarching umbrella brand FORVIA, a leading automotive supplier worldwide, presents a use case in the PHABULOuS project. Free-form micro-lens arrays (FMLAs) offer aesthetics, potential for space and weight reduction, and low-cost manufacturing. HELLA's insights into automotive market requirements have led to significant steps in developing a free-form micro-optics-based solution. Watch the video of the use case here.

Micro-Optics Video



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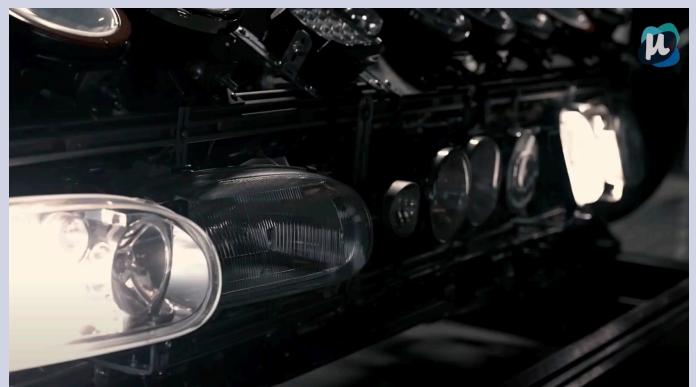
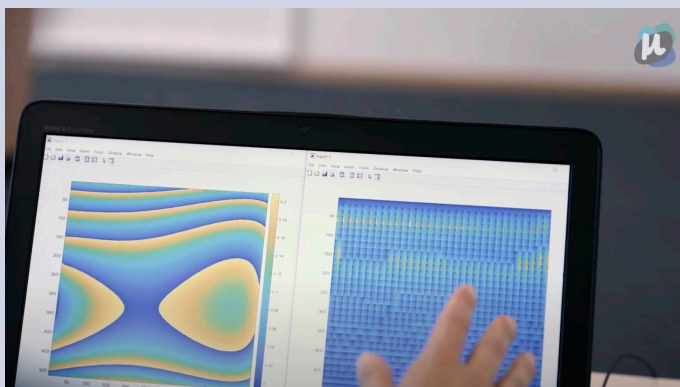
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Light + Building Follow-Up

In the May/June edition of LED professional Review (LpR) we will delve into some aspects of the Light + Building report, focusing on the topics of light quality and lighting control. In addition, we will feature an interview with a representative from CIE who will discuss the latest developments in research and application. Another article will cover the latest research in the field of lighting eco-design and recycling. In the domain of optical design, we will explore the subject of free-form optics, specifically for rail vehicle lighting. A further article will examine market trends in Asia with a special emphasis on China.

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Cover Page: Gallery Xavier Hufkens in Brussels. Photos: Thomas Mayer, Neuss/Germany. ERCO products: Eclipse InTrack, Jilly. (c) ERCO GmbH, www.ercos.com.

Imprint

LED professional Review (LpR)
ISSN 1993-890X

Publishing Company

Luger Research e.U. | © 2001–2024
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Published by
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