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Review

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INSIGHTS FROM CARLA WILKINS AND KLAUS VAMBERSZKY

THE ROLE OF LED LIGHTING IN CLIMATE CHANGE

SMART LIGHTING IN FOCUS: EVENTS, METHODS & SENSING

The Global Information Hub for Lighting Technologies and Design


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The Good Light Group is an international non-profit organisation promoting the use of biologically effective light, indoors and outdoors, for better sleep, mood and overall health. We collaborate with leading researchers, architects, lighting designers, engineers and lighting companies to bring evidence-based daylight solutions into everyday environments.

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Light + Building 2026

We are pleased to present the first issue of this year with a special focus edition published just ahead of Light + Building, the leading international trade fair for lighting and building services technology.

Against the backdrop of rapid developments in the lighting sector, this issue brings together a rich selection of timely and forward-looking contributions. Two in-depth interviews provide valuable perspectives: Klaus Vamberszky, former CTO of the Zumtobel Group, shares his views on the future of professional lighting, while Markus Helle speaks with IALD president Carla Wilkins about current and emerging trends in lighting design. J. Norman Bardsley examines the role of LED lighting in the context of climate change, supporting his analysis with recent research findings.

A key thematic focus of this issue is smart lighting, including insights from the LS2025 IEEE World Conference, new approaches to in-field commissioning and reconfiguration, and developments in sensor technology based on thermal intelligence. Further articles explore the impact of light on the human organism, highlighted by an HCL study related to Parkinson's disease, as well as current topics in photometric data for light and LEDs.

The issue opens with an overview by Elena Scaroni, Secretary General of LightingEurope, followed by our compact International Lighting News section.

We wish you an engaging read and a successful Light + Building.

Yours Sincerely,

Siegfried Luger

Founder & CEO of Luger Research e.U.
Publisher of LED professional, Trends in Lighting, LpS Digital, and the Global Lighting Directory

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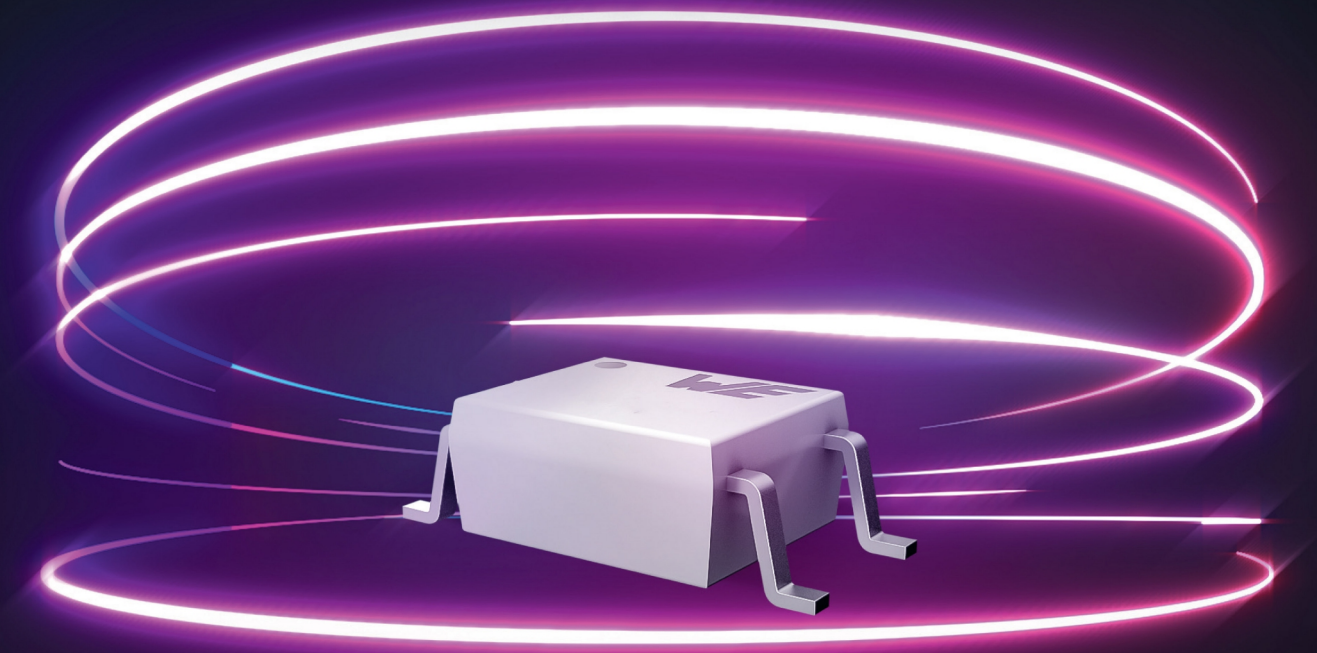

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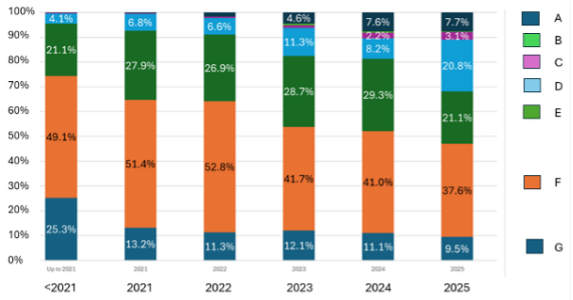
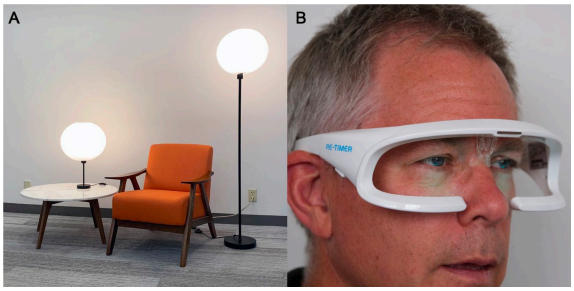
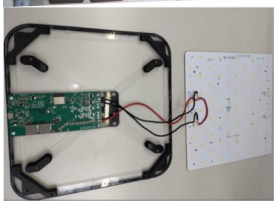


HUMAN-CENTRIC LIGHTING

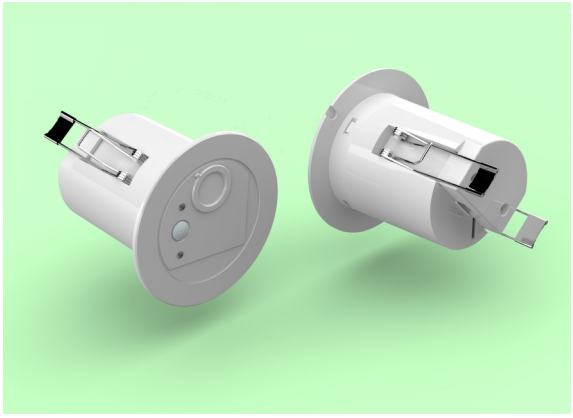


SMART LIGHTING – METHOD



MEASUREMENT

SMART LIGHTING – SENSING



ADVERTISING INDEX

Chances & Challenges for the Lighting Sector – LightingEurope at Light + Building 2026 in Frankfurt

Elena Scaroni

Elena Scaroni is LightingEurope's Secretary General, appointed in June 2023.

Prior to this role, she served as policy director since joining LightingEurope in September 2016. Scaroni has been at the forefront of advocating the interests of the European lighting industry in the recent ecodesign and energy labelling regulations for light sources.

Prior to joining LightingEurope, she spent eight years in European affairs at Enel, a multinational energy company. Her responsibilities included managing relations with the European Parliament on all relevant issues such as climate, energy and corporate social responsibility.

She studied in Rome and Paris and holds a master's degree in law, specializing in European Affairs.

Further LightingEurope Events:

9 March, 17.00–18.00:
'LightingEurope Open Days' – Focus on our priority policy areas Value of Light and Better Enforcement.

11 March, 10.30–11.30:
'LightingEurope Open Days' – Focus on our priority policy areas Sustainability and Product Rules.

This year, LightingEurope will be participating in Light + Building 2026 in Frankfurt, with its own booth in Hall 4.1 (FOY3). We will also be hosting three events in the Europa Saal (Hall 4), aiming to promote dialogue within the European lighting industry.

It seems that we have arrived at a pivotal moment. On the one hand, many lighting companies are suffering from a combination of stagnating European economy, aggressive commercial strategies from certain third countries and the resulting flood of non-compliant products being sold in Europe via online marketplaces. On the other hand, events that would never have happened before are happening now.

The EU Green Deal is being implemented, and at the same time, there are massive efforts made by the EU institutions, to simplify rules. The SCIP database, created with the goal of reporting on all hazardous substances present in all products has been deemed ineffective, and the European Commission is proposing its deletion. Other amendments to the EU Green Deal legislation proposed by the European Commission are calling for the digitalization of almost all printed information required to accompany a product. The deletion of SCIP and the digitization of product documentation could bring substantial savings to our companies, in line with LightingEurope's advocacy. We will work to ensure that both take place.

Rising unfair competition from third countries seems to be opening the door to a possible 'Made in Europe' label to support European sustainable and quality products. We are currently discussing LightingEurope's position in detail, and we will ensure that it is duly considered in the political debate.

The massive shift towards decarbonizing our industry and improving transparency regarding the environmental footprint of lighting products is also remarkable. Companies are investing in EPDs and LCAs, as well as in efforts to increase efficiency and reduce emissions. Our association is encouraging them to do so by creating and harmonizing product-specific rules for lighting products, and by supporting decarbonization efforts via training sessions and a dedicated cohort program for all LightingEurope members (and members of our national associations). Some key issues (e.g. those related to lifetime) remain unresolved. We are working on them to improve the tools available to our industry for decarbonization. All lighting companies are warmly invited to help us.

As is often the case, unexpected opportunities may arise during times of crisis. We will have the chance to discuss these and more at the LightingEurope events during Light + Building, as well as in more detail at our internal LightingEurope meetings.

CEOs Event: Challenges and Opportunities for the Lighting Industry
10 March, 15:15–19:00,
Europa Saal Hall 4, Level 0
The CEO debate will be the chance to finally meet all together and hear their views from the leading managers of the European lighting industry and from an influential policymaker at the European Commission.

The event starts with a keynote by Robert Nuij (European Commission – DG Energy) on EU energy efficiency strategies, including lighting products, followed by a CEO debate moderated by me, Elena Scaroni (LightingEurope).

CEOs of lighting companies, **Alfred Felder of Zumtobel**, **Mark-Oliver Schreiter of ERCO**, **Hubertus Volmert of Trilux**, **Paolo Cervini of Gewiss**, and **As Tempelman of Signify**, will exchange views and answer questions from the audience on challenges and opportunities for the Lighting Industry.

Some key topics are likely to emerge from the LightingEurope CEO event: Smart buildings & IoT integration, sustainability demands, and fair competition.

The event concludes with a networking cocktail. We are looking forward to meeting you there. Register for all events on our website. ■ E.S.

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Signify Reports Full-year 2025 Sales of EUR 5.8 Billion

www.signify.com

Signify (Euronext: LIGHT), the world leader in lighting, announced the company's fourth quarter & full year results 2025.

Signify's performance in 2025 highlighted the resilience of our business as we responded to reduced demand, the ripple effect of tariffs, and price pressure in our trade channels. In this context, our full-year results were mixed. Our professional business grew in the US but declined in Europe. Our consumer business delivered sustained growth in all regions except China. Connected lighting showed strong growth in both professional and consumer markets, but this was offset by a decline in non-connected, particularly in trade channels. Both businesses maintained a strong gross margin. OEM faced reduced demand and pricing pressure. Adjusted EBITA was 8.9%, and we generated strong cash flow of EUR 440 million, or 7.6% of sales.

"In the fourth quarter, continued connected growth and a strong topline performance in the US and India was offset by declines in a number of other regions. The adjusted EBITA margin for the quarter was impacted by a lower contribution from Consumer, OEM and Conventional." said As Tempelman, CEO of Signify.

Through what will be a transitional year for Signify, our immediate priority is to outperform in a tough market by strengthening our commercial and operational excellence, and cost competitiveness. To drive this, we are announcing a EUR 180 million program to structurally reset our cost base, which will unfortunately impact 900 roles across Signify. To focus the business for future success, we are conducting a full strategy and portfolio review and will share our conclusions at our Capital Markets Day on June 23, 2026.

We anticipate the challenging conditions to persist through 2026. Considering the diverging dynamics in our end markets, we are not providing guidance on full-year sales at this stage. We expect an adjusted EBITA margin of 7.5-8.5%, and free cash flow generation of 6.5-7.5% of sales. We intend to pay an increased dividend of EUR 1.57 per share, while pausing share buybacks for capital reduction purposes, to preserve financial flexibility during our strategic review.

"I want to thank our employees for their commitment and resilience throughout the year. Their dedication is essential as we position Signify for sustainable, profitable growth."

Having completed its Brighter Lives, Better World 2025 sustainability program, Signify will introduce its new sustainability program in the first quarter of 2026. In the final quarter of the 2025 program, Signify achieved the following results:

Signify surpassed its 2025 target to reduce greenhouse gas (GHG) emissions across its entire value chain by 40% against the 2019 baseline - double the pace required by the Paris Agreement.

Circular revenues reached 37% of sales, beyond the 2025 target of 32%. The main contribution was from serviceable luminaires in the professional business, with strong performance in the Americas.

Brighter lives revenues were at 34% of sales, surpassing the 2025 target of 32%. This included strong contribution from consumer and special lighting products.

The percentage of women in leadership positions remained at 27%, which did not meet the 2025 target of 34%. Signify remains committed to increasing representation through focused hiring practices for diversity across all levels, and through retention and engagement actions that reduce attrition.

The company will structurally reset its cost base and establish continuous productivity improvements, while remaining committed to its operating model.

To drive this, Signify is announcing a EUR 180 million cost reduction program. The majority of savings will be delivered through 2026, with the full benefit realized in 2027. ■

Casambi Announces Leadership Transition: Introducing a Dual CEO Model

www.casambi.com

Casambi, the leader in smart lighting, has announced a significant leadership change as the company adopts a dual CEO model to drive its next phase of growth and innovation. Effective immediately, Kristian Jenkins and Timo Pakkala will assume the roles of Co-Chief Executive Officers. Kristian will focus on Sales & Operations, while Timo, one of Casambi's founders, will lead Technology.

This new leadership structure reflects Casambi's commitment to agility and strategic depth. By combining Kristian's proven operational expertise with Timo's visionary technological leadership, Casambi is positioning itself to accelerate global expansion and deliver cutting-edge solutions to its customers.

Kristian joined Casambi in early 2019 and has since contributed to the company's international growth through a series of key roles. From 2020 to 2023, he focused on developing sales and expanding regional partnerships in Benelux and the Middle East, strengthening Casambi's presence in these markets.

In 2023, whilst completing his Executive MBA, Kristian relocated to Singapore to support the opening of Casambi's APAC office as Business Development Lead and a member of the regional management team. Since April 2024, he has led Casambi's Indian expansion as Country Manager, delivering excellent results and building strong foundations for future growth.

Kristian is highly valued within Casambi and among partners for his global experience, collaborative approach, and commitment to driving success.

Kristian Jenkins, Co-CEO: "I'm honored to take on this role alongside Timo. Our dual leadership approach ensures we can stay close to our customers while continuing to innovate at the core of our technology. Together, we aim to strengthen Casambi's position as the global leader in smart lighting control."

Timo Pakkala, Co-CEO: "Casambi was founded on the idea of challenging the status quo. This new model reflects that spirit. Kristian and I share a clear vision for the future, and we're excited to lead Casambi into its next chapter of growth and technological excellence."

The company also announced that Mark McClear, who has served as CEO since 2023, will step down by mutual agreement. During his tenure, Mark played a pivotal role in Casambi's success, driving significant growth and strengthening global customer relationships.

Kay Pawlik, Chair of the Board: "On behalf of the entire board, I want to express our heartfelt gratitude to Mark. His dedication, tireless efforts, and leadership have been instrumental in Casambi's journey over the past two years. We wish him happiness and success in this new chapter of life."

Casambi's dual CEO model underscores its belief that collaboration and complementary strengths are key to navigating the complexities of the smart lighting industry. With Kristian and Timo at the helm, the company is well-positioned to continue delivering innovative solutions and exceptional value to partners worldwide. ■

Instrument Systems Appoints Dr. Marc Lünnemann as New CEO

www.instrumentsystems.com

The DALI Alliance and the International Association of Lighting Designers (IALD) have announced a collaboration aimed at strengthening the connection between lighting design professionals and cutting-edge digital lighting control standards.

This partnership aims to empower specifiers, designers, and architects by sharing knowledge, launching educational initiatives, and fostering more substantial alignment across the lighting ecosystem. It focuses on joint efforts in education, outreach, and the promotion of open standards to enhance lighting outcomes in architectural, commercial, and public space projects.

"Lighting designers play a critical role in shaping the built environment," said Paul Drosihn, General Manager of the DALI Alliance. "Partnering with the IALD allows us to build a direct bridge to the design community, ensuring that DALI-based technologies continue to support creativity, flexibility, and performance where it matters most."

The collaboration reflects both organizations' commitment to supporting a more connected, informed, and design-forward industry.

"This partnership is about ensuring designers have access to the tools, training, and standards they need to deliver exceptional results," said Christoper Knowlton, CEO of the IALD. "By working with the DALI Alliance, we're helping to close the gap between evolving control technologies and real-world design practice."

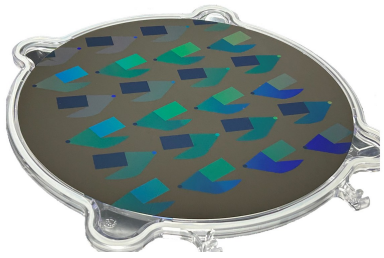
The DALI Alliance and the IALD view this collaboration as a crucial step in empowering lighting professionals to make informed decisions about control systems and in supporting the long-term success of sustainable, human-centric lighting design.

More about the DALI Alliance and its work standardizing and advancing intelligent lighting can be found at dali-alliance.org. Information on the IALD and its advocacy for the lighting design profession and the global community can be found at iald.org ■

AAC Technologies and Eulitha Announce Use of Eulitha's Optical Lithography for Volume AR Waveguide Production

www.aactechnologies.com

AAC Technologies, a global leader in advanced consumer electronics components and modules, and Eulitha AG, a pioneer in high-throughput optical lithography, announced at the SPIE AR/VR Conference that AAC will begin utilizing Eulitha's lithography technology for the volume production of Augmented Reality (AR) waveguides. This represents a significant milestone in the industry's pursuit of scalable and affordable AR waveguide manufacturing.



AR devices are widely expected to become a primary interface for ubiquitous access to information through small displays placed in the user's field of view. These devices are especially effective for the seamless delivery of AI-generated information. Periodic nanostructures, often called diffractive optics, are patterned on glass plates (waveguides) to enable images to be projected to the user's eye while maintaining a clear view of the surroundings. Eulitha's proprietary optical lithography technology enables the high-fidelity printing of high-resolution periodic patterns required for these diffractive optics at a low cost. The technology is akin to the photolithography methods that serve as the backbone for semiconductor fabrication, leveraging the same established supply chains for photomasks, photoresists, and EDA tools.

Production using Eulitha's technology is expected to be available at AAC's manufacturing facilities within this year, marking an important step toward meeting the growing demand for next-generation AR devices.

Howard Tao, Head of the AR/VR Business Unit at AAC Technologies, said: "We have been collaborating with Eulitha to qualify their unique optical lithography technology for our production lines and have been impressed by the performance. We are enthusiastic about the potential of this adoption to boost our position in this competitive field, thanks to the high-quality and low-cost production enabled by Eulitha's tools."

Harun Solak, CEO of Eulitha AG, added: "The adoption of our technology by a leading manufacturer like AAC is a significant step in the recognition of the advantages we offer to our customers. We believe the high throughput and reliability enabled by optical lithography will address the scalability issues currently facing the AR industry. We look forward to continuing our collaboration with AAC Technologies to enable the production of leading AR devices for consumers worldwide."

AAC Technologies brings deep expertise in optical components, modules, and system-level integration. Through in-house capabilities and partner integration, AAC offers fully functional composite AR display modules, including waveguides, light engines (LEA), electrochromics, push/pull lenses, and eye-tracking, to its global customers.

This collaboration highlights a shared commitment by AAC and Eulitha to accelerate the industrialization of AR waveguides and support the broader ecosystem as AR moves toward mass-market adoption. ■

Inventronics and Synapse Wireless Strengthen Partnership with Integrated Wireless Lighting Control Solutions

www.inventronicsglobal.com

In a bold move to enhance lighting solutions, Inventronics and Synapse Wireless strengthen their long-term partnership to offer customers a fully integrated approach of lighting components and control systems.

Synapse Wireless, a leading provider of innovative wireless lighting control, offers intuitive and reliable solutions that address core needs across the board: empowering designers, optimizing asset value for owners, reducing operational energy use, and boosting management efficiency. This delivers on the shared goal of sustained energy savings and precise cost control. With high market acceptance, particularly in North America, Synapse has built a robust service and support ecosystem for the global outdoor and sports lighting markets.

Inventronics, a premier global producer of lighting system solutions, adheres to its core principle of being "customer-centric and creating value for clients." Its lighting system solutions cover multiple application fields, including street and area, sports, horticulture, industrial, commercial, retail/residential, hospitality, architectural, and signage. Currently, Inventronics' product solutions are sold in over 100 countries and regions. The company has established a comprehensive business network in more than 30 of these locations, creating a competitive advantage through "global coordination and local response." As a result, Inventronics holds significant influence in the lighting industry.

Inventronics is recognized for its expertise in LED drivers, while Synapse is known for its advanced lighting control solutions and SimplySnap cloud software. This collaboration offers customers a professional and harmonized system tailored for sports and outdoor applications. Their combined experience results in proven, stable system setups.

As new features continue to emerge in both driver and control technologies, customers increasingly seek components that are fully compatible. To address this need, a dedicated compatibility list covering validated driver–control combinations will be released. This aims to reduce testing time and streamline the design-in process for lighting professionals. ■

ams OSRAM Sells Non-optical Analog/mixed-signal Sensor Business to Infineon

ams-osram.com

ams OSRAM sells non-optical analog/mixed-signal sensor business to Infineon for EUR 570 m in cash, reduces pro-forma leverage ratio to 2.5 and is creating the leader in Digital Photonics.

"With the focused sale of our non-optical automotive, industrial & medical sensor business to Infineon for EUR 570 million in cash, we are effectively killing two birds with one stone: we are accelerating the deleveraging of our balance sheet while at the same time creating a compelling strategic pure play – the leader in Digital Photonics. We are emerging as the Photonics Powerhouse, offering the broadest suite of cutting-edge semiconductor emitting & sensing platforms, uniquely positioned to capture the major inflection points in Digital Photonics across automotive, Augmented Reality smart glasses, biosensing, home and industrial robotics, AI data-center optical interconnects and potentially even visionary applications like laser fusion." said Aldo Kamper, CEO of ams OSRAM. ■

Farnell and Fulham Announce Global Distribution Partnership

Farnell has announced a new global distribution partnership with Fulham, expanding access to advanced LED drivers, emergency lighting and intelligent control solutions for customers across EMEA. The agreement strengthens Farnell's lighting portfolio in the region, supporting engineers and buyers across commercial, industrial and architectural lighting applications.

Fulham brings more than 30 years of expertise in LED drivers, modules, emergency lighting and intelligent control systems. Headquartered in the United States, the company operates globally, with manufacturing in India, supply channels in India and China, and a strong presence across Europe. Its portfolio includes indoor and outdoor LED drivers, emergency lighting systems, UV ballasts, and smart control technologies, all designed to meet key international standards, including CE, ENEC, DALI-2, and UL.

Through this partnership, Farnell will distribute Fulham's lighting solutions globally, improving availability and access to future-ready technologies for engineers and buyers worldwide.

The agreement includes Fulham's core lighting portfolio, including emergency lighting systems, indoor LED drivers, and constant-voltage driver platforms, with key ranges including the HotSpot® Series, WorkHorse® DALI-2 constant-current drivers, and the ThoroLED® Series for architectural lighting, signage, and LED strip applications.

Customer benefits include:

- Broader access to certified, future-ready lighting technologies.
- Global availability through Farnell's established distribution network.
- Support for a wide range of lighting applications and form factors.
- Access to Fulham's deep technical expertise and proven product platforms.

Jose Lok, Global Product Category Director – Onboard Components & SBC, Farnell, said: "Farnell has a strong commitment to adding value for our customers, and this partnership expands both choice and access to innovative lighting technologies. By working with Fulham, we are enabling customers worldwide to source advanced LED drivers, emergency lighting and control solutions through a trusted global distribution partner."

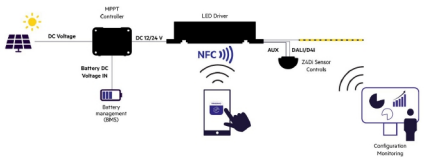
Antony Corrie, CEO, Fulham, added: "Fulham is extremely excited to embark on this new relationship with Farnell Global. As a Yorkshireman, and with Farnell headquartered in Leeds, I'm especially proud to work with a company I've known and respected since starting my career in the mid-1990s. This partnership brings together shared values, strong heritage and a commitment to global innovation. Farnell will be selling Fulham's LED drivers, emergency battery backup solutions, exit signs and UV-C power systems across their global customer base." ■

From Sunlight to Night Light with ILIORA

www.tridonic.com

Lighting streets and squares ensures safety and thus increases well-being. In connection with climate targets, energy self-sufficiency and digitalization, the market for solar-powered outdoor luminaires is growing.

They relieve the strain on the power grid or enable lighting where there are no power lines. To pave the way for a new era of solar-powered outdoor lighting Tridonic is launching ILIORA technology.



Traditional street lighting was developed for power grids that changed more slowly in the past than they do today. The costs of expanding the lighting infrastructure are high, especially when construction work in public spaces is necessary to lay underground cable installations. In many parts of the world, the power grids are still underdeveloped, and electricity prices have exploded in many countries in recent years. Even well-developed power grids are increasingly at risk of blackouts caused by power surges.

New outdoor lighting to relieve the burden on power grids: New technological advances offer high potentials to significantly improve the outdoor lighting network and help save energy and reduce CO emissions. Technologies such as advanced smart city solutions and the higher quality and performance of solar technology, batteries and LEDs offer opportunities to reduce the burden on current power grids. The EU climate targets, which are laid down in the EU Green Deal, among other places, have drawn attention to self-sufficient, sustainable solutions. However, to achieve this, outdoor lighting needs to be rethought.

ILIORA – from sunlight to night light: Solar-powered luminaires make outdoor lighting more flexible and sustainable. The ILIORA solution from Tridonic heralds a new era in outdoor lighting. At the heart of the technology is a new, D4i-certified DC/DC LED driver that enables the easy integration of different sensors and light management systems. This means that for every application the perfect solution can be realized. Solar lighting thus becomes a reliable and scalable solution for modern urban environments. An MPPT controller manages the energy flow and ensures that the stored energy is efficiently transferred to the LED luminaires. Integrated sensors and state-of-the-art controls complement the solution, both for a small group of luminaires and for a smart city application.

As no excavation or cabling work is required, installation costs can be significantly reduced. The sustainable design, which does not require a mains connection, ensures that the operation of the luminaires does not produce any emissions. As they are independent of the mains power supply, the systems continue to function without interruption even in the event of a power failure. In addition, modern masts can be used as sensor hubs that collect environmental and usage data. In this way, the lighting support the smart city concept.

ILIORA Planner: Tool for dimensioning components: To optimize the system architecture of solar-powered outdoor luminaires easily and efficiently, Tridonic offers a tool called the ILIORA Planner. By analyzing project-specific requirements and using location-based data, the calculation tool automatically selects the appropriate components, such as solar modules, batteries and LED modules, and dimensions them to meet the desired requirements, for example with regards to the daily lighting duration. The interactive user interface with graphical instructions enables precise configurations based on street type, lumen requirements and desired autonomy duration.

ILIORA in use: In combination with a sensor for ambient light and motion detection, footpaths and cycle paths in urban parks can be illuminated more efficiently. If the sensor

detects movement from pedestrians or cyclists, the light intensity is increased and the luminaire shines brighter. When there are no people in the vicinity of the luminaire(s), the lighting is dimmed to a very low light intensity or even switched off completely to save energy.

ILIORA can also be used at temporary construction sites, for example on motorways. Individual luminaires with the chronoSTEP function, in conjunction with a light sensor, ensure that the lighting is switched on automatically as soon as darkness falls.

Another application is in industrial areas with connected car parks. There, the luminaires can be connected to each other via a basicDIM Wireless mesh network and controlled via light sensors and motion detectors. Thanks to basicDIM Wireless, groups of luminaires can be switched on and off simultaneously by remote control.

In rural areas without their own power supply, such as mountain huts in alpine regions or safari lodges in Africa, sensors with ambient light and motion detection automatically switch on the lighting when darkness falls or increase the light intensity as soon as movement is detected. ■

Emergency Lighting Built for Installation Readiness

www.ledvance.com

Emergency lighting is a fundamental component of building safety, helping to ensure that occupants can safely exit a space in the event of a power failure or emergency. For commercial, industrial and public environments, the correct specification and installation of emergency luminaires is essential not only for safety, but also for compliance with current regulations and standards.

When planning an emergency lighting system, specifiers and installers must consider a range of practical factors. These include light output and coverage, emergency duration, environmental protection, and long-term reliability. Installation efficiency is also an important consideration, particularly on projects with tight deadlines or limited access. Increasingly, flexibility and futureproofing are also valued, allowing systems to be adapted as building use or requirements change.

To support these needs, LEDVANCE has expanded its emergency lighting portfolio with two new solutions designed to combine dependable performance with practical installation features.

The LEDVANCE Emergency Twin Spot luminaire is designed for applications where high visibility and directional emergency lighting are required. Suitable for use in both indoor and outdoor environments, its IP65-rated housing offers protection against dust and moisture, making it appropriate for areas such as warehouses, car parks, plant rooms and external escape routes. Two adjustable spotlights allow installers to direct light precisely where it is needed, helping to improve coverage along defined escape paths. The luminaire is equipped with a LiFePO4 battery, providing a minimum of three hours emergency operation, and is supplied with mounting accessories to help streamline installation on site.

Complementing this is the Wallpack Combo IP65 luminaire, which introduces LEDVANCE's Plug & Upgrade concept to outdoor emergency lighting. This modular approach allows the wallpack to be installed initially as a standard luminaire, with emergency functionality added later via an emergency kit if required. This can be particularly useful on projects where emergency lighting requirements may change, or where budget and program considerations call for a phased approach. Options come with or without an integrated photocell - providing additional flexibility for exterior applications.

"Safety and ease of installation are the two pillars of every professional lighting project," said Nelo Neves, Managing Director, LEDVANCE "These new emergency luminaires underscore LEDVANCE's commitment to solutions that are not just technically excellent, but also genuinely easier to fit and commission."

Supported by LEDVANCE's technical documentation and installer guidance, the new luminaires are intended to help professionals deliver effective emergency lighting solutions while keeping installation and future maintenance considerations firmly in mind. ■

Orion Announces $3M LED Lighting and Electrical Infrastructure Initiative at One of America's Largest Food Distribution Companies

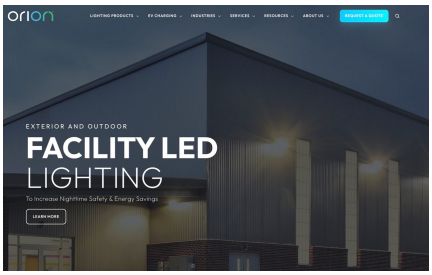
www.orionlighting.com

Orion Energy Systems, Inc. (NASDAQ: OESX) (Orion Lighting), a provider of energy-efficient LED lighting, electric vehicle (EV) charging stations and maintenance services solutions, has announced that it has initiated a $3 million LED lighting and electrical infrastructure engagement for one of the leading food-service distributors in the United States.

The initiative consists of deployments and upgrades of LED lighting and electrical infrastructure at multiple facilities of one of Orion's longtime enterprise customers. The food-service distributor operates more than 150 facilities in the United States.

"Our longtime ongoing relationship typifies how Orion serves so many of America's largest and most important extended enterprises," said Orion Chief Executive Officer Sally Washlow. "We are greatly appreciative that some of the most prominent industrial names in the U.S. rely on Orion on such a consistent basis."

"The large number of facilities operated by this industry leader have a recurring need for installing and upgrading their LED lighting and electrical infrastructure at multiple locations at any one time," said Orion Chief Operating Officer Scott Green. "Orion has enjoyed a very close partnership with this customer for a number of years, and it is gratifying to see it continue to grow."



Orion is committed to operating responsibly throughout all areas of our organization. ■

Two Senior Leaders Elevated to Associate Executive Director Roles as Organizations Leverage Strategic Partnership

www.ies.org

The Illuminating Engineering Society (IES) and Audio Engineering Society (AES) announced the promotion of two senior staff members to newly created Associate Executive Director positions, effective January 1, 2026. The appointments reflect both organizations' commitment to strategic growth and enhanced industry engagement following their recent shared management arrangement.

Brienne Willcock has been promoted to Associate Executive Director, Strategy, Standards, and Industry Engagement at IES. Willcock currently serves as Director of Education and Standards at IES, where she has been instrumental in advancing the society's technical excellence and educational programs.

Graham Kirk has been promoted to Associate Executive Director, Strategy, Events, and Industry Engagement at AES. Kirk currently serves as Director of Marketing and Business Development at IES and will bring his extensive experience in strategic positioning and event expertise from both AES and IES to his new role.

"Brienne and Graham have been invaluable in helping IES achieve significant milestones over the past several years," said Colleen Harper, CEO and Executive Director of IES and Executive Director of AES. "These promotions recognize their leadership and expertise while positioning both organizations for continued innovation and growth. As we integrate our management structures, having leaders of their caliber focusing on strategy and industry engagement will be essential to serving our respective technical communities."

"I'm honored to step into this expanded role and continue advancing IES's work at the intersection of education, standards, and industry collaboration," said Brienne Willcock. "As IES evolves, aligning our strategic initiatives with the needs of the lighting community is more important than ever. I look forward to helping guide that direction and ensuring our work remains both rigorous and deeply relevant."

"I'm excited to return to AES and help stabilize and grow an organization with such a rich legacy," said Graham Kirk. "AES has long been known for its exceptional educational events and publications, and I look forward to building on that foundation to serve the audio engineering community and strengthen the Society's position as the leading voice in professional audio."

Both appointments support the strategic vision of IES and AES to maintain their distinct identities while leveraging operational synergies through shared management. The new roles will focus on advancing each organization's strategic priorities, strengthening industry partnerships, and enhancing member value.

About the IES: Established in 1906, the Illuminating Engineering Society is the recognized technical and educational authority on illumination. Our mission is to improve the lighted environment by bringing together those with lighting knowledge and by translating that knowledge into actions that benefit the public. We provide a variety of professional development, publications, networking and educational opportunities to our membership of engineers, architects, designers, educators, students, contractors, distributors, utility personnel, manufacturers and scientists in nearly 60 countries. Through our American National Standards Institute (ANSI) accredited process, we publish and maintain the Lighting Library®, with over 100 standards written by subject matter experts in our technical committees. In all our efforts, we strive to improve life through quality of light. ■

Bridgelux Expands into High-Power Outdoor Lighting with New High-Efficacy LED Platforms

www.bridgelux.com/smd-outdoor

Bridgelux, a leading developer and manufacturer of LED light source solutions, recently announced its strategic expansion into the high-power outdoor lighting segment with the launch of three advanced product families: Ceramic 3535, EMC5050, and CSP2424. These new platforms deliver class-leading efficacy, exceptional color consistency, and outstanding lifetime performance, setting a new benchmark for professional outdoor luminaires.

Designed specifically for demanding street, area, high-bay, and flood lighting applications, the new Bridgelux high-power outdoor portfolio achieves 200–230 lm/W at ~2 Watts operating condition (CRI70 and 4000 K), representing one of the highest efficacies commercially available in the high-power category as shown in the following table. This breakthrough enables luminaire manufacturers to dramatically reduce system power consumption, lower total cost of ownership, and meet the most stringent energy-efficiency regulations worldwide.

"Bridgelux has long been recognized for delivering innovative, high-performance LED solutions," said Dr. Yi-Qun Li, Chief Executive Officer of Bridgelux. "With this launch, we are bringing that same innovation and quality to the high-power outdoor market. These new products combine record-breaking efficacy with the reliability and color quality that designers demand for critical infrastructure lighting projects."

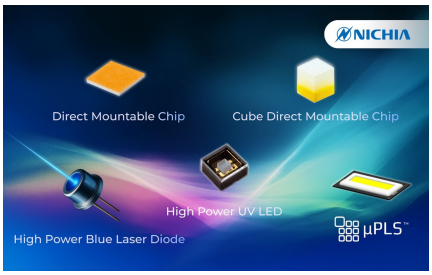
The Ceramic 3535, EMC5050, and CSP2424 families are fully qualified and in volume production. Samples and evaluation boards are available immediately, with standard lead times for production quantities.

About Bridgelux: Bridgelux is a leading provider of high-performance LED light sources that help customers achieve superior optical performance, cost efficiency, and sustainability goals. With decades of innovation in phosphor, packaging, and chip technology, Bridgelux continues to push the boundaries of solid-state lighting. ■

Nichia Innovation Gallery Staged During Light + Building Week as Part of Wider Milestone Year

www.nichia.co.jp/en

As Nichia marks the key milestones of 70 years in business and 30 years since pioneering the white LED, its European division has organized a two-day, invite-only Innovation Gallery. Held on 10 and 11 March at Bernhard Knaus Fine Art, a prestigious art gallery in Frankfurt, the showcase takes place during Light + Building week (8–13 March 2026). The regional team chose this timing to complement the trade fair experience for visitors already in the city.



Nichia's portfolio goes beyond general and architectural lighting that dominates the exhibition halls at Light + Building. At the Innovation Gallery, visitors will be able to engage with the full breadth of Nichia's optoelectronics range, from automotive, industrial and medical to horticultural and other specialist applications. The gallery also offers an opportunity to explore where technologies already intersect today and where future crossovers could unlock new creative possibilities for lighting professionals.

Rather than attempting to replicate a large trade show stand, the Innovation Gallery enables customers and partners to experience novel demonstrations tailored to real use-cases, highlighting integration opportunities in a calm and creative environment. The setting is designed to encourage longer, more meaningful conversations with engineers and company representatives, as well as informal exchange among visitors.

The Innovation Gallery is just a seven-minute walk from the Light + Building exhibition grounds. For added convenience, a shuttle service will be available for registered participants.

"Anniversaries give us a moment to reflect — and to look ahead," said Anna Müller, Head of Marketing at Nichia Europe GmbH. "Our Innovation Gallery in Frankfurt offers a contemporary setting to mark two milestones: Nichia's 70-year anniversary and 30 years since the company developed the white LED. By stepping outside the traditional trade-fair setting, we are creating space for deeper dialogue across our full optoelectronics portfolio beyond general lighting — from automotive and UV to industrial and laser technologies." ■

Zumtobel Realizes James Turrell's Skyspace "Sustenance 2024" at the University Children's Hospital Zurich

www.zumtobel.com

With the Skyspace "Sustenance 2024," American light artist James Turrell has created an extraordinary light space at the University Children's Hospital Zurich, Switzerland, that combines art, space, and light into a unique experience. Turrell refers to Skyspace as observation rooms in which natural light flows through openings in the ceiling and, in combination with LED lighting, creates fascinating effects within the space.

The Skyspace "Sustenance 2024" is intended for patients and their families as well as for staff. After a disturbing conversation, a delicate procedure or a difficult diagnosis, a visit to the Skyspace provides a welcome distraction. The contemplative perception of light and sky invites visitors to pause and meditate. The ellipsoid, eight-meter-high Skyspace in the heart of the University Children's Hospital Zurich stretches like a dome vault over two floors. The walls taper upwards to form an elliptical light inlet. The space is illuminated by a precisely coordinated LED lighting system. 433 high-performance lights distributed across three light rings choreograph unique color gradients. The LEDs also illuminate the uppermost diffuser in the roof structure, which in turn serves as a reflective medium and pushes human perception to its limits by contrasting the dark floor and the roof opening.

The Skyspace "Sustenance 2024" thus fits seamlessly into the concept of the Zurich Children's Hospital, which focuses on healing architecture: rooms positively support healing through art, natural materials, and human-centered lighting. As general planner and lighting partner, Zumtobel was responsible for the technical implementation of the project and contributed its expertise from many years of collaborating with James Turrell. "This work of art is the most elaborate and best we have ever created," says Zumtobel project manager Jürgen Häcker. As project manager on site, he coordinated all the trades.

In addition to fire protection and earthquake safety, the Skyspace "Sustenance 2024" had to overcome a very special challenge: the children's hospital's helipad is in the immediate vicinity. A three-ton dome on rails slides over the art space whenever a rescue helicopter approaches – as well as in rain, snow, or strong winds. When the roof is closed, it creates an effect of dimensionlessness. The shell that closes the dome is illuminated by another ring of light in such a way that the lighting effect remains extraordinary even when the dome is closed.

The Skyspace consists of individual, precise 3D elements that form this unique space. The floor and benches, made of granite slabs weighing up to 120 kilograms, were cut with millimeter precision to create a highly accurate joint pattern. The whole structure is held in place by an invisible steel framework that has been mounted in such a way that it is both absolutely stable and movable.

With a passion for light and a deep understanding of James Turrell's highly sophisticated light art, Zumtobel Licht AG has put its heart and soul into this unique task. The magnificent, solution-oriented external team coordinated by Zumtobel Licht AG also deserves special mention.

A Radiant Partnership: The long-standing partnership between Zumtobel, led by Herbert Resch, the Zumtobel family, and James Turrell has already produced several unique pieces. In 2018, Zumtobel was the lighting partner for Turrell's exhibition "The Substance of Light" at the Frieder Burda Museum in Baden-Baden, Germany. And in 2015, he designed the Zumtobel Group's annual report under the title "Extraordinary Ideas – Realized." With the new light room at the Children's Hospital in Zurich, this creative collaboration, which combines art and social responsibility, has reached a new high point.

"We have been working closely and trustingly with James Turrell for many years. His artistic standards inspire us time and again to break new ground in our approach to light. We are particularly proud to have been able to realize this unique project at the University Children's Hospital in Zurich—because here, art and lighting contribute to healing and give hope," says Isabel Zumtobel, Director of Arts & Culture at the Zumtobel Group. ■

DALI Alliance Launches Test and Certification Specifications for Wireless to DALI Gateways

www.dali-alliance.org

The DALI Alliance, recognized as the international authority in lighting technology standardization, proudly announces the launch of its new test and certification specifications for Wireless to DALI Gateways. This groundbreaking release allows seamless control of wired DALI devices from either Bluetooth® NLC (Networked Lighting Control) or Zigbee wireless ecosystems, and provides access to data from DALI systems, paving the way for increased interoperability and flexibility in the lighting industry.

The new specifications allow wired and wireless connectivity within lighting systems and give the flexibility to choose the best lighting control solution for the application. The test and certification specifications will ensure that standardized gateways translate effectively between DALI systems and the wireless protocols, Bluetooth NLC or Zigbee, providing a crucial link between these diverse technologies. These standardized gateways promote market confidence and accelerate the adoption of DALI-based solutions in the evolving world of smart building technologies.

Key Features and Benefits

- The new specifications allow wired DALI products, both DALI-2 and D4i, to be controlled within wireless ecosystems, offering greater flexibility and adaptability.
- Gateways translate seamlessly between DALI and Bluetooth NLC or Zigbee wireless protocols, providing robust interoperability.
- These standardized gateways allow

wireless ecosystems to access data from wired DALI devices, including the rich set of luminaire, power and energy and diagnostics data available from D4i luminaires.

As Paul Drosihn, General Manager of the DALI Alliance, explains, “The introduction of these test and certification specifications for Wireless to DALI Gateways is a significant milestone. It opens up new possibilities for integrating DALI with wireless systems, creating a broader range of solutions for the industry. By standardizing these gateways, we’re promoting interoperability and providing a path forward for developers, manufacturers, and professionals in building automation.”

“The completion of the Bluetooth® NLC to DALI Gateway Specification suite marks a significant milestone for lighting control systems,” said Neville Meijers, CEO of the Bluetooth SIG. “These standardized gateways enable seamless integration between DALI’s trusted wired systems and the leading wireless lighting standard. The collaboration highlights the power of open, industry-defined standards in driving innovation, building market confidence, and untapping the full potential of intelligent lighting systems to deliver consistent, value-added solutions for building management and occupants.”

Together, these standardized gateways extend the reach of DALI into both Bluetooth NLC and Zigbee ecosystems, ensuring interoperability across the industry’s leading wireless platforms.

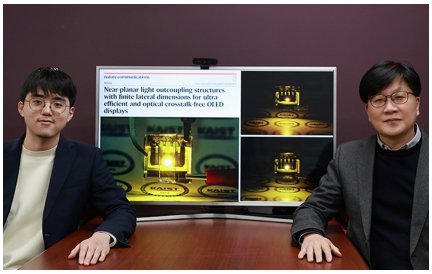
“The integration of Zigbee and DALI represents a pivotal moment in the evolution of smart lighting and building automation,” said Tobin Richardson, President and CEO of the Connectivity Standards Alliance. “Zigbee’s robust, interoperable wireless mesh technology, combined with the precision and scalability of DALI’s digital lighting control, bridges the gap between field-level lighting devices and wireless IoT networks. The standardized gateways enhance flexibility, lower deployment complexity, and pave the way for more intelligent, energy-efficient buildings.”

The DALI Alliance’s commitment to open, industry-defined specifications is essential to ensure the correct functionality of these gateways. Unlike closed, proprietary solutions, standardized gateways help avoid compatibility issues and ensure a consistent user experience across different systems. ■

KAIST Develops OLED Technology with Double the Screen Brightness

www.kaist.ac.kr

Organic light-emitting diodes (OLEDs) are widely used in smartphones and TVs thanks to their excellent color reproduction and thin, flexible planar structure. However, internal light loss has limited further improvements in brightness. KAIST researchers have now developed a technology that more than doubles OLED light-emission efficiency while maintaining the flat structure that is a key advantage of OLED displays.



KAIST (President Kwang Hyung Lee) announced on the 11th of January that a research team led by Professor Seunghyup Yoo of the School of Electrical Engineering has developed a new near-planar light outcoupling structure* and an OLED design method that can significantly reduce light loss inside OLED devices. * Near-planar light outcoupling structure: a thin structure that keeps the OLED surface almost flat while extracting more of the light generated inside to the outside.

OLEDs are composed of multiple layers of ultrathin organic films stacked on top of one another. As light passes through these layers, it is repeatedly reflected or absorbed, often causing more than 80% of the light generated inside the OLED to be lost as heat before it can escape.

To address this issue, light outcoupling structures such as hemispherical lenses or microlens arrays (MLAs) have been used to extract light from OLEDs. However, hemispherical lenses protrude significantly, making it difficult to maintain a flat form factor, while MLAs must cover much larger area than individual pixel sizes to achieve sufficient light extraction. This creates limitations in achieving high efficiency without interference between neighboring pixels.

To increase OLED brightness while preserving a planar structure, the research team proposed a new OLED design strategy that maximizes light extraction within the size of each individual pixel.

Unlike conventional designs that assume OLEDs extend infinitely, this approach takes into account the finite pixel sizes actually used in real displays. As a result, more light can be emitted externally even from pixels of the same size.

In addition, the team developed a new near-planar light outcoupling structure that helps light emerge efficiently in the forward direction without being spread too widely. This structure is very thin—comparable in thickness to existing microlens arrays—yet achieves light extraction efficiency close to that of hemispherical lenses of the same lateral dimension. As a result, it hardly undermines the flat form factors of OLEDs and can be readily applied to flexible OLED displays.

By combining the new OLED design with the near-planar light outcoupling structure, the researchers successfully achieved more than a twofold improvement in light-emission efficiency even in small pixels.

This technology enables brighter displays using the same power while maintaining OLED’s flat structure and is expected to extend battery life and reduce heat generation in mobile devices such as smartphones and tablets. Improvements in display lifespan are also anticipated.

MinJae Kim, the first author of the study, noted, "A small idea that came up during class was developed into real research results through the KAIST Undergraduate Research Program (URP)."

Professor Seunghyup Yoo stated, "Although many light outcoupling structures have been proposed, most were designed for large-area lighting applications, and many were difficult to apply effectively to displays composed of numerous small pixels," adding, "The near-planar light outcoupling structure proposed in this work was designed with constraints on the size of the light source within each pixel, reducing optical interference between adjacent pixels while maximizing efficiency." He further emphasized that the approach can be applied not only to OLEDs but also to next-generation display technologies based on materials such as perovskites and quantum dots.

This research, with MinJae Kim (Department of Materials Science and Engineering, KAIST; currently a Ph.D. student in Materials Science and Engineering at Stanford University) and Junho Kim (School of Electrical Engineering, KAIST; currently a postdoctoral researcher at the University of Cologne, Germany) as co–first authors, was published online on December 29, 2025, in Nature Communications. □ Paper title: "Near-planar light outcoupling structures with finite lateral dimensions for ultra-efficient and optical crosstalk-free OLED displays" DOI: 10.1038/s41467-025-66538-6

This research was supported by the KAIST Undergraduate Research Program (URP), the Mid-Career Researcher Program and the Future Display Strategic Research Lab Program of the National Research Foundation (NRF) of Korea, the Human Resource Development Program of the Korea Institute for Advancement of Technology (KIAT), and the Korea Planning & Evaluation Institute of Industrial Technology (KEIT). ■

High-Efficiency Phosphor-Free Yellow LED Technology Redefines Low-Color-Temperature Lighting

573600737@qq.com

A breakthrough in silicon-based GaN LED technology is enabling a new generation of energy-efficient, phosphor-free lighting solutions for education, infrastructure, and outdoor applications.

The global lighting industry has long faced a fundamental trade-off in yellow and ultra-low color temperature LEDs: either accept low efficiency and thermal instability or rely on phosphor-conversion with its inherent drawbacks in color purity, aging, and reliability. A new technological milestone now overcomes these limitations.

A New Benchmark for Yellow LED Performance: In 2018, Nanchang Silicon-Based Semiconductor Technology Co., Ltd. achieved a major breakthrough with the development of a silicon-based gallium nitride (GaN) yellow LED chip, setting a new world record in luminous efficacy for yellow LEDs. The chip delivers 318 lm/W at 565 nm, with a wall-plug efficiency of 51.6%, while maintaining high color purity and exceptional thermal stability.

Unlike conventional phosphor-converted solutions, the chip emits yellow light directly, eliminating phosphor-related degradation and color shift at the source. Compared with traditional AlGaInP yellow LEDs, it shows significantly reduced temperature-induced light output droop, making it highly suitable for demanding real-world environments.

Enabling a New Generation of Phosphor-Free Lighting Systems: Building on this core technology, two major phosphor-free lighting product categories have emerged:

Multi-Color LED Phosphor-Free Lighting for Human-Centric Environments: Designed for applications requiring high visual comfort and spectral control—such as classrooms and educational facilities—multi-color LED phosphor-free systems enable dynamic spectrum adjustment tailored to different use scenarios.

By reducing short-wavelength blue light through precise spectral tuning, these systems help lower eye strain and mitigate myopia risks among adolescents. Typical classroom luminaires deliver 3000 lm at 36 W, with Ra >90, R9 >90, and a correlated color temperature adjustable from 2000K to 5000K.

Golden Light LED: A New Standard for Outdoor and Road Lighting: For road, tunnel, and outdoor lighting, the high-efficiency yellow GaN LED chip is combined with high-performance red LEDs to create a unique golden-light spectrum, entirely free of phosphor conversion.

The resulting LED packages deliver warm light at 1800–2200 K, with Ra >70, excellent luminous efficiency, and outstanding environmental adaptability. In street-lighting systems, efficacies of up to 145 lm/W at 2000 K are achieved—a level previously unattainable at such low color temperatures. ■

International Conference on Energy Efficiency and Smart Communities Returns to Frankfurt in March 2026

Paolo.Bertoldi@ec.europa.eu

The International Conference on Improving Energy Efficiency in Commercial Buildings and Smart Communities (IEECB&SC'26) will take place on March 11, 2026, in Frankfurt, Germany, followed by the European ESCO Conference 2026 on March 12, 2026. Both events will be held at Messe Frankfurt in conjunction with the Light + Building exhibition.

Now in its 13th edition, IEECB&SC has established itself as a leading international platform for the exchange of knowledge and best practices on energy efficiency, sustainability, and smart solutions for non-residential buildings, districts, and cities. The conference brings together researchers, policy makers, ESCOs, utilities, engineers, architects, technology providers, financiers, and commercial property stakeholders from around the world. ■

Amendment: The commentary in issue #112 included a figure regarding LED energy conversion that wasn't accurate. The editors reviewed and consequently adjusted the figure to a more exact range of 40 - 60%.

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Efficiency Is Not Enough: Rethinking the Future of Professional Lighting – Klaus Vamberszky, Former CTO at ZUMTOBEL Group

Dipl.-Ing. Klaus Vamberszky: "Light spectra from UV to IR still hold the biggest untapped potential."

With more than four decades of experience spanning product development, R&D leadership, and international standardization, Former CTO at ZUMTOBEL Group, Dipl.-Ing. Klaus Vamberszky has witnessed—and helped shape—the most transformative phases of the lighting industry. From the early days of CAD-supported lighting design to the LED transition and today's debates on sustainability, regulation, and human-centric lighting, his perspective bridges technology, architecture, and strategy. In this interview, he reflects on past turning points, current structural challenges, and the directions that may define the future of lighting in Europe and beyond.

zumtobelgroup.com

LED professional: **Mr. Vamberszky, how would you describe your professional journey in the lighting industry, and which stages or roles were particularly formative for you?**

Klaus Vamberszky: I entered the lighting industry in 1985, after having studied mechanical and chemical engineering at the Vienna Technical University ("Verfahrensingenieurwesen" an der TU Wien) as a mechanical engineer and designer. It was the time of CAD/CAM, of the first software programs to support lighting design. At that time Zumtobel even participated as an exhibitor at the CEBIT fair in Hannover, along with their CAD-supplier Matra Datavision.

Two of my roles that I would like to highlight are:

- Head of product development at Zumtobel; working personally with famous architects like Ettore Sottsass, Jean-Michel Wilmotte, Nicholas Grimshaw but also the young Austrian designer, Karin Pesau. Creating benchmark standard products and realizing challenging customized project solutions, and being close to customers and markets. It was the time when Zumtobel entered the architectural lighting segment, with the first spots and downlights to be developed (downlight family OPTOS (**Figure 1**), spotlight ARTOS). Prestigious projects needed to be delivered, mainly in the UK (for example Waterloo Station (**Figure 2**) or CAA Southampton).
- CTO in the times of the LED transition. Here I was also acting in parallel as head of R&D at Tridonic. Entering new businesses like LED retrofit bulbs, exploring both polymer as well as small molecule OLEDs in joint-ventures and cooperations with Fraunhofer and Cambridge Display Technologies – working on new technologies but always with an eye on the professional lighting market and application. This added a strategic lever to all the decisions that needed to be taken and also involved the topic of Intellectual Property. In addition to this, it was the time of and after the acquisition of Thorn with a lot of so-called post-merger-integration initiatives. I also enjoyed the global view of it, the involvement in Zumtobel US as well as the early and frequent travel to Japan and Korea regarding LED and OLED suppliers.

LED professional: **Looking at the lighting domain today, how would you characterize its current state compared to earlier phases of development?**

Klaus Vamberszky: The current state is – in my view – characterized by too much focus on energy saving and cost: it is a sign of a highly commoditized business. Even in product design and architecture there is too much "mainstream"; everything looks the same. This was definitely different in the years before 2000.

LED professional: **What changes over the past decade have had the greatest impact on the industry — technological, economic, or regulatory?**

Klaus Vamberszky: By far the biggest change was created by technology; the transition from fluorescent and high pressure discharge lamps to LEDs. The former dominant lamp industry lost importance and leadership; the luminaire industry is very fragmented and now the lighting industry is left without "industrial leadership". On one side this is a disadvantage (no common voice anymore), and on the other side, it leaves room for the own positioning of companies. The LED was the first light source that was not developed for general illumination, and this brought some very interesting developments.

I remember very well, the talk I gave at LpS 2011 in Bregenz where I predicted the production cost of a 2,000 lm downlight based on Haitz and Moore's law to come down from 120 € in 2010 to approx. 20 € in 2020 (**Figure 3**).

At the time, the prediction was viewed with skepticism; today we know it may even have been too conservative. I always like to cite the law of Amara in this respect: "We tend to overestimate the short-term impact of new technologies but underestimate their long-term effects". Technology management is and has always been one of my favorite interests.

The other big impact was the financial crises in 2007/2008 which reduced the new construction volume dramatically; even today it hasn't recovered to its old peak.

LED professional: Where do you currently see the main strengths of European lighting companies, and where do structural challenges remain?

Klaus Vamberszky: The strength of the European lighting companies is the holistic understanding of the "lighting application", including cultural aspects. It is a balanced view consisting of architecture and aesthetics, understanding lighting, technology, optics, and the application itself. The challenge is on the cost and complexity side of the business; the trade-off between mass products with economies of scale, and a lot of product niches with small quantities.

LED professional: LED technology has become firmly established. In your view, where are the most relevant impulses for future development on the light source now coming from?

Klaus Vamberszky: I still see the biggest potential in the light spectra, ranging from UV up to IR radiation; there is a lot of interesting scientific work being done on this right now. In the future we might have an efficient multi-channel multi-color light source without wavelength conversion methods, avoiding the Stokes losses. In terms of technology, Steven Paolini and his Telelumen company have already shown what is possible there, and in terms of architecture I would like to mention the early work of the architect Philippe Rahm, from French-speaking Switzerland, on "climatic architecture".

Another interesting topic is the brightness of light sources, including laser diodes on the upper end of the range, and organic light emitting diodes (OLEDs) on the lower end. These light sources have been around for quite a while, and used in other industries, like, for example, automotive lighting. But so far they have not been widely used in general illumination.

The lighting industry is a very slow business: It is difficult to get a quick return on investment. However, there may be some tailwind from sustainability and circular economy for new light sources like the ones mentioned before.

LED professional: How do you assess the growing importance of connected, software-driven lighting systems compared to traditional product innovation?

Figure 1: Downlight Optos; Design Sottsass Association. © Zumtobel Group.

Figure 2: Waterloo Station Terminal; Architect Nicholas Grimshaw. Photo: Jo Reid & John Peck. © Zumtobel Group.

Klaus Vamberszky: Well, this is a complex topic: Lighting is a mediator business, the real "end-user" of lighting (meaning the people sitting below the luminaires installed) is not integrated in the choice of the lighting system itself. There are very different "verticals" in professional buildings, like HVAC (heating, ventilation and cooling), fire detection, entrance control, and others, and the final user is untrained in the systems in place. The business case is difficult, as energy savings achieved through controls and "lighting comfort" are not understood by many. This has actually been shown by the recent discussions about "indoor environmental quality" on a European level in connection with the EPBD directive (Energy Performance of Buildings directive).

LED professional: What role will interoperability (e.g. DALI, Zhaga), open interfaces, and data play in the future development of lighting solutions?

Klaus Vamberszky: This question, too, has different viewing angles; there is the customer and the specifier who want

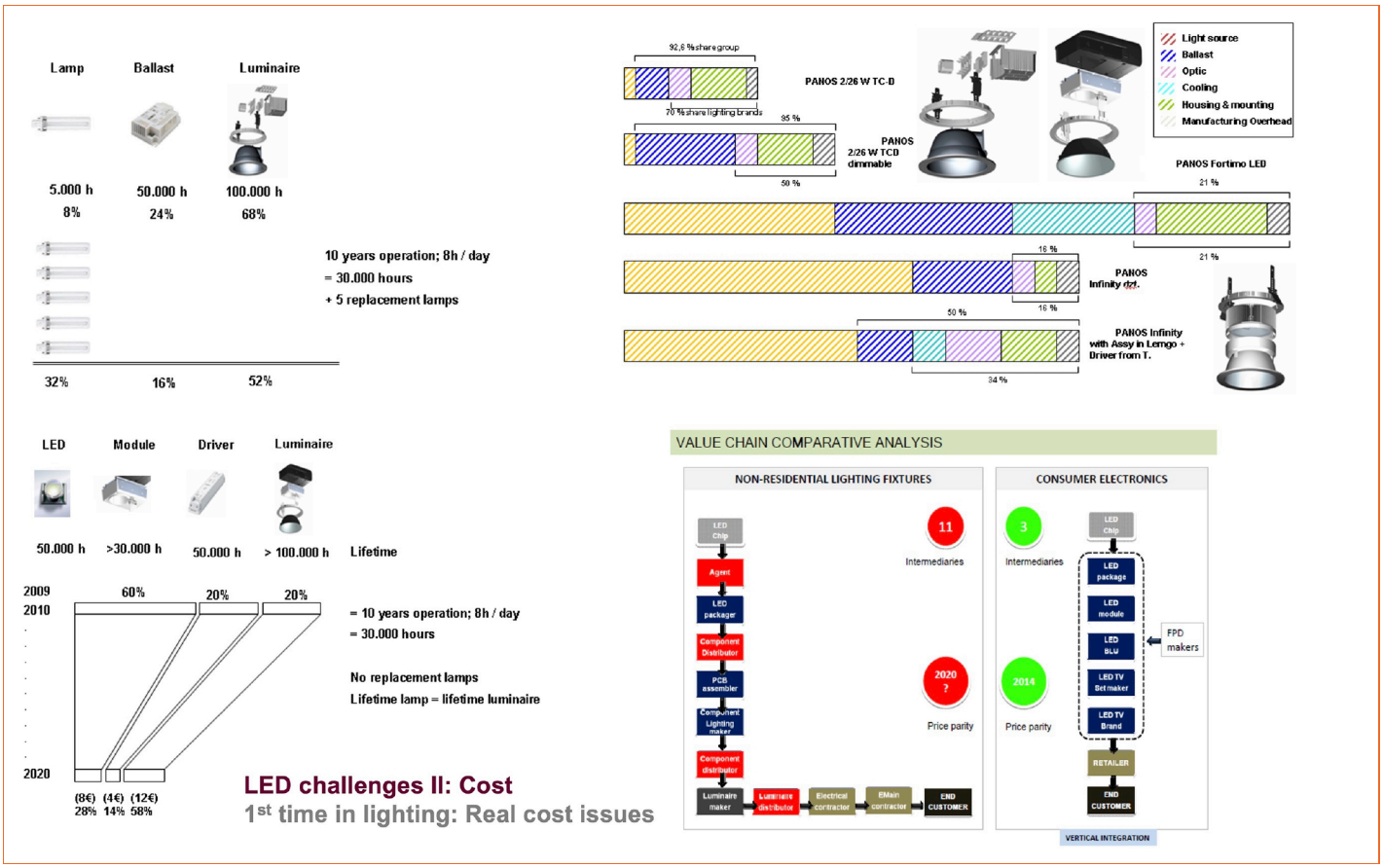

Figure 3: Predicted versus actual cost development of LED downlights (2010–2020) presented by Mr. Vamberszky at the LpS2011 in Bregenz. Source: Zumtobel Group Klaus Vamberszky.

to choose the best products to fit the application, and they need to be interoperable. The producer himself might prefer to differentiate himself via an own proprietary system. The situation in mobile operating systems like IOS and ANDROID shows this dilemma quite well; interoperability is more easily achieved in a closed proprietary system than in an open one.

Regarding data, we have to differentiate between "neutral system data" and the personal settings, in the understanding of "my light" according to "my age" and "my preferences". This is where data protection plays a big role.

LED professional: **Are there technological trends that currently receive too much attention—and others that you believe are still underestimated?**

Klaus Vamberszky: As already mentioned, there is too much focus on energy efficiency and CO_2, and too little focus on glare, individual influences like age, sex, cultural background and mood of the user. Longterm effects of light are still not considered at a sufficient level, and usability of lighting systems in general is bad. It is an expert business dominated by technicians and regulation in a fragmented industry.

LED professional: **Are market dynamics today driven more by technological progress, or by changing expectations from designers, planners, operators, and end users?**

Klaus Vamberszky: In the past the dynamics came from technological progress, mainly on the light source itself. Actually, somehow, there is a vacuum, due to the difficult economic situation, complexity of the business, uncertain activities in the regulatory environment, and saturation of LED efficiency gains. The future will bring an end to the energy efficiency race; resource efficiency will replace energy efficiency (**Figure 4**).

LED professional: **In which application areas do you see the greatest potential for high-quality and value-driven lighting solutions in the coming years?**

Klaus Vamberszky: I believe in healthcare – there is a lot of ongoing research on the influence of light on the human body, and maybe still in the "workplace lighting area" like office and education. People are stressed in these environments, burnout rates are increasing, and "mental wellness" gets more and more attention. All this can be positively influenced by a good lighting installation.

This is also true for private life; look at the activities of small start-ups and companies like LYS or Zeitgeber. Personal light sensors attached to people, dedicated Lighting App's and light diets are definitely something to watch.

LED professional: **How important is it for manufacturers to develop a deeper understanding of usage scenarios, operation, and the full lifecycle of lighting systems?**

Klaus Vamberszky: It is of growing importance; deliver and forget are methods from the past. Service content is increasing rapidly, but in a lot of markets we have a 2 stage multi-channel sales process, and the story is difficult to tell,

and even more difficult to sell. In the end it can only be done in a direct business, either in projects or with key accounts.

LED professional: You have been actively involved in European lighting committees. What role do standards and norms play today in shaping the industry?

Klaus Vamberszky: Well, we have to differentiate between 3 different kinds of "standards":

- Real standards, which come out of a "standardization organization" like IEC, ISO, CIE, with examples like LVD, EN 60598, EN 12464.
- Regulations and directives of the European Union, like SLR and ELR, DPP, Reach, RoHS, but also taxonomy and PPWR, and – in addition – national or even regional installation standards or rules.
- Special interest groups like DiiA, BTLE, Zigbee, Thread, Matter, industry consortia which define rules for interoperability (**Figure 5**).

All 3 fields require attention and resources, but the risks of non-compliance are very different. So "standards" as a whole play a growing role, and they add a lot of complexity to the business.

LED professional: Do current regulatory frameworks support innovation, or do they tend to slow it down?

Klaus Vamberszky: Yes and no. The ban of the incandescent lamp, the halogen and fluorescent lamp enhanced and supported innovation for sure. On the other side, minimum energy efficiency requirements and thresholds slow down or even forbid innovation in new light sources like OLEDs and Laser diodes.

But the overall complexity due to all the regulatory framework explained above is rising fast, and complexity is THE enemy of innovation. Innovation needs to be focused, at least in the early stages, but with regards to regulatory frameworks this does not work out.

This is one of the advantages of, for example, the US for innovation: the freedom to try out new things is much higher than in the somewhat overregulated Europe.

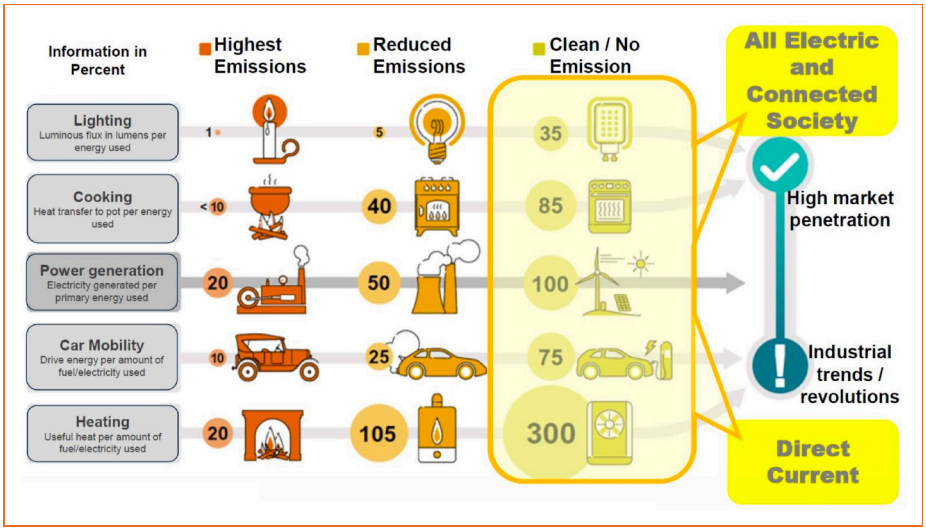

Figure 4: From energy efficiency to resource efficiency – a paradigm shift in professional lighting. Source: IEC President Vihal Mahendru; slide shown at ÖVE Innovation Day 2025 (translated). Original source: Dr. Tim Meyer, 3 EPunkt, Design: A. Timmins; LinkedIn.

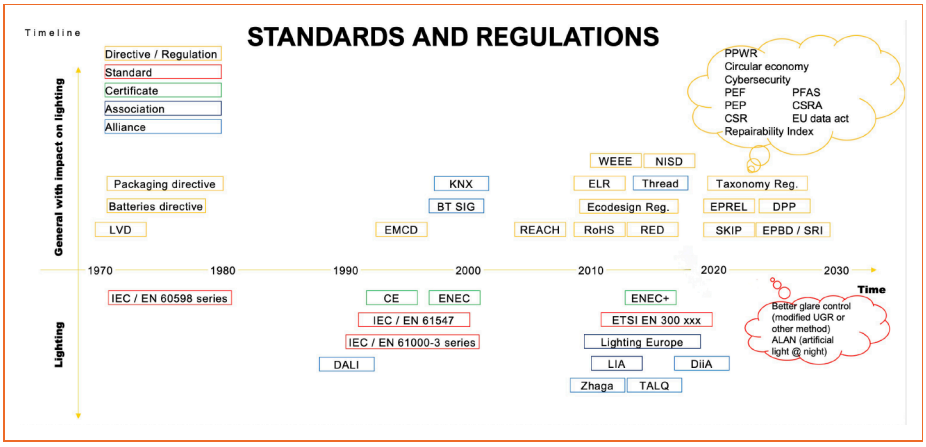

Figure 5: Fragmentation of Standards and interoperability initiatives in professional lighting. Source: Zumtobel Group Klaus Vamberszky.

LED professional: What role should Europe play in the future development of international lighting standards?

Klaus Vamberszky: Europe should play an important, if not a leader role in this, but this will most likely not happen. Standardization is in a difficult position, especially in Europe. Standardization – at least content wise - is not driven by the associations but by the experts of the industry. But the European lighting industry is suffering, decreasing potential, turnover and margins. And we will run out of resources for standardization rather soon.

It was, and still is a "baby boomer business", an expensive expert business, including a lot of travelling. Having a wide technological and application overview and knowledge, finding difficult compromises, being diplomatic, sorting positions out in a lengthy and slow negotiation process is not something young people are very interested in.

This is different in China or even India; it is defined by the government to shape future standards in future-orientated business fields. And they pay for it, they heavily support this from a financial perspective. They think in years, if not decades – not in quarters. An interesting example is germicidal lighting where almost all standardization activities are driven out of the Far East. If we do not participate in an active way we might have to accept standards we are not very happy with from a content point of view.

LED professional: From your perspective, what role does Light + Building play today for the lighting industry?

LED professional: The development of the SOLENA luminaire for the Hortus Switzerland Innovation Park in Allschwil marked an important recent milestone for Zumtobel. What makes this innovation so distinctive?

Klaus Vamberszky: One of its defining characteristics was the uncompromising commitment to sustainability. This ambition required entirely new approaches to both development and production, demanding a high level of innovation and expertise. This applied not only to construction, but also to material selection and the close collaboration between the experts at Herzog & de Meuron and Reflexion. Achieving an ecologically and economically viable lighting solution depended on an interdisciplinary, agile development process. Our goal was to combine lighting precision and efficiency with a high lumen output—without glare, and with maximum functional and aesthetic quality. The result is the SOLENA glass tube luminaire, which unites a sense of subtle brilliance and refined aesthetics with technical precision and outstanding efficiency. It represents a true symbiosis of sustainability, functionality, and design.

Klaus Vamberszky: In my view, although trade fairs are losing importance, Light + Building remains a key event for the lighting industry. It showcases the evolution of lighting from a standalone product to an integral component of sustainable, networked buildings. Most importantly, the international dialogue between manufacturers, planners and technology partners accelerates innovation and ensures quality, helping the industry take on technological responsibility and develop long-term, sustainable solutions. From a brand perspective, visibility in the market is also essential. You have to demonstrate your company's values, and a trade fair is part of the customer journey.

LED professional: **Which topics should gain more visibility at future editions of the fair—and which ones perhaps less?**

Klaus Vamberszky: Show, explain, train, perceive and experience the wide content of light. No longer a product show, but a mixture of sessions, conferences, a meeting point between scientific community, target groups and the industry itself. Such a model, a combination of a conference and a trade-show, so far was not very successful in Europe, even in other businesses. But why not give it a try and merge LICHT and the Light + Building?

It definitely must no longer be a pure product show; those times have gone and will not come back.

LED professional: **Zumtobel positioned itself early as a solution and systems provider. Which decisions or developments were particularly influential in shaping this direction?**

Klaus Vamberszky: Well, there are several aspects to this; first of all the founder family Zumtobel, with 2 generations of engineers/technicians to run the company, the founder Dr. Walter Zumtobel himself, and later his two sons Fritz and Jürg Zumtobel. All brands of the Zumtobel Group are always targeted to be innovation and not cost-leader. Then having a component company with Tridonic, and now two lighting brands with Thorn and Zumtobel under one roof, helped a lot. To cover a wide part of the value chain is definitely an advantage if you want to be innovative and to offer a complete solution. And in terms of systems and solutions provider we can't forget the visionary view of Dr. Walter Werner, the mastermind behind Luxmate as a classical lighting management system.

LED professional: **How important are brand strength, partnerships, and system competence for an internationally active lighting manufacturer today?**

Klaus Vamberszky: All very important, but closeness to customers, markets, target groups, applications are even more important. This also needs to be mentioned in combination with the answers to the question before.

You can't do a project business in Europe out of China, and in future you will not be able to drive a circular lighting business out of Asia for Europe.

LED professional: **From a leadership perspective, what has changed most noticeably in managing a technology/design-driven industrial company over the past years?**

Klaus Vamberszky: Complexity and uncertainty have been continuously increasing, over the last decades. There are always a lot of possibilities, mainly on the technical side, but the economic side of it remains unclear. Nowadays, it is much more about risk taking and managing this complexity.
Where can we be better than the competition and where do we need to be different from the competition? Also, where do both ways not pay off ? Strategy is always about focus, and it is at least as important to decide what not to do as where to concentrate.

Additionally, cost and overhead management is much more important than in the past because players from the Far East have a superior cost position, and a much leaner value chain as vertically integrated manufacturers.

LED professional: **Looking ahead, which issues do you believe will most decisively shape the lighting domain in the coming years, and what advice would you give to the next generation of leaders entering the lighting field today?**

Klaus Vamberszky: In my belief, the topic "light and health" will be the most important development to watch and to engage in. CEN/TC 169 has just started to work on a part 3 of EN 12464 regarding the non-visual effects of lighting. Key will be to find a good compromise of visual and non-visual effects in lighting installations, to support both the task in the application and consider the amount of time users spend at their workplaces under artificial light.

Content-wise, I can't imagine a lot of businesses that are more interesting than lighting. The mixture of architecture and design, mechanics, electronics, hard- and software and services, physics and optics, and now more and more biological and medical knowledge is unmatched and is THE reason why I have stayed in lighting for more than 40 years. But nowadays it is also a very challenging industry, with ups and downs, with better and worse times. I will definitely go on watching the developments for quite a while.

LED professional: **Thank you very much for taking the time for this exclusive interview.**

Klaus Vamberszky: My pleasure. ■

The **Zumtobel Group** is a leading international lighting company headquartered in Dornbirn, Austria, with a long-standing reputation for innovation, quality, and design excellence in professional lighting. The Group develops and delivers holistic lighting solutions, luminaires, light management systems, and components for demanding indoor and outdoor applications across sectors such as offices, education, healthcare, industry, retail, and urban infrastructure.

Operating through its strong and complementary brands — Zumtobel, Thorn, and Tridonic — the Zumtobel Group covers a broad portion of the lighting value chain, from high-quality luminaires and advanced control systems to LED modules, drivers, and digital solutions. This integrated brand strategy enables the Group to provide tailored, application-focused lighting solutions that meet diverse architectural, technical, and regulatory requirements worldwide.

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Lighting Design Without Borders: How Global Perspectives Transform Architecture – Carla Wilkins, IALD President

Carla Wilkins:
"Lighting design is not just about selecting luminaires — it is about defining the architectural identity of a space."

Carla Wilkins is one of the founders of Lichtvision in Berlin and IALD President. Today, the firm operates with several international offices, including Hong Kong and Shanghai. Markus Helle, Editor-in-Chief of HIGHLIGHT, met with Carla Wilkins in Guangzhou, China, during the GILE trade fair to discuss day-to-day planning in an international context, the various aspects of global project work, and her commitment to the lighting designer community within the IALD.

lichtvision.com | iald.org

HIGHLIGHT: **From a global perspective, do you observe cultural differences in lighting design across continents? Or can such distinctions even be identified on a national level?**

Carla Wilkins: Lighting design and lighting concepts indeed reveal cultural differences, which we experience both internationally and nationally.

These differences may be influenced by a variety of factors, including climate conditions, historical developments, technological advancements, and cultural preferences. The identity of a place and its client is reflected in the lighting solution—this also applies on a national level. In Germany, lighting design generally represents a symbiosis of technology, sustainability, and design. The German approach tends to be rational and standards-driven, but with an increasing awareness of the emotional and cultural dimensions of light.

As lighting designers gain greater involvement in diverse projects, the design component—through deliberate use of light qualities and lighting hierarchies—becomes more than the selection of decorative luminaires. It becomes a definition of the architectural lighting identity of a space. Since its founding, Lichtvision has pursued this goal.

HIGHLIGHT: **When you work on projects in Asia, for example, to what extent are your international offices involved alongside the local team in Hong Kong?**

Carla Wilkins: A project in Asia does not necessarily have to be anchored exclusively in our Asian office if the core project team happens to be based in Europe. At Lichtvision Design, active collaboration across all offices is part of daily life. Particularly in large-scale projects, the other offices contribute through defined work packages, knowledge exchange, and design charrettes. We see ourselves as one team—thinking globally, acting locally.

HIGHLIGHT: **How would you describe internal knowledge-sharing at Lichtvision when it comes to projects and the lessons learned from them?**

Carla Wilkins: Across all locations, Lichtvision Design holds a global virtual meeting every week with all team members. During these sessions, workflows and projects are presented and discussed internationally. Every voice is heard—there are no hierarchies in this format. As a result, if needed, further in-depth digital sessions are arranged in smaller groups.

HIGHLIGHT: **Is it possible to implement lighting design using locally sourced luminaires and control systems in different parts of the world? Are there specific challenges or advantages?**

Carla Wilkins: Implementing our lighting solutions using locally sourced luminaires and control systems is generally feasible worldwide and comes with both advantages and challenges.

A major advantage is cost efficiency due to shorter delivery routes and lower customs duties. In addition, locally manufactured products are often already adapted to regional climate conditions, voltage infrastructure, and applicable standards. Local sourcing also strengthens regional economies and supports sustainable value chains.

However, challenges do exist. In some regions, the quality of locally available products can vary significantly. We have an obligation to our clients to specify the best, most economical, and most sustainable solutions. A lack of skilled professionals for implementing complex lighting concepts can also be an issue—this is where internationally experienced firms can provide essential on-site support.

Our goal is always to develop a robust solution that withstands local implementation challenges. The decision between national or international sourcing is therefore evaluated individually for each project.

HIGHLIGHT: **Sustainability is a ubiquitous buzzword, but it is interpreted differently across regions. Where do you see the differences between Europe and Asia? And what, in your view, should be the next steps?**

Carla Wilkins: Sustainability is understood and implemented differently in Europe and Asia, shaped by cultural, political, and economic frameworks.

In Europe, sustainability is value-driven and highly regulated. The focus lies on

long-term environmental responsibility, energy efficiency, and resource conservation. This is reflected in lighting design through strict eco-design directives, an emphasis on daylight integration, and a preference for durable, repairable products. Sustainability is seen as a holistic concept, interlinking ecological, social, and economic components.

Light pollution has become a crucial global topic within sustainability discussions. Increasing awareness among designers, decision-makers, municipalities, and standards bodies is essential. Balancing the needs of wildlife, vegetation, and people must be a priority. Qualified lighting designers play a key role in achieving this.

In Asia, sustainability is often technology-driven and pragmatic. Many countries rely on innovation and scalability—for example, through the widespread adoption of smart lighting, mass production of efficient LED technologies, and integration of solar and IoT systems in infrastructure. Our joint visit with world-architects to GILE in Guangzhou reflected this trend. Efficiency and progress are key priorities, while social and ecological aspects are increasingly addressed as dedicated lighting design teams become more involved in projects.

For Europe, the next steps include further digitalization of lighting systems to enable dynamic energy control, as well as strengthening local production to reduce emissions from supply chains. In Asia, a stronger alignment of technological solutions with social and ecological sustainability goals—for example through recycling initiatives or harmonization with international standards—would be valuable.

Both continents can learn from each other: Europe from Asia's innovative drive in digitalization, and Asia from Europe's holistic sustainability approach.

HIGHLIGHT: **Lichtvision also operates a technical division in addition to its design practice. How did this come about, and what are its responsibilities?**

Carla Wilkins: Lichtvision was founded with the idea of bringing practical design knowledge into the industry while supporting design with the technical expertise of our engineering team. Initially the concept was somewhat abstract, but around the turn of the millennium the DALI standard emerged, and our engineering team enthusiastically delved into this new technology—initially through contract development projects.

In developing DALI products, mainly control gear, we realized that DALI still offered significant room for improvement regarding standardization and quality assurance. We therefore became active in the ZVEI, and made our initially internal testing devices available to the broader market. Today, Lichtvision Engineering is a global leader in DALI quality assurance. Every device bearing the DALI-2 logo has been tested and qualified with our ProbitLab.

More recently, our engineering team launched ProbitSite, a product that evaluates the quality of DALI installations and all connected devices. This enables installers to capture even complex errors on site, which can then be analyzed by experts at our development locations. With the rise of wireless communication standards in lighting, new projects have emerged—for example, integrating sensors and other control elements into open standards such as Wi-Fi, Bluetooth, or proprietary systems like Casambi.

Because the engineering team is located in the same office as the Berlin design team, both benefit from shared experience and lessons learned.

HIGHLIGHT: **You are currently President of the International Association of Lighting Designers (IALD) and will assume the presidency next year. What are your goals for the lighting design community locally and globally?**

Carla Wilkins: As IALD President, I see my future role as strengthening the international lighting design community with the vision: think globally, act locally. With more than ten years of involvement in the IALD and as Global Creative Director at our international, independent lighting design firm, I am well trained to understand the diversity of our profession—culturally, economically, and creatively.

The IALD is undergoing a transformation initiated by the 2023 vote. My goal is to further anchor this change in the organization's day-to-day operations and, together with the task forces and headquarters, build a stable, transparent, and future-oriented structure. Key priorities include financial consolidation, clear communication, and fostering a strengthened sense of community.

IALD has opened its doors beyond the circle of independent lighting designers, creating opportunities for membership for lighting designers in industry, lighting enthusiasts, media designers, and other creative professionals working with light.

For lighting designers worldwide, I want to make the benefits of IALD membership more visible—through expanded networking, targeted professional development, and a stronger presence in the international lighting community. The impressive participation in local chapters and in the most recent election demonstrates how committed our community is. I hope to further encourage this engagement on a global scale.

In Germany, the "German IALD Chapter" is coordinated by Philip Rafael, Carla Jardim, Reza Jalalzadeh, and Stephan Horn, who are already bringing lighting designers, lighting enthusiasts, and the industry together through various formats. I see my presidency as an opportunity to combine continuity with change. The IALD should be a strong international voice for lighting—with an open, inclusive mindset toward all stakeholders.

HIGHLIGHT: **Thank you very much for taking the time for this exclusive interview.**

Carla Wilkins: My pleasure. ■

About Carla Wilkins: Following her training as an architect, Carla Wilkins worked at independent lighting design firms in New York City, Cologne, and Berlin. At Lichtvision, she is responsible for concepts and planning, and oversees global design. She has been a board member of the International Association of Lighting Designers (IALD) for more than ten years and currently serves as President. She is also a professional member of the Werkbund Berlin and is active in promoting lighting design through lectures and industry engagement.

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The Role of LED Lighting in Climate Change

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

Proponents for LED lighting have hoped that the gain in efficiency would compensate for the growth in the demand for artificial lighting and so reduce the impact on carbon emissions and global warming. This article reviews the technological progress made since 2000 and surveys the state of the lighting industry in 2025. Suggestions are made for future R&D that could lead to even greater improvements in efficiency.

Each year the International Solid State Lighting Alliance (ISA) publishes a report on the status of the industry with an emphasis on technical developments. The 2025 edition [1] provided an opportunity to look back over the past 25 years of LED development as well as to summarize the data on recent commercial activity.

The Historical Perspective

The opportunities for substantial reductions in the use of electricity for lighting through the adoption of SSL were presented in "Light's Labour's Lost: Policies for Energy-efficient Lighting" [2]. The IEA estimated that in 2005 the global production of artificial light was 135 petalumen-hours (Plmh), consuming 2651 terawatt hours (TWh) of electricity, equating to an average efficacy of approximately 50 lm/W.

Concern about the rapid growth in electricity demand for lighting prompted governments around the world to invest in R&D programs on solid-state lighting (SSL). These investments led to LED lighting becoming the dominant global light source. Today, nearly 20 years after *Lights, Labour's Lost*, the global average efficacy of lighting has roughly doubled to approximately 100 lm/W.

Despite these improvements, determining the current global demand for artificial light remains challenging. Inflation-adjusted global GDP increased by a factor of 2.3 between 2005 and 2024, while satellite-based analyses [3] show that global nighttime emissions have grown even faster.

Based on these trends, ISA estimates global light production to exceed 350 Plmh per year, implying global electricity consumption for lighting of approximately 3,500 TWh, or about 12% of total end-use electricity demand.

Importantly, a significant share of this growth reflects rising demand for lighting services in regions experiencing increased economic prosperity. In contrast, in mature markets, both aggregate electricity consumption for artificial lighting and its share of total electricity use have declined.

The substantial progress in LED technology has led governments to declare success in their energy-efficiency programs for lighting. In the US the DoE has closed its SSL R&D initiative and the Horizon research program in Europe has reduced the number of projects on lighting. In China, support for R&D on wide-bandgap semiconductors is still strong but the emphasis has moved from lighting to other applications, such as mobile electronic devices and AI data centers.

The NGOs concerned with energy efficiency have also reduced their involvement in lighting. In May 2025 CLASP announced the conclusion of its Clean Lighting Coalition [4]. The scope of the Global Off-Grid Lighting Association (GOGLA) has been expanded to include non-lighting applications of off-grid solar energy [5]. Within the lighting industry, some commentators have suggested the priority for new development should move from efficacy to quality of light.

ISA is concerned about these trends for two reasons. First, the demand for artificial light is continuing to grow, as other countries follow the example of China. The lighting industry has the opportunity to contribute further cost-effective energy savings through LED technology and controls. Secondly, the greater gains in LED efficiency have come mainly from improvements in sources of blue light. To enable the realization of "human-centric" lighting and efficient displays, substantial efficacy gains are needed at green and amber wavelengths. Despite the amazing development of flat-panel displays, there are very few displays with a wall-plug efficiency over 10%. Almost all LED displays are illuminated by white or blue light, most of which is absorbed inside the display. OLED panels have demonstrated direct-emissive displays using RGB light at the sub-pixel level and inorganic LED systems need to follow their lead.

One of the consequences of reduced interest by governments in lighting efficiency is that there is little data on the current demand for lighting or the consumption of electricity. For example, the most recent information in the IEA energy tracking program [6] is for 2022. The IEA data does not include outdoor lighting and seems to underestimate use in China. An attempt to fill this gap is being made by the IEA 4E Smart Sustainability in Lighting and Controls (SSLC) Platform [7,8] which is focusing its activities on smart lighting and controls and follows quality and efficiency of LED lighting through product databases and measured data.

The Efficacy of LED Lights

The available data on current products suggests that improvements in LED performance are slowing. The European Product Registry for Energy Labelling (EPREL) database gathers data on lighting products sold in the EU, including general lighting service (GLS) lamps [9].

Table 1 shows that the distribution of the lamps in the registry at four dates since 2022. Most still have efficacy below 110 lm/W and that the proportion in the top three groups has risen only slowly since 2022.

The products remain in the registry until they are taken off the market and some legacy products are included. The IEA 4E SSLC Platform [8,9] has separated the lamps in the EPREL database by year of introduction.

Figure 1 shows how the distribution in claimed efficacy of new GLS LED lamps has evolved over the past six years.

Class	Efficacy	Product Distribution (%)			
	lm/W	April 2022	Dec 2023	Dec 2024	Jan 2026
A	over 210	0.07	0.6	0.8	1.1
B	185-210	0.51	1.4	1.6	2.5
C	160-185	3.2	5.9	6.6	7.0
D	135-160	8.9	13.1	13.6	12.8
E	110-135	23.1	23.6	23.2	23.3
F	85-110	43.2	35.6	34.6	33.9
G	below 85	19.7	19.5	19.6	19.4

Table 1: Evolution of the efficacy distribution of the lighting products in the EPREL registry.

The box plot in **Figure 2** shows the evolution of the percentile distribution of luminous efficacy for GLS LED lamps in the EPREL database over each market introduction year. Although the median efficacy has risen by about 4 lm/W per year since 2021, the annual improvement at the 20^{th} percentile has been close to 1 lm/W.

The upcoming report by the IEA 4E SSLC Platform will give more information on this data and set it in a broader context **[10]**.

The distinction between the rates of efficiency improvements in the lower performance classes is of special concern because of the substantial difference in price. The data in the EPREL database takes no account of the relative sales of each model. An informal study of the best-selling omnidirectional LED lamps available at the major hardware stores in California at the beginning of 2026 shows a medium efficacy of 91 lm/W with no lamps offering more than 100 lm/W. In 2024 DOE finalized amended standards that would dramatically raise efficacy for most omni-directional lamps to over 120 lm/W for those manufactured or imported on or after July 25, 2028. However, it seems doubtful whether this regulation will be enforced by the current administration.

The efficacy of lighting products in the commercial and municipal markets has improved more rapidly. In the US, the Design Lights Consortium maintains recommended performance standards for a wide range of products. For example, since 2020 the minimum standard efficacy for most outdoor lighting products has been 105 lm/W and that for indoor troffers (ceiling luminaires) was 110 lm/W. From January 2026 these levels are being raised to 125 lm/W for streetlights and 120 lm/W for troffers.

The published DLC data **[11]** makes it easier to track the efficacy improvement in the products that qualify each year. **Figure 3** shows the trends in the efficiency of pole-mounted streetlights at the 75^{th}, 50^{th} and

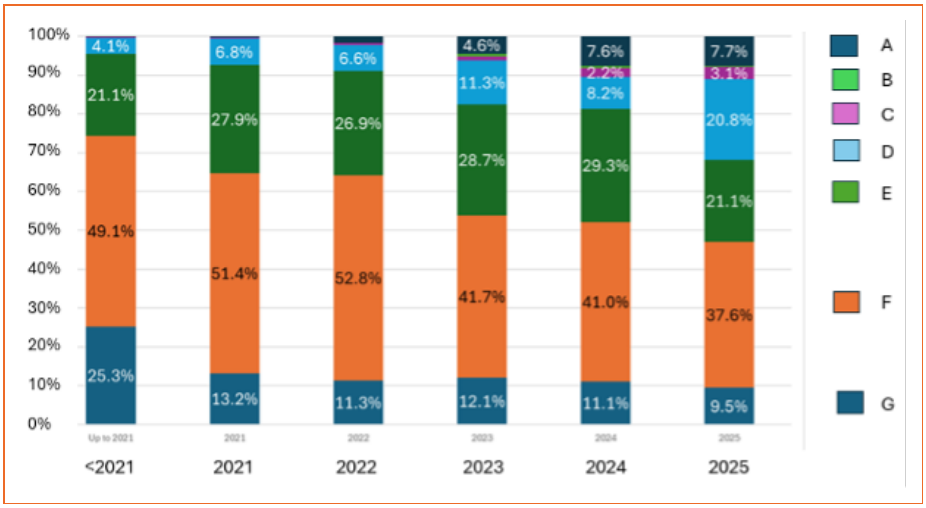

Figure 1: Energy label distribution of GLS lamps in the EPREL database by year of market introduction (IEA 4E SSLC Platform).

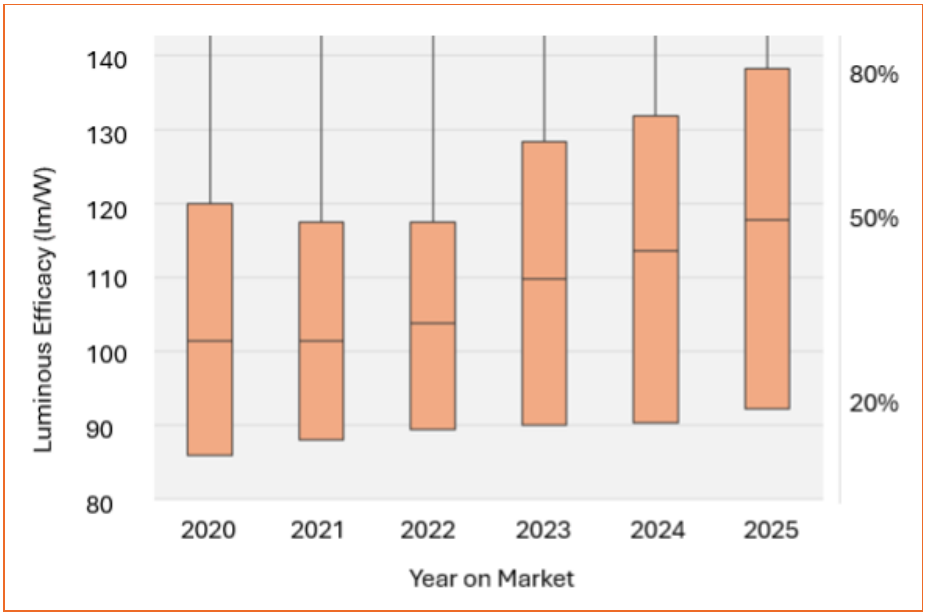

Figure 2: Percentile distribution of luminous efficacy of GLS LED lamps in the EPREL registry as a function of the market introduction year.

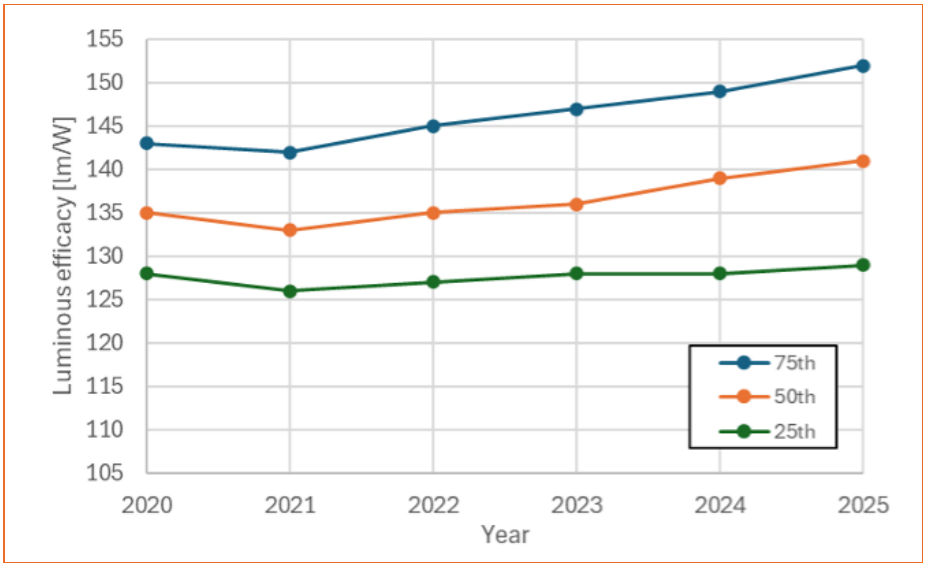

Figure 3: Change of luminous efficacy at the 25^{th}, 50^{th} and 75^{th} percentile for polemounted streetlights in the DLC database.

25^{th} percentiles when ranked by efficacy. These data show that although the efficacy of the most efficient lamps has improved at about 2 lm/W per year, that of the poorest has hardly changed.

The corresponding data for 2x4 troffers is shown in **Figure 4**. In this case, the annual increase in efficacy has been ~2% at all three levels.

The data presented above suggests strongly that further effort is required to improve manufacturing processes as well as the underlying technology. At the epitaxial level, tighter control is needed in process windows to reduce the wide range in performance seen from LEDs emerging from each manufacturing line. Over the whole supply chain ways should be found to reduce the price differential that is hindering the adoption of efficient lighting products.

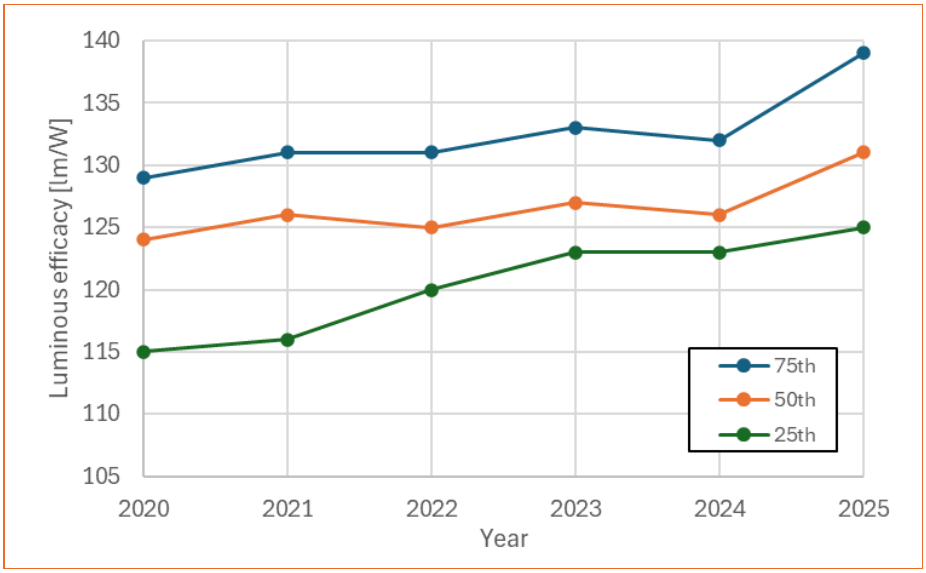

Figure 4: Change of luminous efficacy in the 25th, 50th and 75th percentile for 2x4 troffers in the DLC database.

The Global Lighting Market in 2025

The demand for LEDs grew rapidly in the decade up to 2020 but has slowed as nearly all traditional lights have been replaced and the extended life of LED devices reduces the need for their replacement. The revenues and profits of the leading manufacturers of LED chips or packages are summarized in **Table 2**.

Company	Units	Revenues			Profits		
		2025	2024	Change	2025	2024	Change
San'an	M yuan	13817	11854	17%	89	247	-64%
Jucan Opto (Focus)	M yuan	2499	2022	24%	178	155	15%
Jufei Opto	M yuan	2342	2294	2%	124	147	-13%
Foshan Nationstar	M yuan	2500	2694	-7%	52	69	-25%
HC Semitek	M yuan	4129	2953	40%	-196	-360	-
Seoul Semiconductor	B KrW	748	795	-6%	-32	4	-
Seoul Viosys	B krW	543	520	4%	-14	8	-
Ennostar	B $Tw	17	19	-10%	-1.9		
Everlight	B $Tw	10	10.5	-5%	0.9	1	-8%
AMS Opto	M euro	1045	1098	-5%	209	221	-5%

Table 2: Revenues and profits of LED manufacturers in first 9 months of 2025 and 2024.

All manufacturers outside China have struggled to maintain revenues or make any net profits. Nichia does not release data on its LED sales. Little, if any, information has been released about the revenues of Lumileds in 2025, but sales in 2024 were estimated to be ~USD 600 million, well under half of those in the Philips era. Cree LEDs are now produced by a subsidiary of Penguin Solutions. Revenues in FY 2025 were essentially flat at USD 256 million, while operating profit increased from USD 2.5 million to USD 9 million.

Within China, HC Semitek has benefited from major capital investments from BOE and the subsequent focus on the production of mini- and micro-LEDs for displays. San'an's continued growth has been accompanied by an increased proportion of sales on other applications of compound semiconductors.

Moving downstream, **Table 3** summarizes the financial results of some of the major suppliers of lighting products. The results for Acuity and Zumtobel are for the 12 months ending in August 2025 and October 2025, respectively, while the others are for 2025 calendar years. The results for

Company	Months	Units	Revenues			Profits		
			2025	2024	Change	2025	2024	Change
Acuity	**12**	**M US$**	**4346**	**3841**	**13%**	**564**	**553**	**2%**
AMS L&S	**9**	**M euro**	**657**	**731**	**-10%**	**118**	**136**	**-13%**
Signify	**9**	**M euro**	**4270**	**4488**	**-5%**	**286**	**299**	**-4%**
Zumtobel	**12**	**M euro**	**1058**	**1077**	**-2%**	**11**	**22**	**-52%**
Fagerhult	**9**	**MSEK**	**5815**	**6266**	**-7%**	**412**	**494**	**-17%**
Foshan	**9**	**M yuan**	**6532**	**6887**	**-5%**	**141**	**247**	**-44%**
MLS	**9**	**M yuan**	**12178**	**12190**	**0%**	**210**	**363**	**-42%**
Opple	**9**	**M yuan**	**3216**	**3366**	**-3%**	**369**	**385**	**-4%**
Endo Lighting	**6**	**B yen**	**20**	**19.6**	**2%**	**2.2**	**1.9**	**17%**

Table 3: Revenues and profits of major lighting companies in 2025.

AMS-Osram are for the Lamps and Systems Division.

The growth in the sales of Acuity Brands has come mainly from their Intelligent Spaces segment. Most of the gains at Endo Lighting were also due to control systems. All the other companies show deterioration in both sales and profits.

India is still experiencing growth in the demand for LED lighting. **Table 4** compares company results for the first half of the fiscal year, 2025 (April - September) with the corresponding period in 2024. Most of the

companies are showing improved profitability.

Company	Revenues			Profits		
	2025	2024	Change	2025	2024	Change
Bajaj	274	279	-2%	13	9	46%
Crompton Greaves	548	582	-6%	66	55	20%
Dixon	456	312	46%	66	45	47%
Havells	1058	1122	-6%	108	122	-12%
Surya Roshni	1030	980	5%	83	70	19%

Table 4: Revenues and profits of Indian lighting companies in crores.

The transfer of LED manufacturing capacity to China has had major implications for equipment manufacturers. In the first 9 months of 2025, only 14% of the 290M euro equipment revenues of Aixtron came from the LED segment, while 66% were generated with equipment for power electronics based on GaN and silicon carbide SiC. In the same period, Veeco's total revenues from compound semiconductors was only USD 39 million, down from USD 55 million in 2024 and USD 96 million in 2022. Meanwhile, the operations of Advanced Micro-Fabrication Equipment of China (AMEC) have grown rapidly. Revenues in the 12 months ending in June 2025 were 11.6B yuan, up from 9.1B yuan in calendar year 2024 and 6.3B yuan in 2023. In 2024 AMEC received 4.9B yuan in government subsidies, enabling it to report net income of 1.9B yuan.

SSL in China

The China Solid State Lighting Alliance (CSA) estimates that China's share of the global lighting market is now over 75%. There are thousands of manufacturers of LEDs or LED products, and the top 100 companies produce less than one third of total revenues. Thus, it is important to follow the whole industry in China. The CSA 'blue book' provides a good way to do this **[12]**.

CSA estimates that the total output value of the LED industry in 2025 fell by 1% to 609B yuan. Chip production was down by 11% to 27B yuan, while the packaging segment fell by 2% to 77B and sales of LED products was stable at 506B yuan. **Figure 5** shows the trend in these three segments since 2014.

Revenues in the general lighting market fell by 11% to 213B yuan. This reduction was balanced by increased sales in specialty markets, such as displays, automotive, horticulture, UV LEDs and smart systems.

In the first three quarters of 2025, LED companies listed on the major stock exchanges achieved a cumulative operating income of 141B yuan, a year-on-year increase of 6.2%; however, the total profit fell by 3.6% to 10.1B yuan. 56% of the companies reported revenue growth, but only 47% of the companies achieved profit growth and nearly 30% suffered losses.

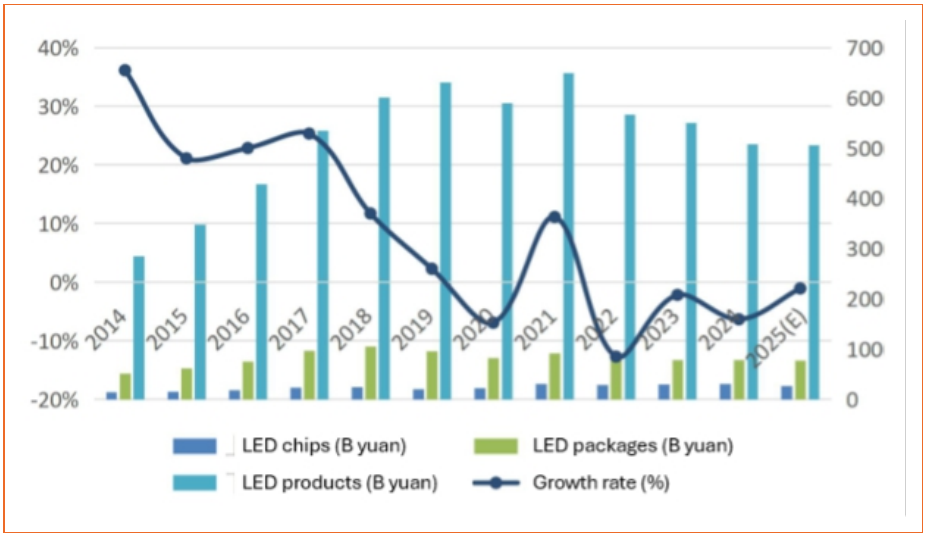

Figure 5: Evolution of the LED industry in China.

According to data from the Guangya Lighting Research Institute, from January to November 2025, the value of China's LED lighting product exports fell by 7.2% to US $35.1B. The reduction was mainly due to falling prices. For example, although the total export volume of LED light source products (bulbs, tubes and modules) rose by 37% to 14.8B, the value decreased by 11%. LED products accounted for 78% of all lighting exports from China. Part of the remainder was due to a surge in the sale of halogen lamps in Vietnam and Cambodia.

Exports to the US fell by 22% while those to Europe remained stable. Each region now constitutes about 20% of the global total. Exports to ASEAN regions increased, partly driven by an 82% rise in LED modules supplied to factories established by Chinese companies in other Asian countries.

Opportunities for Further Research on Efficiency

Further research will be necessary if the lighting industry is to make a substantial contribution to the reduction in carbon emissions and remove the conflict between maximum efficiency and light quality. The achievements that have been made in blue and red emitters should be replicated over the full range of wavelengths and in micro-LEDs. In addition, new manufacturing techniques will be required to reduce the differential in cost between the most and least efficient lights on the current market.

Perhaps the most critical challenge for general lighting is to fill the green gap. Although high efficacy has been achieved at low currents, it drops rapidly as current is increased. **Figure 6** shows the analysis of this droop made by researchers from the University of Illinois **[13]**.

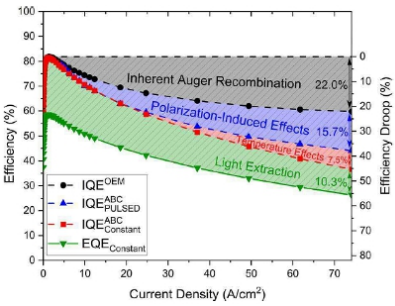

Figure 6: Causes of droop in green LEDs.

Many groups have tried to reduce the droop using various forms of GaN or GaP devices, while others have suggested radically different approaches using quantum dots or perovskites, but no solution has yet been demonstrated.

Most current UV lamps for disinfection still use plasma discharges with mercury. LED sources have made some market penetration at wavelengths around 280 nm, but their efficiency is still low. Emission near 222 nm has advantages for air cleaning, while VUV sources below 200 nm has special value for water disinfection. Further R&D is needed if LED sources are also to dominate these markets and reaching below 200 nm is a formidable challenge.

There are very few displays with efficiency above 5%. The basic problem in inorganic LED displays is that in order to create vivid images, most of the light created in the backlight is absorbed within the display.

OLED displays have demonstrated that the desired light can be created within each sub-pixel, but extracting the light is difficult and new blue emitters are needed. Some progress has been made in LED displays through the use of mini-LEDs in segmented backlights. Deploying individual sources at the sub-pixel level for medium and large size displays requires LEDs of around 0.1 mm. Gains in efficacy are required at those sizes and efficient means of defect-free transfer from the manufacturing substrate need to be developed.

The data presented above show that the industry cannot afford major increases in spending on R&D. Despite the reduction in support from governments outside China, there is still a healthy academic community involved in lighting, as evidenced by the recent LS2025 conference in Tunisia **[14]**. However, the academic community does not have the resources to tackle the core issues described here without renewed coordination with industry supported by government programs.

Conclusion

The good news is that lighting's share of global electricity use has fallen from approximately 19% in 2000 to about 12% in 2025. The bad news is that its consumption has grown from approximately 2,650 TWh to about 3,600 TWh over this period. If lighting is to make a major contribution to the amelioration of global warming, further R&D on efficiency will be needed. This would require continued support from governments and NGOs across the globe. ■

Acknowledgements

The author is grateful to Gillian Isoardi PhD, Carsten Dam-Hansen PhD and Michael Scholand LC regarding the data and other input for this article on the work of the IEA 4E SSLC Platform.

The International Solid State Lighting Alliance (ISA) is a global, non-profit organization dedicated to promoting the development and adoption of solid-state lighting (SSL) technologies worldwide. ISA brings together key stakeholders from industry, research, standardization bodies, and public institutions to foster international cooperation and knowledge exchange.

ISA focuses on advancing energy-efficient, high-quality, and sustainable lighting solutions through policy dialogue, technical collaboration, and the dissemination of best practices. The alliance actively supports harmonization of standards, market transformation initiatives, and capacity building across regions, contributing to global energy efficiency and climate goals.

By serving as a neutral international platform, ISA facilitates collaboration between governments, industry leaders, and experts to accelerate innovation, improve lighting quality, and support the transition toward sustainable lighting infrastructures on a global scale.

isa-world.org

About the IEA 4E SSLC Platform
The IEA 4E Solid State Lighting (SSL) Annex was established in 2010 under the framework of the International Energy Agency's Energy Efficient End-use Equipment (4E) Implementing Agreement. Its purpose has been to provide advice to its member countries seeking to promote energy-efficient lighting and to implement quality assurance programmes for SSL lighting. In March 2024, the SSL Annex renamed itself the Smart Sustainability in Lighting and Controls (SSLC) Platform in recognition of the significant opportunity for additional energy savings through smart lighting systems and controls.

Member countries and economies participating directly in the work of the SSLC Platform include Australia, Denmark, the European Commission, France, the Republic of Korea, Sweden and the United Kingdom.

www.iea-4e.org/ssl/

Dr. J. Norman BARDSLEY, 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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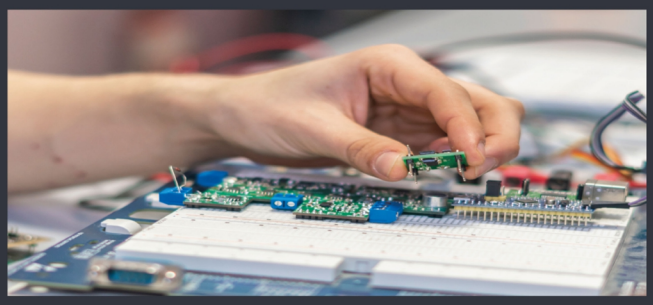

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Report on the IEEE Sustainable Smart Lighting World Conference, LS2025

Stuart Mucklejohn, Secretary – LS2025 International Scientific Committee

The IEEE Sustainable Smart Lighting World Conference (LS2025), see: https://ls2025monastir.com/[1], was held 08 to 10 December 2025 in Monastir, Tunisia hosted by the Université de Monastir in collaboration with IEEE and the Smart Cities Technical Community.

This meeting marked the 50th anniversary of the first event in the LS series which began as the Symposium on Incoherent Light Sources held at Loughborough in April 1975.

Following the opening ceremony and welcome from Georges Zissis, Chair of the International Scientific Committee, Boutheina Abassi gave her presentation 'Illuminating the mind: Light and mental health from circadian rhythms to therapeutic applications'. This highlighted the importance of light and lighting both for the physical and mental health of humans, particularly those who spend much of their time indoors.

Kamel Charrada, Vice-President - Université de Monastir, introduced the panel discussion on 'Humanitarian actions for lighting'. The contributors were: Georges Zissis (France); Toby Cumberbatch (USA); Hichem Amri (Tunisia); Lambros Doulos (Greece); Laurent Canale (France). This highlighted the plight of the approximately 1.3 billion people who do not have access to a mains electricity supply. This lack of infrastructure has a major impact on their ability to benefit from electric lighting. Either educational studies and productive industry stops at sunset or artificial lighting from fuels such as kerosene have to be used. These difficulties can be alleviated by LED light sources but these are still dependent on a reliable electricity supply. Lead-acid batteries are not suitable for such applications, solar powered battery packs are ideal but widespread use of this combination needs much more funding. Locally-based microgrids for electricity supplies are probably the best solution.

[1] https://ls2025monastir.com

The panel stressed the importance of two other factors: systems must be highly reliable otherwise they will not be used; there is a pressing need to educate governments and the public about how best to use artificial lighting.

Nozomu Yoshizawa posed the question 'Why do we use totally different metrics and methods for evaluating visual effects?'. For example, the metrics for evaluating glare for daylight through windows are not the same as those for small light sources. He went on to outline methods to characterize scenes based on neurophysiological models with edge detection algorithms. The size of the visual target and chromaticity differences as well as luminance are important inputs to such models.

The symposium then had two parallel sessions – 'Visual and non-visual effects of light' and 'Light applications & societal impacts'. In the former session Stefan Källberg summarized a study of Swedish data for nighttime traffic accidents and the role of headlamp glare. This has recently become a widely recognized problem and the topic of much concern. Probable reasons for this include: higher luminance from LED headlamps; a shift to lamps with more blue light content; higher mounting heights, especially on SUVs, crossovers & pickups; an ageing population; reduced road lighting for energy saving reasons; optimized LED-lamps are more sensitive to misalignment; adaptive driving beam systems not functioning properly. From their analyses the authors drew tentative conclusions: increased glare annoyance does not necessarily lead to more accidents; only ~0.1% of all accidents are caused by glare from other vehicles; glare from the sun is a more common factor. However, the most important finding was probably that 'Modern headlamps likely make your visibility better but make other drivers' visual comfort worse'.

During the latter session Zouaghi *et al.* detailed supply chain strategies for sustainable and resilient lifecycle management of smart lighting systems. Key factors to a successful system include being able to reliably predict the need for replacement items and to ensure warehouses hold the necessary components. Predicting failure rates for LED drivers by Preston and Mucklejohn complemented the previous study.

Two papers, by Novak *et al.* and Mokni *et al.*, addressed the causes of light pollution in urban surroundings. In both examples, street lighting proved not to be the dominant source of light pollution, the main contributors being billboards and unshaded windows. Rania and her colleagues presented a smart lighting study of an urban green space. To be successful lighting for these areas must be discretely positioned to avoid glare, have a warm *et al.* temperature and, ideally, solar powered.

Véronique Perruchon outlined her thoughts on how to get the best from LEDs for stage lighting, it is not so much the color of the source that is important for the theatre audience but the appearance of fabrics and costumes.

Erkki Ikonen opened the afternoon session with his keynote address on photometric measurements based on cone fundamentals which relate to the responses of the S, M and L cones in the retina. This change would have implications for reporting the parameters of commercially available light sources. Changing from a system based on the CIE $V(\lambda)$ function, i.e. values of spectral luminous efficiency for photopic vision, to one based on a new function, $V_f(\lambda)$ would cause confusion unless the transition was carefully managed over a period of many years. These potential difficulties generated considerable debate within the audience.

Following an interactive poster session participants headed for a guided tour of the city of Monastir with the setting sun providing a beautiful backdrop to the ribat and its surroundings.

The second day opened with Anne Berends giving an overview of the importance of near-IR to maintain human health and to promote healing. Near-IR is a component of sunlight but is largely absent from indoor environments, this has been more noticeable in the era of LED light sources. Research since the 1960s has shown near-IR radiation: reduces inflammation and accelerates wound healing; has been approved by the FDA for pain relief in cases of head & neck pain, arthritis and carpal tunnel syndrome; become the recommended standard care for oral mucositis. Near-IR is now being used to promote bone healing in dentistry, healing diabetes-induced wounds and to treat retinal diseases. Indoor lighting can be supplemented by near-IR LED sources (www.sunbooster.health) to redress the balance of the missing components in natural light.

Maria Nilsson-Tengelin summarized the initial findings from the Swedish cohort evaluating the use of wearable light loggers, this is linked to a wider study (the MeLiDos project) on the non-visual effects of light. These phenomena include circadian rhythm disruption, impact on mood and alertness and links to other health issues. Recruiting subjects to wear the loggers proved difficult but those who did agree to be part of the early study did comply with the discipline needed to collect reliable data. Improvements to the design of the loggers have been identified to help make them more convenient for the participants.

Graeme Lister illustrated that both old and new light source technologies are playing important roles in air and water sterilization processes. Vacuum UV radiation (VUV), i.e. wavelength <200 nm, is used for water treatment. This can be generated by fluorescent lamp technology to produce 185 nm radiation from Mercury atoms, while newer the newer technology employs micro-plasma devices for 172 nm and 197 nm radiation from excited Xenon dimers. Although Mercury-Rare gas discharges have been studied for many years, most of the effort has been concentrated on 254 nm radiation for fluorescent lamps and there is more research needed to understand the best way to generate 185 nm radiation.

Micro-plasma devices are also used to generate 222 nm radiation (far-UVC) for air sterilization from KrCl excimers.

Octavio Pérez gave a masterly review of sports lighting concentrating on the most recent requirements to meet the needs of multi-national broadcasters. Televising sports events is a huge economic driver which generated >160 billion USD in 2024. However, sports lighting is also important at the community level to help promote exercise and social engagement.

For major football matches, goal line technology and related systems have placed additional demands on lighting. The appropriate illuminance, color temperature, uniformity and the avoidance of glare are vital not only for the cameras and television audiences but also for the players.

The year 2025 marked the passing of John Waymouth, one of the founders of the LS series. John was a giant of lighting and lamp research, he was a great advocate for all aspects of lighting education and had a tireless enthusiasm for sharing his knowledge and enthusiasm with those new to the lighting community. Graeme Lister gave a tribute to John during the symposium dinner.

The final day of the symposium started with Richard Caratti-Zarytkiewicz addressing lighting design for art, architecture and theatre in its visual and non-visual dimensions. He paid particular attention to the visual field of the observer dividing this into the central, near-, mid- and far-peripheral regions. He highlighted a stunning lighting display of Leonardo Da Vinci's 'Lady with an ermine' where the attention is drawn to the picture by a black background covering all but the central part of the observer's visual field.

Toby Cumberbatch introduced the IEEE 'Let's Make Light Competition' (letsmakelight@ieee.org) by highlighting again the plight of those many millions of people who do not have access to a reliable electricity supply by simply asking 'Who are we talking about?' These people are predominantly subsistence farmers living in parts of Africa, India and South America. To move out of the circle of poverty education is key, especially for women. Ready access to electric lighting enables study to continue beyond sunset in safe conditions.

The challenge for those entering the competition is to show they understand the importance of both engineering, business and the synergy needed between these two disciplines to ensure successful and sustainable enterprises. The 2026 competition opens in January.

Toby closed his presentation by reminding the audience - 'People do not understand poverty'.

In his wide-ranging survey Lambros Doulos reviewed his thoughts on a holistic approach to lighting design, engineering and intelligence. He stressed the importance of paying attention to all aspects of a project – one example compared the energy required to maintain 100 lx at 4,000 K giving 67 m-EDI (melanopic equivalent daylight illuminance) but with a 3,000 K source the 100 lx gave only 41 m-EDI. To raise the latter to 67 m-EDI, the illuminance must be increased to 167 lx requiring ~65% more energy.

Lambros cited two examples to illustrate the potential dangers of relying on AI-generated lighting design rather than using a lighting designer, the comparisons were striking. His most important conclusion was 'avoid stupidity'!

Congratulations go the Local Organizing Committee under the leadership of Zouhour Araoud and Kamel Charrada for arranging such a stimulating and informative symposium with a warm and welcoming atmosphere. This meeting fully kept the tradition of the lighting industry as a friendly and supportive community.

This report covers only a selection of the papers and posters presented during the symposium, the full program can be downloaded from the conference website: https://ls2025monastir.com/program-schedule/. Abstracts and papers from the conference will be available via IEEE Xplore.

Georges Zissis closed the meeting and confirmed the next conference in this series will be held in Athens in early December, 2026, and hosted by Professor Lambros Doulos.

Professor Georges Zissis

Supplemental Ambient Lighting Intervention to Improve Sleep in Parkinson's Disease: A Pilot Trial

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Keywords: Actigraphy, circadian system, circadian-effective light exposures, light therapy, mood, Parkinson's disease, sleep quality

Importance: Sleep disturbances in Parkinson's disease (PD) are common and often adversely affect quality of life. Light therapy has benefited sleep quality and mood outcomes in various populations but results to date with conventional light therapy boxes in PD patients have been mixed. We hypothesized that a passive lighting intervention, applied in the morning and designed to maximally affect the circadian system, would improve measures of sleep and mood in PD patients.

Methods: In this single-arm, within-subjects intervention study, baseline objective sleep (actigraphy), subjective sleep quality (questionnaires), and subjective mood (questionnaires) data were collected for 1 week. Lighting was then administered to participants via table/floor lamps installed in the home or via personal light therapy glasses for 2 hours in the morning, 7 days per week, over the following 4-week period. Post-intervention data for the same outcomes were collected during the final week of the intervention period.

Results: Among 20 participants (12 women, 8 men; mean [SD] age 72.1 [9.5] years, disease duration 9.0 [5.2] years), duration increased significantly by 28.5 min ($p = 0.029$) and objective sleep time increased significantly by 19.9 min ($p = 0.026$).

Conclusion: Passive and easily administered lighting interventions for improving sleep in PD patients hold promise as a treatment for mitigating symptoms and improving quality of life in PD.

Introduction

Parkinson's disease (PD) is classically defined by the presence of hallmark motor symptoms, but sleep disturbances have also emerged as major non-motor factors in the course of the disease [1]. REM sleep behavior disorder, insomnia, fragmented sleep, and daytime sleepiness [2] occur in up 60% of people with PD [1], adversely impacting their quality of life and likely affecting motor symptoms, mood, fatigue, and cognition [3]. Research suggests that circadian rhythms disruption is associated with sleep disturbances and primary symptom expression in PD [4] and may also be closely related to the etiology of the disease.

A preliminary clinical intervention study by Videnovic et al. employing therapeutic light boxes concluded that bright light improved sleep quality in PD [5]. This is consistent with studies showing improvements to sleep — as well as mood and behavior — from a supplemental lighting intervention (SALI) developed by author Figueiro and employed in Alzheimer's disease (AD) patients [6]. However, light boxes can pose compliance-related problems due to their high light output (usually 10,000 lx); participant discomfort (e.g., glare, eye strain, headaches, photophobia, trouble maintaining a static viewing position during intervention sessions); and the need for precise placement to achieve consistent viewing distances and angles. The SALI, on the other hand, can be effectively delivered at a far more flexible range of distances and viewing angles while participants go about their everyday activities.

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The present study sought to determine whether the SALI would improve objective (actigraphy) and subjective (questionnaires) measures of sleep and sleepiness (primary outcomes) as well as subjective (questionnaires) measures of fatigue and mood (secondary outcomes) in PD. Participant compliance with the SALI and verification of the SALI's technical specifications were monitored using personal light meters worn by the participants. It was hypothesized that sleep outcome measures would improve with intervention compared to baseline.

Methods

Participant Selection

Twenty-four patients meeting the U.K. Parkinson's Disease Society Brain Bank Diagnostic Criteria clinical diagnosis of PD were recruited (November 2021 through February 2023) from the Bonnie and Tom Strauss Movement Disorders Center at Mount Sinai Beth Israel Medical Center in New York, NY, among patients who were cross-enrolled in the NIH NINDS/NIA U01-NS107016 study (registered as NCT05757414 with ClinicalTrials.gov), and was not limited to those with sleep problems. Twenty-four patients consented to participate in the pilot lighting study, which was approved by the Icahn School of Medicine at Mount Sinai Institutional Review Board and consent for experimentation was obtained from the participants.

Intervention

The lighting intervention combined light spectrum and level to deliver a robust light–dark pattern specified for maximally stimulating the human circadian system based on calculations developed for the mathematical model of circadian phototransduction proposed by Rea and colleagues **[7,8]** and used in previous studies by Figueiro **[6,9]**. Briefly, circadian stimulus (CS) magnitudes are determined from circadian-effective light, or simply circadian light (CL_A), based upon the spectral sensitivity of the human circadian system. Above the modeled threshold ($CS = 0.1$), CL_A values are transformed into CS values until they reach a point of diminishing return ($CS = 0.7$) where higher CL_A values have no greater effect. The intervention targeted a CS value of 0.3 (the effective value for circadian system activation), which has been shown to improve sleep, mood, and behavior in various populations such as AD patients **[10]**.

The lighting intervention was delivered for 2 hours every morning over a 4-week period via custom-configured table and floor lamps (chosen by 17 participants) at home or portable light therapy glasses (chosen by 3 participants) (**Figure 1**). Device selection was based on participants' preferences.

The table and floor lamps were positioned to ensure a light level of 400 lx reached participants' eyes, which was equivalent to a $CS > 0.3$ at the study's criterion distance of 46 cm. Lamps were fitted with a single A23 LED bulb emitting 3,200 lm of 3,000 K warm white light (Green Creative, San Bruno, CA, US) and programmed to automatically turn on at times preferred by the participant, but no later than 9:00 AM. The light therapy glasses (Re-timer, Londsdale SA, AU) provided green light that was verified to provide a $CS > 0.3$ at the participants' eyes.

Study Design

The 5-week study included a 1-week baseline data collection period followed by a 4-week lighting intervention period that concluded with a second data collection period on the fourth week. Objective measures of sleep (wrist-worn actigraphy) and subjective measures of sleep, fatigue, and mood (questionnaires) were collected at baseline and on the study's final week to permit pre- and post-intervention comparisons. The questionnaires were filed by the participants themselves and/or administered by caregivers.

Actigraphs (Philips Respironics Actiwatch-L, Murraysville, PA, US; **Figure 2**A) were worn on the participants' non-dominant wrist while awake and asleep during each data collection period. The actigraphy measures included sleep duration, onset latency, wake after sleep onset, sleep time, sleep efficiency, nap time during the day (a measure of daytime sleepiness), sleep start time, and sleep end time.

Subjective sleep was assessed via the Parkinson's Disease Sleep Scale 2 (PDSS-2) and Epworth Sleepiness Scale (ESS)

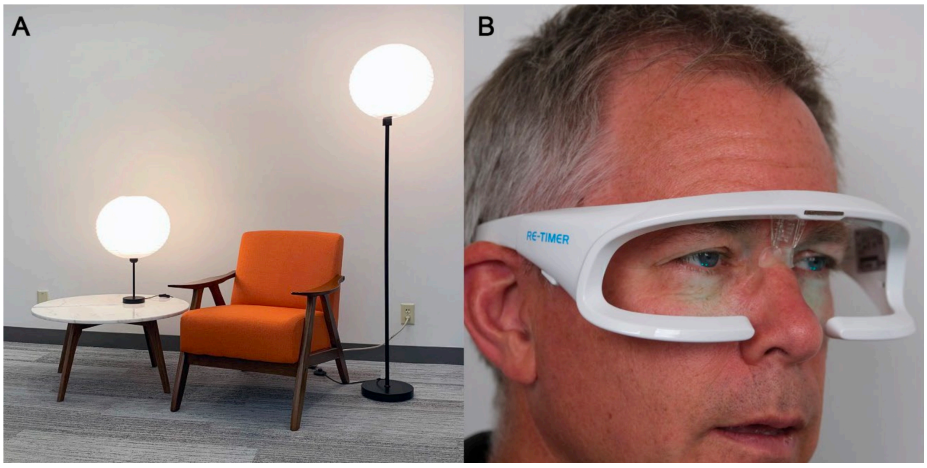

Figure 1: The lighting intervention devices employed in the study: **A**, table and floor lamps used in the lighting intervention; **B**, light therapy glasses used in the lighting intervention.

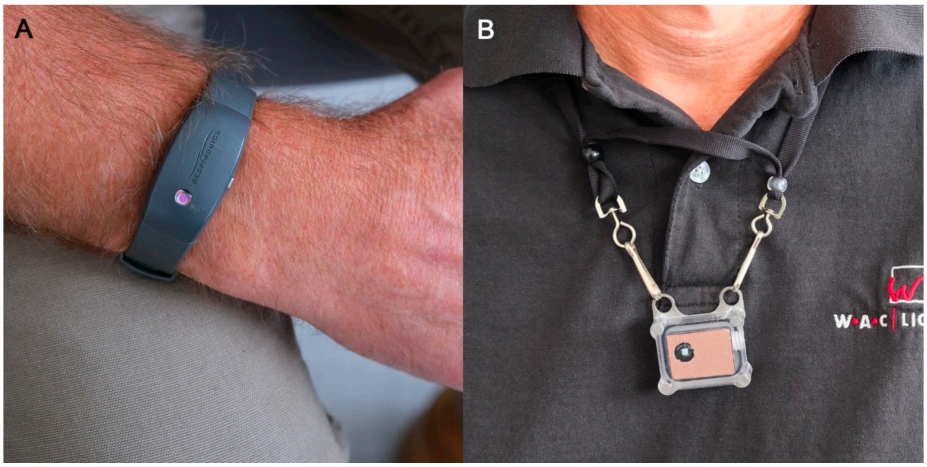

Figure 2: Data collection devices employed in the study: **A**, wrist-worn actigraph; **B**, Daysimeter worn as a pendant. The Daysimeter measures 4.5 cm (l) × 3.7 cm (w) × 1.6 cm (h). Actigraphic monitoring highly correlates with polysomnography and sleep logs. Data collected from the pendant-worn device closely correspond to Daysimeter models worn at eye level.

questionnaires, and fatigue was assessed via the Functional Assessment of Chronic Illness Therapy – Fatigue Scale (FACIT-F) questionnaire. The mood outcomes of depression, anxiety, and apathy were assessed using the Hamilton Depression Rating Scale (HDRS), Hamilton Anxiety Rating Scale (HAM-A), and Apathy Scale (AS) questionnaires, respectively (**Table 1**).

Personal light meters (Daysimeters) were worn as pendants by the participants to continuously record personal light exposure data (**Figure 2**B), thereby verifying compliance. Calibrated to the spectral sensitivity of the human circadian system, the recorded Daysimeter values were converted into illuminance (lux), CL_A, and CS levels (see Intervention).

Name	Abbreviation	Citation
Apathy Scale	AS	Starkstein, Mayberg, Preziosi, et al. [11]
Epworth Sleepiness Scale	ESS	Johns [12]
Functional Assessment of Chronic Illness Therapy – Fatigue Scale	FACIT-F	Mallinson, Cella, Cashy and Holzner [13]
Hamilton Anxiety Rating Scale	HAM-A	Matza, Morlock, Sexton, et al. [14]
Hamilton Depression Rating Scale	HDRS	Zimmerman, Martinez, Young, et al. [15]
Parkinson's Disease Sleep Scale 2	PDSS-2	Suzuki, Miyamoto, Miyamoto, et al. [16]

Table 1: The questionnaires employed in this study.

Category	Baseline	Post-intervention	*p* value
Demographic/characteristic			
Age (years): mean (SD, range)	72.1 (9.5, 52-85)	—	—
Sex	12 women, 8 men	—	—
Disease duration (years): mean (SD, range)	9.0 (5.2, 2-19)	—	—
H&Y stage: mean (SD, range)	2.17 (0.82, 1-4)	—	—
H&Y Stage 1 (n)	3	—	—
H&Y Stage 2 (n)	13	—	—
H&Y Stage 3 (n)	2	—	—
H&Y Stage 4 (n)	2	—	—
Levodopa-equivalent daily dose (mg): mean (SD, range)	523 (344, 0-1300)	—	—
MoCA score: mean (SD, range)	26.0 (3.17, 16-29)	—	—
Genetic PD (n)	12	—	—
LRRK2 G2019S	8	—	—
GBA variants	3	—	—
Dual *GBA* and *LRRK2* carriers	1	—	—
Melatonin dose (mg): mean (number of participants)	11.8 (n = 5)	—	—
Actigraphy outcome			
Sleep duration (min)	422.0	450.5	**0.029***
Sleep onset latency (min)	14.7	16.4	0.34
WASO (min)	41.4	50.0	0.15
Sleep time (min)	380.5	400.4	**0.026***
Sleep efficiency (%)	84.8	84.6	0.76
Sleep start time (clock time)	11:42 P.M.	11:22 P.M.	0.074

Table 2: Demographics and characteristics of study participants and actigraphy outcomes. Demographics and characteristics of 20 participants who performed lighting and completed actigraphy. RBD, REM sleep behavior disorder was present in 13 individuals. These individuals endorsed RBD behaviors on question 1 on the Mayo Sleep Questionnaire, although polysomnography was not done. Abbreviations: GBA, GBA gene encoding for glucocerebrosidase; H&Y, Hoehn and Yahr Scale; LRRK2, Leucine-rich repeat kinase 2 gene; MOCA, Montreal Cognitive Assessment; RBD, REM sleep behavior disorder.

Statistical Analysis

The actigraphic sleep measures and two of the sleep questionnaires (i.e., PDSS-2, ESS) served as primary outcomes. The fatigue and mood assessments (FACIT–F, HDRS, HAM-A, AS) served as secondary outcomes. Pre- and post-intervention outcome measures were compared using one-tailed paired t-tests for normally distributed data or paired sample Wilcoxon signed rank test for non-parametric data. We hypothesized an increase in mean for actigraphic measures, as has been seen in other studies **[5,6,9,11]**. Statistical analyses were conducted using Stata 17 statistical software (StataCorp, College Station, TX, US) and open-source statistical programming language R and integrated development environment RStudio (The R Foundation for Statistical Computing, Vienna, Austria). Comparison questionnaire scores were determined for participants who completed both the pre- and post-intervention questionnaires. Data from 4 participants were excluded due to non-compliance (i.e., incorrect use of the lighting devices or actigraphs). The final actigraphy analysis included data from 20 participants. The questionnaire analyses included data from 18 to 20 participants, with full questionnaires excluded for a participant if there was missing data in a particular questionnaire. The threshold for statistical significance was $p < 0.05$.

Results

The study participants' demographic data and health characteristics are listed in **Table 2**. Post-intervention mean sleep start time occurred 20 min earlier and mean sleep duration increased significantly (Wilcoxon rank $p = 0.029$) by 28.5 min compared to baseline (**Figure 3**A). Post-intervention mean sleep time increased significantly ($p = 0.026$) by 19.9 min (**Figure 3**B). These remained significant in sensitivity analyses excluding those using light goggles. The differences in the remaining actigraphy sleep outcomes were not statistically significant (**Table 2**).

Despite overall good objective sleep efficiency throughout the study (**Table 2**), the questionnaire data revealed substantially impaired subjective sleep quality at baseline (PDSS-2) that marginally improved post-intervention, although the difference did not reach statistical significance (**Table 3**). Post-intervention improvements were also noted for depression (HDRS) and anxiety (HAM-A), but again as with the remaining questionnaire outcomes, the differences compared to baseline did not reach statistical significance. The mean

scores throughout the study for subjective sleepiness (ESS) and fatigue (FACIT-F) were within normal range. Overall, mean depression scores (HDRS) were in the range for mild depression.

Discussion

This pilot study demonstrated that the SALI led to significantly increased sleep duration ($p = 0.029$) and sleep time ($p = 0.026$) as measured by actigraphy. Improvements of subjective measures of sleep quality, fatigue, depression and anxiety were also observed, but not statistically significant. This lack of significance may be due to the small sample size of the present study or the short duration of the intervention (e.g., 4 weeks). Figueiro et al. showed that the SALI's benefits of are observed and increased with a longer exposure time [6,9]. These results augment those from a randomized clinical trial performed by Videnovic et al. [5] among 31 PD participants with excessive daytime sleepiness (ESS scores ≥12) who were randomized to either bright light or a dim red light for 14 days. Their pilot study showed that a 14-day course of bright light therapy (compared to a dim red light placebo intervention) significantly reduced daytime sleepiness and improved several other self-reported sleep metrics (ie., sleep fragmentation, sleep quality, and ease of falling asleep).

Light therapy has the benefit of being a minimally invasive, non-pharmacologic intervention that can improve sleep in those with neurological disorders, but lack of careful delivery and control of the lighting intervention may result in highly variable outcomes. In fact, while one meta-analysis concluded that bright light significantly improved depression and insomnia symptoms [17] in PD, another meta-analysis concluded that bright light did not have a significant impact on depression and sleep disorders in PD [18]. The authors attributed the lack of significance to protocol variability, including timing and doses of the lighting intervention [18]. While studies in AD have demonstrated increased sleep efficiency and reduced depression and agitation after 4 weeks of the SALI [9], few studies have looked at the effects of lighting intervention to improve sleep and mood in PD. Current approaches to light therapy for reducing sleep disturbances, including those used in studies with PD patients, do not integrate lighting therapy into a practical delivery system, thus compromising therapeutic value.

This pilot study is the first study to demonstrate the feasibility of administering an in-home SALI to participants with PD using a passive intervention that facilitates compliance. Unlike previous published studies, light exposures in this study were assessed and confirmed using a personal light measurement device that was calibrated to the spectral sensitivity of the circadian system. Our choice of bright morning light delivered from standing lamps or light therapy glasses differs from approaches employed in other studies, such as the recent ENLITE PD study (ClinicalTrials.gov Identifier NCT04291014), which required participants to sit close to a lightbox and look at the device at different times throughout the day.

Here we showed that the SALI indeed increased participants' daily light exposures, as evidenced by the increase in circadian-effective light with the intervention. We also showed that the SALI was well tolerated with the accessibility of an in-home installation or option for portable light therapy glasses. In this small group of 20 participants, objective sleep measures improved, despite starting with a cohort with overall good sleep efficiency (85%).

Further, in sensitivity analyses evaluating whether an effect was present in early and late PD, mean change in sleep time in early-stage PD (defined as Hoehn and Yahr 1 or 2, $n = 16$) improved with SALI (mean 24.4 min, $p = 0.036$); however the group with advanced PD, (defined as Hoehn and Yahr 3 or 4, $n = 4$), did not ($p = 0.178$).

Another limitation was the SALI's 4-week duration, which may have been insufficient for improving behavior outcomes. Further, all of the participants were of Ashkenazi Jewish heritage owing to the parent grant's focus on genotypes that are enriched in this cohort. As the gains observed through application of the SALI and AD patients could possibly be not as readily generalizable to other populations, follow-up studies currently in place will include a larger sample of participants not limited to Ashkenazi Jewish background and will be conducted over 8 weeks. This pilot study did not include a placebo control arm, although every subject served as their own control, and thus all participants received interventional therapy. We cannot exclude that participants did not have a placebo effect.

Future studies will assess effects of the SALI vs. placebo control in a cross-over study design. The study's notable strength,

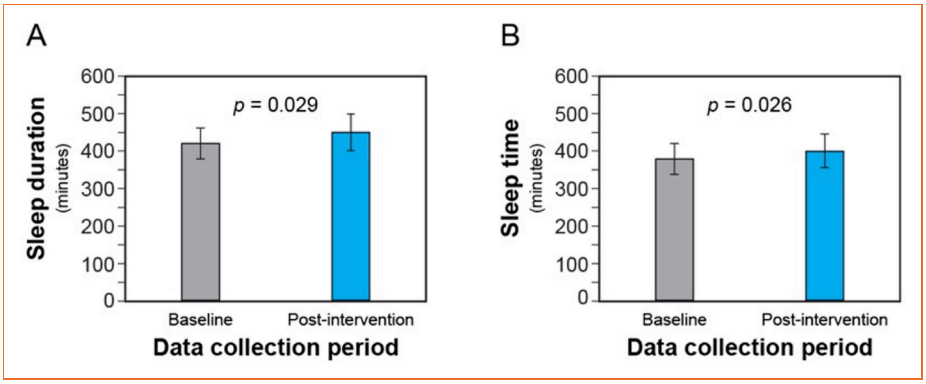

Figure 3: Change in sleep parameters as measured via actigraphy for 20 participants. **A)** Mean sleep time was significantly greater post-intervention compared to baseline. The error bars represent SEM. **B)** Participants' mean sleep time was significantly greater post-intervention compared to baseline.

Outcome	Participants (n)	Clinical cutoff score	Baseline	Post-intervention	*p* value
Primary					
Sleep (PDSS-2)	18	≥15	16.3	15.1	0.24
Sleepiness (ESS)	19	>10	6.2	6.5	0.55
Secondary					
Fatigue (FACIT-F)	20	<30	34.6	35.8	0.28
Depression (HDRS)	19	≥8	11.3	10.4	0.30
Anxiety (HAM-A)	20	≥8	10.8	10.0	0.39
Apathy (AS)	17	>14	12.1	11.9	0.89

Table 3: Results for baseline (i.e., pre-intervention) and post-intervention questionnaires. Abbreviations: AS, Apathy Scale; ESS, Epworth Sleepiness Scale; FACIT-F, Functional Assessment of Chronic Illness Therapy - Fatigue Scale; HAM-A, Hamilton Anxiety Rating Scale; HDRS; Hamilton Depression Rating Scale; PDSS-2; Parkinson's Disease Sleep Scale 2.

on the other hand, lies in its demonstration that delivering a circadian-effective SALI to PD patients can improve sleep measures and mood symptoms while being both well accepted and feasible. ■

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Disclosure statement

All authors report no disclosures relevant to the manuscript.

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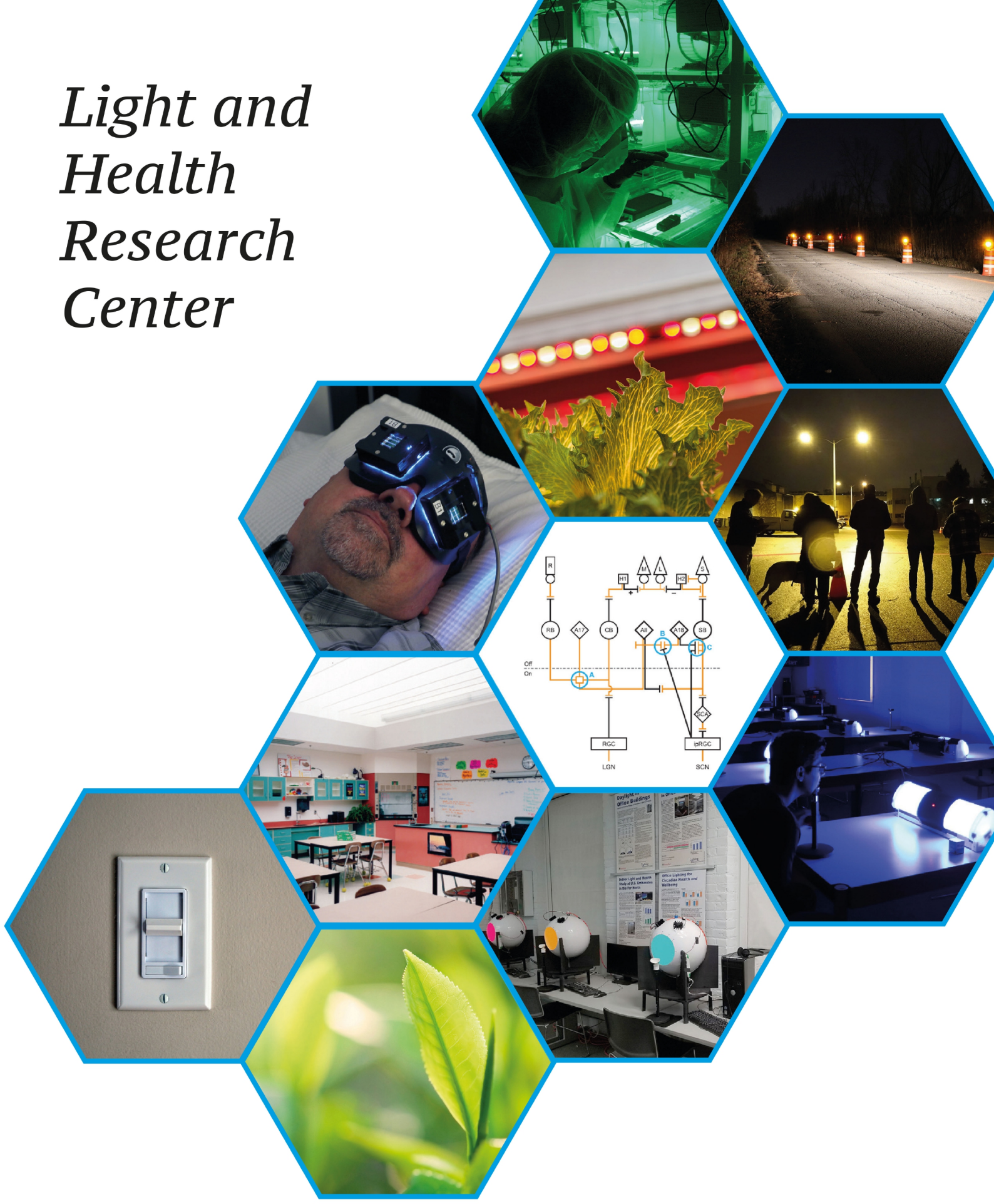
Light and Health Research Center



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LumaNet – A Novel Method for Infield Luminaire Commissioning and Reconfiguration

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Today, all or most industrial lighting installations are controlled by building management systems, or are at least connected to some kind of digital control. The increasing demand for energy efficiency, cost savings and optimized working environments will drive the industry towards intelligently controlled systems. This can be considered the state-of-the-art.

Plenty of technologies have been developed to support this progress. The main focus, for many years, has been to make digital interfaces available at no or low cost. Much less focus has been on maintenance and commissioning of complex systems and on technologies to simplify the involved tasks. The project "LumaNet" showcased a simple and yet highly efficient method to change the configuration of individual luminaires within extended networks without any prior information about the installed system.

Maintenance or reconfiguration of luminaires in industrial environments is a costly task. ©HTLR

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Motivation and Background

Once a digital lighting system with any degree of complexity is installed in a new or renovated building, both commissioning and maintenance over the full service-life begins, which constitutes a substantial part of the total cost of ownership. In many cases the involved service personnel have little knowledge of the system configuration and the access to individual devices via the installed communication channels is tedious. This process of assigning individual configuration data to luminaires is time consuming and error prone. The light generated by a light source is an obvious but not often used channel for communicating relevant device information such as unique network IDs, manufacturer data and capabilities. In the project, LumaNet, an innovative solution has been developed and prototyped which enables compatible luminaires to be reconfigured instantly in any fully mounted building situation.

The configuration or reconfiguration process involves four basic steps (**Figure 1**):

1. Tell all luminaires inside an area (room or workshop section) to enter config mode. This is done via a broadcast command over the network from any mobile device or equipment.
2. Use a smartphone or tablet equipped with a dedicated sensor clipped into the USB connector and point the mobile device sensor to the light source to be reconfigured. The lamp to which the sensor is pointing indicates its presence by any kind of visual effect (e.g. short flashing).
3. Confirm that the selected lamp is the one to be serviced.
4. Make any configuration changes instantly without any further information of addresses or fixture IDs or locations.

After reconfiguration is completed, the system switches back into its normal operation mode either manually or automatically. Using this process commissioning of luminaires is an issue of seconds, saving workload and cost. No manual accessibility of the lamp driver is required.

Fundamentals

The starting point is a system comprising a set of luminaires equipped with a compatible driver. Each luminaire is connected to any kind of building management network and is addressable via a unique ID. The ID can be an IP address, MAC address or any other address uniquely identifying one luminaire. The set of luminaires shall be one room or department within a larger hall; however the number of involved luminaires can range from one to many with no upper limit.

Upon the request, the luminaires are set into a "communication mode" by means of a broadcast command. In this mode, each luminaire sends its own ID via PWM modulated light output. The modulation is such that there is absolutely no visible effect to the user. The IDs are detected by a smart digital sensor which is plugged into a mobile device. Upon reception of an ID the lamp may indicate it with a visual effect, helping to establish a correct selection. The indication is initiated by the sensor device over the BMS as soon as a valid address is received.

The task of the service person is to read, change or reset any configuration parameter within one particular luminaire or driver.

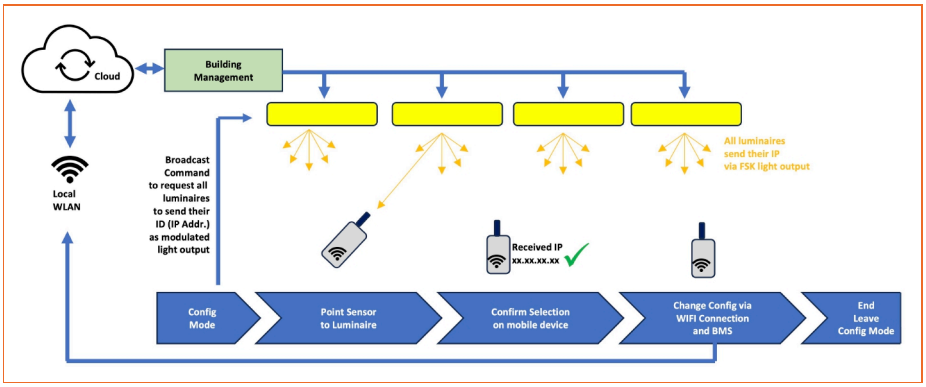

Figure 1: The configuration process within LumaNet is easy and fast. ©HTLR/SZK

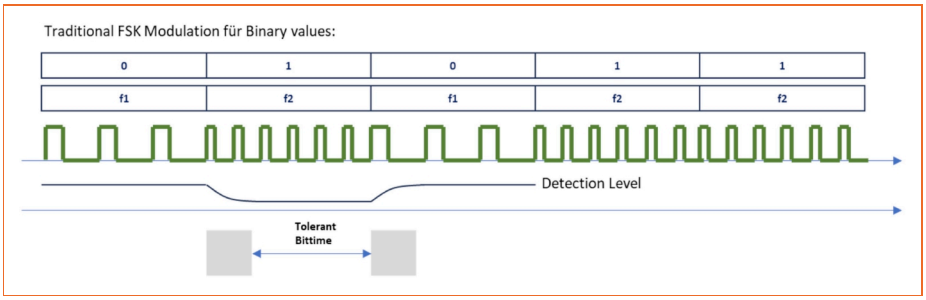

Figure 3: Bit detection has error windows in FSK with two modultation frequencies requiring higher cycle periodes per bit. ©HTLR/SZK

The user (service person) uses a smartphone equipped with a dedicated SW app as well as an HW sensor-dongle that sticks in the USB-C port of the smartphone. By pointing the smartphone in the direction of the luminaire to be serviced, the sensor and app are able to detect the particular ID of that luminaire by properly filtering the modulated signal out of the ambient light in the area.

The received ID is, of course, encrypted, and data integrity is checked by means of CRC checksums. Once the app has received a valid ID the corresponding lamp indicates it by visual effects as confirmation to the user. The user can now confirm this lamp to be used for any subsequent configuration command. When the configuration is completed, the system automatically falls back into a new addressing sequence.

If a received lamp ID has been confirmed, communication is established and any configuration is possible. In the prototype system, brightness and color temperature can be changed in each light source.

This system and process allow communication with any lamp in a compound without any prior knowledge of positions or addresses, hence greatly simplifying maintenance or commissioning of building management.

System Concept: Defining the Modulation

The first step in the design process is to define a PWM light modulation scheme to meet the following requirements:

- Fast transmission of small information packages
- No visible effects in light output
- High reliability in data reception
- Low processing effort
- Easy implementation in LED Driver

In order to allow for fast transmission of frames the modulation frequency shall be as high as possible. LEDs as light sources react almost instantly to any change in flow of power, so the PWM frequencies are limited upwards by:

- Capability of the LED Driver
- Impact of second order effects like limited current slew rates and signal distortion in the light receiver

In practice, frequencies in the lower kHz range have proved to be useful. However, this implies some degree of acoustic effects, so it might be beneficial to move into the 20kHz+ range in future designs. In the current prototype, frequencies between 3kHz and 4kHz have been used, which are a compromise between speed of communication and hardware limitations. Frequency Shift Keying is used as a modulation scheme to maintain constant light output at any time.

The human eye is extremely sensitive to small fluctuations in light. In order to maintain constant luminous flux at any time it is mandatory to keep the average value across PWM-cycles exactly constant even when the underlying frequency changes. This may sound trivial but in practice the PMW generation has to be maintained accurately cycle-by-cycle in order to avoid any occurrence of flicker. **Figure 2** shows the conditions for different modulation techniques.

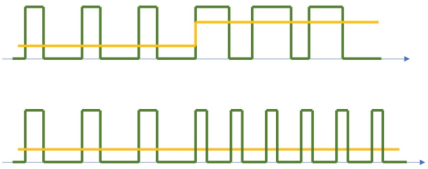

Figure 2: With changes in duty cycle due to modulation, average values may experience changes yielding visual effects (top). With pure and accurate FSK light modulation the average values are constant at any time (bottom). ©HTLR/SZK

PWM frequencies in the kHz domain can easily be achieved with state-of-the-art LED drivers as MOSFETs are used predominantly for switching and the nonlinear effects are negligible.

System Concept: Defining the Modulation Scheme

In order to transmit and receive a binary bitstream, each digital state gets assigned a different frequency (**Figure 3**). This is obviously the case for FSK. The receiver can then decode the bitstream by constantly measuring the inflow of frequencies and then reconstruct the stream of bits.

Identifying ones and zeros in the received luminous flux therefore requires a timing measurement of each received PWM cycle. Due to the required filters in the light receivers some PWM cycles are not exactly correlated to one of the high/low frequencies because of settling times in the required analog filters. The number of PWM cycles used to transmit at high or low frequency for one bit must therefore be long enough to allow for settling and for accurate bit detection. The more PWM cycles are needed, the longer it takes to transfer the entire data frame.

In addition to errors introduced by the communication channel, foreign lamps also introduce noise in the detected signal as they emit modulated light at the same time. It is therefore desirable to have a more ro-

bust scheme. This has been achieved by introducing a 3-level modulation instead of 2 levels. In addition to a first frequency indicating logic level high and a second frequency indicating logic level low, a third "idle" frequency is used to indicate the termination of bits. Any bit is using a minor number of PWM cycles and is terminated by any reception of the termination frequency. **Figure 4** describes this method in more detail.

System Concept: Securing Data Integrity

To secure that any decoded received data stream is holding valid information, the following measures are applied:

A) The transmission protocol must be received consistently.
B) CRC Checksums are sent with each data frame and are checked in the receiver.

The protocol in use is very simple in order to minimize data redundancy:
Every package has a fixed length of 32Bits+CRC Bits, starting with a start bit and terminating with a stop bit. Due to the limited number of bits, a CRC checksum of length 6 has been used. However, this can be adapted in future designs after more extensive test sequences.

By applying these concepts, a robust and secure data transmission and reception is achieved. Finally, a very simple frame encoding concept is used (**Figure 5**). A start bit followed by a 32Bit payload is followed by a 6Bit CRC value. The end of one frame is marked by idle frequency for more than one bit-length. This scheme is easy to decode and due to the error checking provides a fast and reliable detection of ID codes e.g. IP address.

System Concept: Sensing Only One Selected Luminaire Within a Cluster

As all luminaires within a compound – a room or a hall – are transmitting, simultaneous measurements must be taken to secure that only the data from the selected luminaire is received and processed. Again, two measures have been implemented to optimize the selectivity to one particular luminaire (**Figure 6**):

1. The optical channel for the light sensor has a large length/width ratio (a "tunnel")

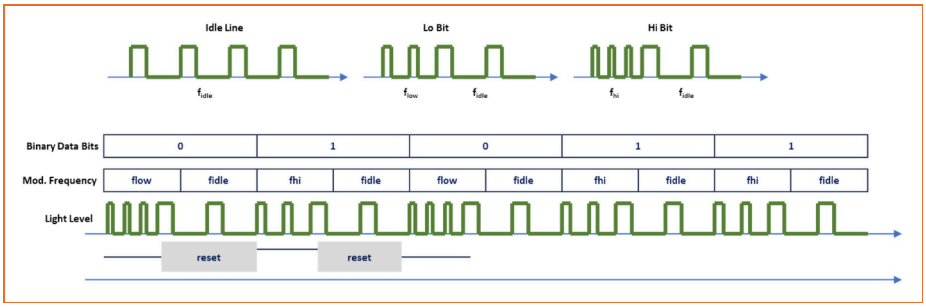

Figure 4: By means of three modulation frequencies, each data bit is terminated, which enables short bit times and more robust detection. ©HTLR/SZK

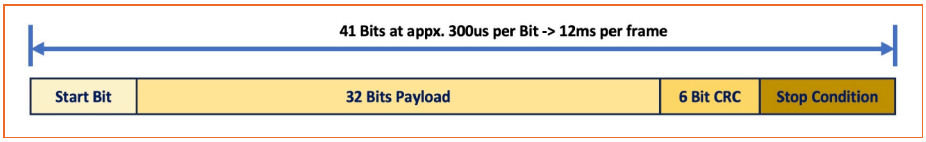

Figure 5: Frame encoding and frame timing. ©HTLR/SZK

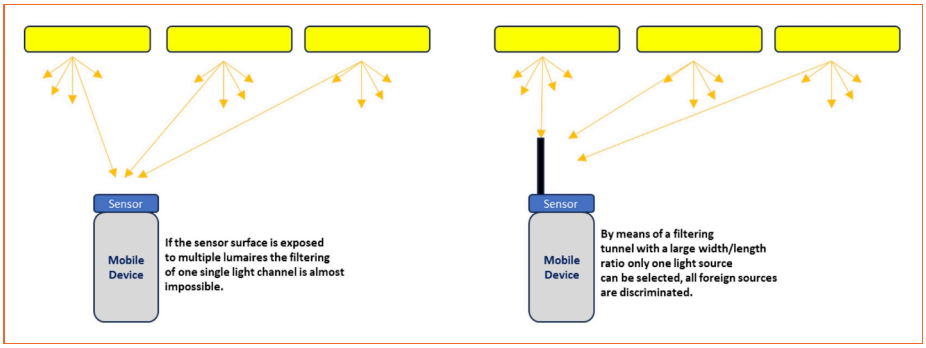

Figure 6: To secure the reception of only one light emitter an optical tunnel in the sensor is provided for a narrow field of view. ©HTLR/SZK

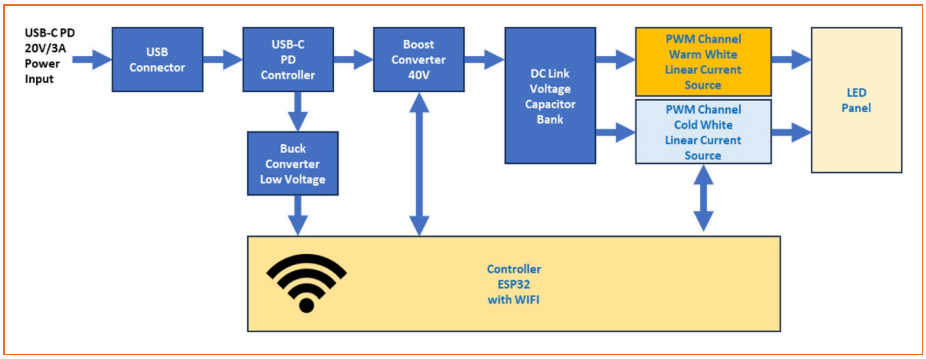

Figure 7: Block schematic of LumaNet LED Driver based on USB-C power. ©HTLR/SZK

2. The tunnel also reduces the signal magnitudes so high gains are applied for robust signal reconstruction.

System Implementation

To provide the functionality described in the previous paragraphs a suitable demonstrator luminaire has been developed. The requirements for the luminaire design have been defined as:

- Capability to modulate light output for data transmission in addition to accurate linear current dimming
- Luminous efficiency ≥150 lm/W
- Tunable white between 2,700 K and 6,500 K
- Dimming capability 10% to 100%
- Max System Power 40 W
- Design as mobile equipment for easy transportation and demonstration
- Linear Mode Dimming and PWM Mode Dimming
- Power supplied over USB-C PD

System Block Schematic LED Driver (Fig. 7)

The USB-C block implements the power delivery protocol such that a 20 V/2 A input voltage is provided by the USB power source. The block is based on the HUSB238 USB-C management chip [1,2].

The central processing unit is an Espressiv ESP32 ARM based controller also providing WLAN connectivity [3]. The 20V input voltage is boosted upwards to 40V to supply the LED strings that are individually managed by a current controller which also acts as a switch if the data modulation is active. A buck converter followed by a linear regulator provides the required internal power supply levels. The 40 V boost converter uses state of the art GaN transistors, and the current and voltage control loops are implemented in software on the ESP32 [4]. In order to modulate the light output for data transmission a precise and clock accurate timing is necessary. As the processor has to maintain data traffic as well as control loop updates the real time capability is very limited. Therefore, the generation of the bitstream modulation is implemented using hardware peripherals within the controller (**Figure 8**).

Figure 8: LED driver sample (top left). LED driver with USB-C connector mounted under LED panel (top right). LED driver and LED panel (bottom left). Luminaire prototype (bottom right). ©HTLR/SZK

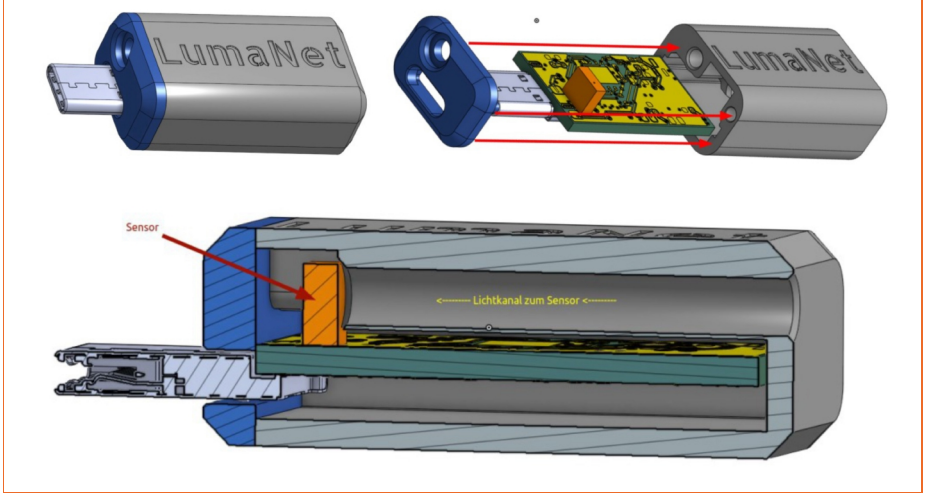

Figure 9: 3D design of the plug-in sensor (top left). Explosion view of sensor with processing PCB (top right). Cross section of plug-in sensor shows the optical tunnel needed for detection. ©HTLR/SZK

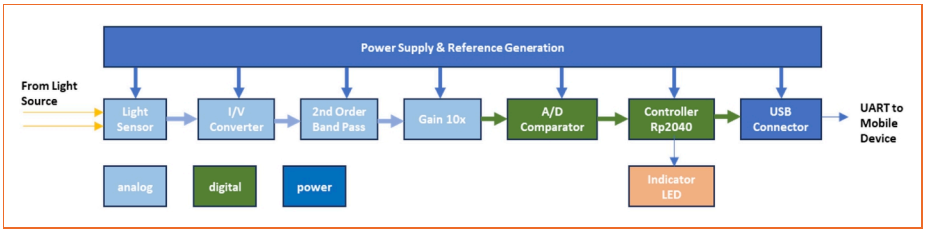

Figure 10: Block schematic of sensor electronics. ©HTLR/SZK

In this proof-of-concept project each luminaire implements its own webserver for data communication. However, it is obvious that the data communication and network protocols do not impact the overall concept at all. To use http as a protocol was the easiest choice in the LumaNet project.

Implementation of the Receiver Module

To receive and decode the modulated luminous flux from a selected luminaire a tiny USB-Dongle like design was chosen. The requirements have been defined as:

- Power supplied by USB interface from mobile device
- Data exchange with mobile app via UART over USB
- Small form factor
- Plug and play capability
- Visual indication whenever a decoded device ID from a luminaire is received
- Selective to a single luminaire up to distances of 4–6 m
- Discrimination of day light and foreign light sources

Real time capability cannot be provided from the app over the USB interface; therefore the signal reception and decoding are implemented inside the sensor module. Only approved data is then forwarded to the mobile device for any further communication tasks.

As mentioned before, an optical channel (**Figure 9**) is implemented to provide the required selectivity of the sensor. With appropriate tuning of the analog and digital processing a particular light source can be selected within a range of up to 4 m.

Analog Processing of Detector Signal (Fig. 10)

The light beam arrives on the photodetector through the “tunnel”. A narrow view angle ensures that only one light source is seen by the detector [5]. The photo current of the receiver is then multiplied at high bandwidth to make sure that any received

modulated radiation is passed through as a voltage signal. In a next stage, band limiting is applied which filters out any daylight component (DC) as well as any potential high frequency noise. A second order bandwidth filter with a passband gain of 20 dB allowing for proper reception of information also at very low dimming levels has been designed. The initial target was to be able to operate the information transfer at dim levels as low as 10% (Filter design with [6]).

The final stage of the analog part is a comparator which outputs a digital signal that perfectly reflects the bitstream that was modulated as PWM light output in the LED Driver.

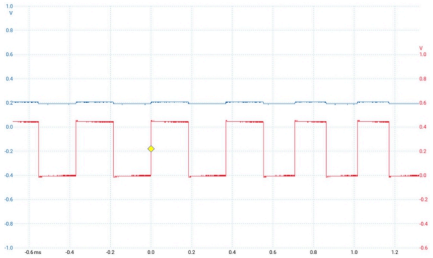

Figure 11: Measured signals during ongoing detection process.

The red curve (**Figure 11**) is the digital signal that is fed into the processor (Raspberry Rp2040, [7]). The blue curve is the modulated signal from the sensor. The image shows that the PWM light pulses are perfectly reconstructed even at very low magnitudes at the sensor. The measurement was taken with 3 Luminaires with a 2 m spacing at a distance of approximately 4 m from the sensor.

Digital Signal Processing of Detector Signal

The next step in the processing chain is to extract any valid data from the bitstream. The digital input is sampled at a fixed data rate and each PWM period is evaluated according to the criteria:

a) A high bit is received if PWM period is within a first window.
b) A low bit is received if PWM period is within a second window.
c) A bit termination is received if PWM period is within a third window.
d) Cycle is ignored if period does not fit in any window.

This sampling and processing scheme requires strict real time execution that shall be implemented in a very small space and low power consumption. The Raspberry Rp2040 was selected as the processing platform as it offers crucial benefits for these requirements:

- Low power <20 mA
- Sufficient data throughput with 125 MHz base clock frequency and 32Bit architecture
- Integral USB interface
- Dual core for parallel processing of signals and user interaction (App)
- Hardware PIO peripherals for “quasi FPGA” clock accurate functionality

The SW Architecture (**Figure 12**) is structured into 3 distinct layers of processing:

The first layer is sampling the incoming digital bitstream with a clock accurate timing based on PIO HW. The PIOs are tiny processing cores that behave similarly to FPGA logic. On this level each incoming signal period is evaluated and any detection of a valid PWM frequency is indicated to the second processing layer. The second layer is using one of the 2 processor cores to evaluate the frame protocol as well as the CRC checking. Once a valid frame is detected, the corresponding IP or MAC address is propagated to the application level. The third layer is the application layer which manages the communication with the service-app on the mobile device where any configuration or control information is forwarded to the cloud and the BMS. The 3^{rd} SW layer is implemented in Micropython [8] for very fast development and efficient implementation of the interface to the mobile app. On the mobile device a service app is installed which manages the data traffic over USB to the sensor dongle as well as the data flow over WLAN to the BMS. In the current prototype, only some basic features are implemented like setting the light level and color temperature.

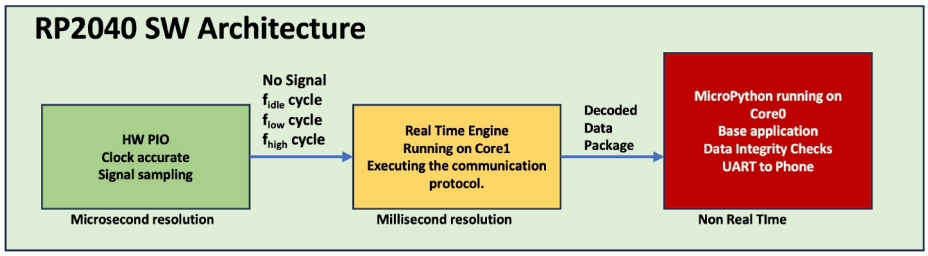

Figure 12: SW architecture in sensor with 3-level processing architecture. ©HTLR/SZK

Figure 13: Smart phone with LumaNet app and mounted sensor (bottom). Sensor in enclosure (right top). Sensor controller HW (right middle). Optical Tunnel on rear side (right bottom). ©HTLR/SZK

Summary and Conclusions

In this project a novel method for commissioning or reconfiguration of installed luminaires is proposed and a prototype system has been developed and tested. The concept foundation is that luminaires send their device address (MAC or unique ID) as PWM modulated light output. Using a tiny dongle-like sensor which plugs into any smartphone and allows the user to communicate with a particular installed luminaire for configuration or reprogramming. A dedicated set of light fixtures and suitable drivers have been developed as well as the dongle sensor. The concept has been proofed, and the initial project requirements could be fully met. The system offers a range of further improvements once a comprehensive field test has been executed (**Figure 13**).

The project was awarded as 3^{rd} best young scientific student project by “Special Award Vorarlberg”.

Many thanks to our project sponsor TRIDONIC and to Mr. Dietmar Klien for their excellent support. ■

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[8] https://micropython.org/

About HTL Rankweil

HTL Rankweil is an Austrian higher-level technical institution providing advanced secondary and post-secondary education in engineering and applied sciences. Situated in the region of Vorarlberg, the institution follows a rigorous, practice-oriented educational model that integrates solid theoretical instruction with applied technical training.

The academic profile of HTL Rankweil encompasses disciplines such as mechanical engineering, electrical engineering, automation, and industrial systems engineering. The curriculum is continuously aligned with technological progress through close cooperation with industrial partners, applied research initiatives, and project-based learning formats. This approach enables students to develop strong analytical, methodological, and engineering competencies.

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Authors: Johannes Rüdisser, Jan Stark and Stefan Zudrell-Koch (left to right). ©Authors

The special award was presented by Dr. Barbara Schöbi-Fink, Regional Minister of Education, and Michael Tagger, a Board Member of the "Special Award Vorarlberg". ©Land Vorarlberg / 7PRO.TV

Author: Johannes Rüdisser is a graduate of HTL Rankweil, where he specialized in Electronics and Technical Computer Science. He served as the team leader for the LumaNet project, where he was responsible for hardware, embedded software and mechanical design. Johannes has received several awards in music and mathematics. Looking ahead, Johannes intends to pursue a degree in Electrical Engineering in the coming years, further enhancing his skills and knowledge in this dynamic field.

Author: Jan Stark graduated from HTL Rankweil specializing in the field of software development. In the LumaNet project he was responsible for mobile app development.

Author: Professor Stefan Zudrell-Koch served as the supervisor of the LumaNet Project. He has extensive experience in lighting research and development, with a focus on the design of drivers and control ICs. After many years in senior management roles within the power electronics industry, he joined HTL Rankweil in 2018 as a Professor of Control Design and Hardware Engineering. His current research activities focus on innovation in power electronics, particularly the application of GaN technology.

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Lighting Metrics Demystified: How Photometric Data Drives Quality and Efficiency

Xavier Denis, Head of Technical Support and Technical Marketing at Nichia Europe GmbH

Why Lighting Metrics Matter

High quality lighting is essential for our well-being, and our ability to function effectively. We need comfortable, glare-free illumination that enables us to work, or that helps us to relax.

How do we define quality in lighting? Traditional approaches have focused on measurable criteria, such as illuminance level, color rendered, and the limitation of glare, while more recently the industry is shifting to human-centric lighting (HCL) approaches, that assess the personal impact of lights[2]. In practice, a combination of HCL thinking and traditional metrics often works best.

For lighting designers, the sheer number of metrics that exist can be overwhelming, and there is no single definition of lighting quality that is accepted by all[3]. Industry bodies and manufacturers provide complex combinations of data, which can be inconsistent and difficult to understand.

Although modern design software can handle much of this complexity, a lighting designer must still understand the key metrics, and how they can be used to evaluate lighting quality. Designers need accurate data from lighting manufacturers, supported by LED chip suppliers, to enable them to create accurate lighting calculations and simulations.

In this article, we'll explain some of the most important criteria for lighting design and quality, and the challenges involved in obtaining and using this photometric data.

The Key Standards

While there are many alternatives that could be used, the best approach is usually to work from a combination of up-to-date metrics, that measure different aspects of the quality of lighting.

We can group these metrics into three main areas:

- Color quality
- Visual comfort (including glare)
- Overall design (including efficiency)

For color quality, the longstanding metric of choice has been Color Rendering Index (CRI), which provides a measure, compared to natural light, of how accurately colors appear when illuminated by the light source being assessed.

While CRI 15, the extended version of CRI, is currently the most commonly used standard, another, similar metric is TM-30[4], which was developed by the Illuminating Engineering Society (IES). As with CRI 15, the TM-30 method evaluates the difference between color samples, which cover a wide range of hue, illuminated by the test light source and a reference source.

Next, when we consider visual comfort, the most important single factor is glare. Unified Glare Rating (UGR) is the standard metric to assess it. As specified in the standard EN 12464-1 "Lighting of indoor workplaces", UGR assesses the visual impact of glare upon a person, considering all the light sources that might contribute, and any reflections. For spaces with significant daylight, another useful metric is Daylight Glare Probability (DGP). Using published data, the UGR standard enables a single figure of glare level to be calculated. Lower numbers are better, and EN 12464-1 specifies that offices should have a glare level of 19 or below[5].

Moving on to overall design and efficiency, designers need to look at the brightness of a light, or luminous flux, which is measured in lumens. This enables a designer to ensure that the space being illuminated is bright enough. Then, the energy efficiency of a light source, or efficacy, in lumen per watt, is an essential data point in enabling sustainable designs that meet environmental standards.

Beyond this core metric, there are multiple other criteria that designers should consider, depending on their specific project. This might include meeting relevant building regulations and legislation related to working with computer screens, as well as rules around providing emergency lighting.

Challenges Faced by Luminaire Manufacturers

Luminaire manufacturers need to provide all the information required by lighting designers, their customers, to create efficient and effective systems. But their biggest challenge can be in getting enough data from LED manufacturers and other component suppliers. Nichia is proud to have a good track record in providing detailed specification documents.

Additionally, there is often a lack of consistent metrics from different luminaire manufacturers, so like-for-like comparisons of lighting products are difficult. Manufacturers also sometimes lack data to show how the performance of a lighting product will change over its lifetime, although this is addressed by standards such as TM-21[6].

[2] The Lighting Handbook, Zumtobel, https://www.zumtobel.com/PDB/teaser/EN/lichthandbuch.pdf

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LED chip manufacturers such as Nichia provide raw data for individual components, such as the luminous flux (lumens), luminous intensity distribution and LED efficacy, under specific and controlled conditions.

However, integrating a chip into a luminaire generates performance losses. Those include efficiency losses, mainly due to heat, from electronic parts, and losses, due to coupling, from optical components. Another factor is variation in the distribution of luminous intensity because of the luminaire's optical design. These losses and variations mean that the overall efficacy of a luminaire is lower than the efficacy of the LED chip alone.

Possible Solutions for Better Data

To overcome these issues, and to provide the photometric performance data needed by lighting designers, luminaire manufacturers need to take several key steps. Firstly, they must provide end-to-end performance data for the entire luminaire, not just the LED chip. This should include efficacy and information on photometric metrics, as well as data on how lumen values will decrease due to aging.

Secondly, luminaire manufacturers should use independent, standardized testing such as the LM-79 measurement standard published by IES[7].

This enables them to measure the impact of optics, drivers, and other components on photometric performance, and to provide data that can be used in comparisons with other vendors' products.

Finally, they need to provide all these data in a convenient form for use in lighting analysis software. Typically, this means creating IES or EULUMDAT files that accurately represent the final performance metrics. All this information should be put together with reference to the standards and guidelines provided by industry bodies, such as the *SLL Code for Lighting*, published by CIBSE in the UK[8].

Conclusion: Driven by Data

Quality in lighting may be seen as a subjective issue, but we have shown how quantified, objective information can enable lighting designers to compare different luminaires, and to optimize their lighting systems.

LED manufacturers and luminaire manufacturers have a responsibility to work together to provide consistent, accurate data, so we can all benefit from efficient, high-quality lighting. ■

LEARN MORE...

Nichia Application Note on Color Rendering Evaluation of LEDs for General Lighting

led-ld.nichia.co.jp/en

Xavier Denis, Nichia Europe GmbH
Head of Technical Support and Technical Marketing

[7]TUV SUD, https://www.tuvsud.com/en-us/industries/consumer-products-and-retail/lighting/testing/lm79

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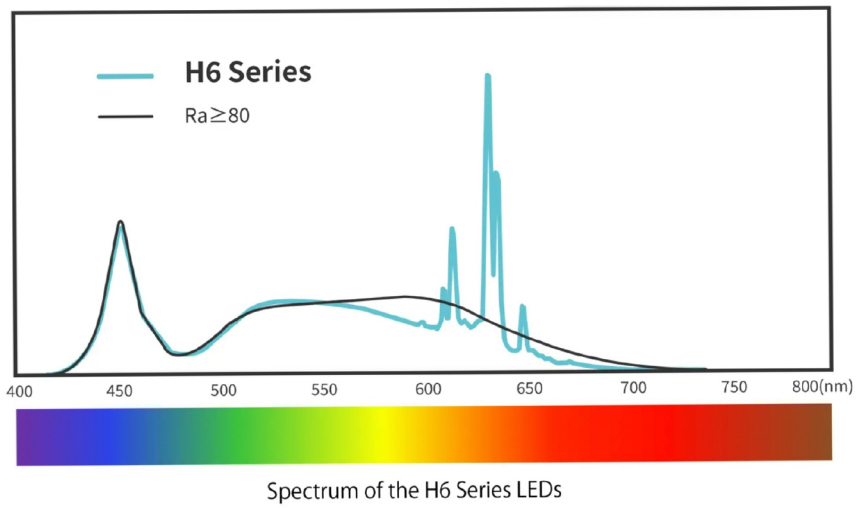
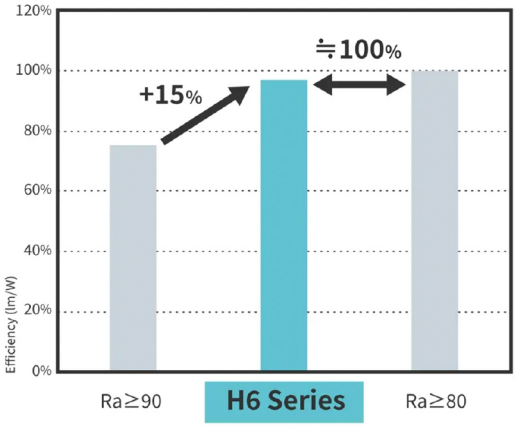


Spectrum of the H6 Series LEDs



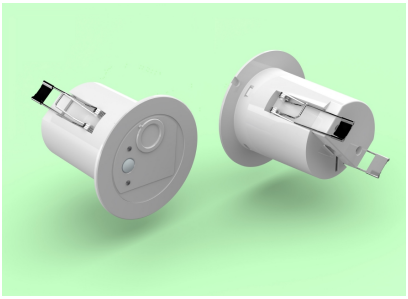
Comparison of Luminous Efficacy : H6 Series LEDs vs. (Ra≥80) LEDs

Nichia's H6 LED is an example that delivers both higher efficacy and higher color rendering than traditional LEDs while maintaining an efficacy better than Ra≥80 LEDs.

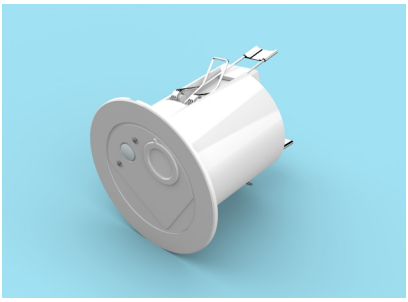
From Lighting Control to Thermal Intelligence

Saara Guastella, Casambi; Kevin Johnstone, Danlers Limited; and Bart de Jong, Calumino

The evolution of lighting control systems over the past decade has fundamentally reshaped how buildings are designed, operated, and experienced. What began as wireless dimming and scene-setting has expanded into a broader platform for data-driven building intelligence. The latest integration between Danlers Ltd., Casambi Technologies, and Calumino marks a significant milestone in this transformation: The delivery of a commercially available, privacy-safe thermal sensing solution embedded directly into the Casambi wireless lighting ecosystem.



Real occupancy data, zero cameras, seamless Casambi integration.



Privacy-safe human detection and counting, built into Danlers controllers.

Danlers, Casambi and Calumino Deliver a Privacy-Safe, Plug & Play Sensing Solution for Smart Buildings

Following the initial partnership announcement between Casambi and Calumino in 2024, the vision of bringing thermal sensing to mass-market smart building applications has now been realized in a ready-to-deploy solution. Through Danlers' plug & play Casambi-compatible sensors with "Calumino Inside," lighting professionals can now access advanced thermal intelligence, occupancy detection, and people counting within a unified lighting control platform.

This article explores how the collaboration moved from concept to deployment, the technical capabilities of the integrated solution, and what it means for the future of smart lighting and building automation.

The Growing Role of Sensing in Lighting Systems

Lighting infrastructure has become one of the most attractive platforms for sensing technologies. Luminaires are already distributed throughout buildings, connected to power, and positioned optimally for observing space usage. As a result, lighting control networks are increasingly used as the backbone for occupancy detection, energy optimization, and data collection.

Traditional sensing methods, such as PIR motion sensors or camera-based systems, have clear limitations. PIR sensors struggle with accuracy in complex spaces and often fail to detect stationary occupants. Camera-based solutions raise privacy concerns, regulatory challenges, and acceptance issues, particularly in workplaces, healthcare environments, and hospitality settings.

Radar-based sensing has emerged as a newer alternative, using radio waves to detect motion, presence, and even micro-movements such as breathing. Radar can perform well in low-light or obscured conditions and offers higher sensitivity than PIR. However, radar systems often come with higher costs, increased power consumption, and greater signal-processing complexity. In dense or reflective environments, radar may also suffer from interference, calibration challenges, or over-detection, which can impact reliability and ease of deployment.

Thermal sensing offers an alternative approach. By detecting heat signatures rather than visual images, low-resolution thermal sensors can identify human presence and movement without capturing personally identifiable information. This makes thermal sensing particularly attractive for applications where privacy, compliance, and trust are critical. And as thermal sensing works based on line of sight, it is easy to commission.

Calumino's mission has been to democratize this form of sensing by making it affordable, scalable, and easy to integrate into existing building systems. The partnership with Casambi and Danlers has been instrumental in turning that ambition into a deployable solution.

From Concept to Market-Ready Integration

In May 2024, Casambi published an article titled "*Calumino brings thermal sensing to mass market applications*", outlining how Calumino's technology could be integrated into Casambi's wireless lighting mesh to unlock new levels of spatial intelligence. At the time, the announcement represented a forward-looking vision rather than an immediately available product.

Over the past year, that vision has been transformed into a fully tested and commercially validated solution through close collaboration between the three companies.

The key development was the embedding of Calumino's intelligent thermal sensor and edge analytics into Danlers' plug & play Casambi-compatible sensors. Danlers

brought its expertise in robust, installer-friendly hardware design; Calumino contributed its sensing technology and analytics; and Casambi provided the wireless mesh ecosystem, commissioning tools, and integration framework.

The result is not a prototype or bespoke integration, but a standardized solution that can be installed, commissioned, and operated using the same workflows familiar to Casambi system integrators.

Privacy-First Thermal Sensing with Edge Analytics

At the core of the solution is Calumino's low-resolution thermal sensor, designed specifically for privacy-safe applications. Unlike cameras or high-resolution imaging systems, the sensor does not capture recognizable visual information. Instead, it detects thermal patterns and processes them locally using embedded edge analytics.

This approach enables reliable human detection, presence monitoring, and people counting without transmitting raw image data or compromising occupant privacy. All analytics are performed on the device, reducing data traffic and minimizing cybersecurity risks. For building operators, this translates into actionable insights without the ethical, legal, and operational challenges often associated with vision-based sensing systems. For occupants, it provides reassurance that their privacy is respected, an increasingly important factor in smart building adoption.

Native People Counting Within the Casambi Ecosystem

One of the most significant outcomes of the integration is the introduction of a native Casambi-supported people counter powered by Calumino's sensing technology. Occupancy and count data can now be used directly within the Casambi ecosystem or shared with connected systems.

This opens the door to multiple use cases:

- Lighting control that responds dynamically to real occupancy rather than simple motion events
- HVAC optimization based on actual people counts rather than schedules or assumptions
- Space utilization analytics for facility management and operational planning
- Integration with building management systems using Casambi's API

By making people counting a native, supported feature rather than a third-party add-on, Casambi strengthens its position as a platform not only for lighting control, but for broader building intelligence.

Multi-Zone Monitoring with the New 1+8 Functionality

A key technical innovation enabled by Calumino's thermal sensing is the new 1+8 presence and absence functionality. With this capability, a single sensor can monitor and independently configure up to eight distinct zones while still treating the overall area as one unified space.

This is particularly valuable in environments such as open-plan offices, hotel lobbies, meeting rooms, corridors, or healthcare facilities, where multiple functional zones exist within a single physical area.

From a practical standpoint, the 1+8 functionality delivers several benefits:

- Reduced hardware requirements by covering multiple zones with one sensor
- Faster installation and commissioning
- Lower system cost
- Simplified configuration and adjustment through the Casambi app

All zone settings and behaviors are managed within the familiar Casambi commissioning environment, ensuring consistency with existing lighting control workflows.

Plug & Play Deployment Through Danlers Controllers

Ease of installation has been a defining principle of Casambi's success, and the Danlers integration maintains this philosophy. The new Danlers controllers with Calumino Inside are designed as true plug & play devices.

System integrators can install a single controller, commission it using the Casambi app, and immediately gain access to:

- Wireless lighting control
- Thermal presence detection
- People counting
- Occupancy-based logic and automation

There is no need for separate sensing networks, additional gateways, or complex system integration steps. Everything operates within the Casambi mesh, benefiting from its scalability, reliability, and device interoperability.

This approach significantly lowers the barrier to adopting advanced sensing capabilities, making them accessible not only to large-scale projects but also to smaller installations where complexity and cost would otherwise be prohibitive.

Unlocking New Applications Across Building Types

The combined capabilities of lighting control and thermal sensing enable a wide range of applications across different sectors.

In **office environments**, accurate occupancy data supports energy-efficient lighting and HVAC operation, improves space utilization analysis, and enhances employee comfort.

In **hospitality**, thermal sensing enables adaptive lighting scenes, optimized climate control, and better understanding of guest movement patterns, all without compromising privacy.

In **healthcare**, the privacy-safe nature of thermal sensing is particularly important, allowing monitoring of space usage and presence without introducing cameras into sensitive areas.

In **education and public buildings**, the solution supports flexible space management, energy savings, and compliance with data protection requirements.

Across all these environments, the integration demonstrates how lighting infrastructure can serve as a foundation for smarter, more responsive buildings.

Ecosystem Collaboration as a Catalyst for Innovation

The success of this integration highlights the importance of ecosystem collaboration in the smart lighting industry. Casambi's open, partner-driven ecosystem allows specialized technologies like Calumino's thermal sensing to be embedded into products from hardware experts such as Danlers, creating solutions that are greater than the sum of their parts.

Kevin Johnstone, COO at Danlers Ltd., emphasizes the practical impact of this approach:

"Our collaboration with Calumino and Casambi represents a major leap forward for intelligent building control. With Calumino's thermal intelligence integrated into our plug & play Casambi controllers, we can deliver smarter, more efficient, and privacy-safe solutions that are ready to install out of the box."

KEVIN JOHNSTONE

From Calumino's perspective, the integration fulfills its original mission. Bart de Jong, Commercial Director notes:

"At Calumino we set out to bring thermal sensing into the mass market—and the partnership with Casambi and Danlers was a catalyst for that mission. Today, with our analytics embedded in a proven lighting-control ecosystem, we are delivering the actionable data that buildings, facilities and people need."

BART DE JONG

Casambi sees the integration as a natural extension of its ecosystem strategy. Viktor Olsson, Director of Ecosystem Sales EMEA, adds:

"Casambi's ecosystem thrives on partners who innovate at the intersection of sensing and control. We are delighted to see Danlers and Calumino deliver the promise we announced in 2024—enabling smarter, more responsive lighting and building systems."

VIKTOR OLSSON

Availability and Outlook

The Danlers sensors with Calumino Inside are available now through Danlers' distribution network and can be seamlessly integrated into any Casambi network using the Casambi app.

Looking ahead, the integration signals a broader shift in the lighting industry. As sensing, analytics, and control converge, lighting systems are evolving into platforms for operational intelligence, sustainability, and user-centric design. Privacy-safe technologies such as thermal sensing are likely to play a central role in ensuring that this evolution aligns with societal expectations and regulatory frameworks.

For lighting professionals, system integrators, and building owners, the collaboration between Danlers, Casambi, and Calumino demonstrates how innovation within an open ecosystem can translate quickly from vision to market-ready reality. ■

Casambi is a Bluetooth Low Energy–based wireless lighting control platform enabling flexible, interoperable, and scalable smart lighting networks.

CASAMBI

Danlers Limited develops and manufactures lighting control sensors and solutions for professional and commercial lighting applications.

DANLERS
Controls for Lighting & HVAC

Calumino develops thermal sensor technology enabling anonymous people detection and occupancy sensing for smart buildings and lighting systems.

CALUMINO
intelligent thermal sensing

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Saara Guastella, Global Product Marketing Manager at Casambi (left); Kevin Johnstone, COO at Danlers Limited (middle); and Bart de Jong, CCO at Calumino (right).

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Light + Building Show Report

The next issue of LED professional Review (LpR), March/April 2026, will primarily focus on the highlights of Light + Building 2026 in Frankfurt. This issue will spotlight the latest trends, technologies, and market developments shaping the lighting industry. In addition, we will present a curated selection of the most important and most interesting new product innovations.

* *Subject to change without notice.*

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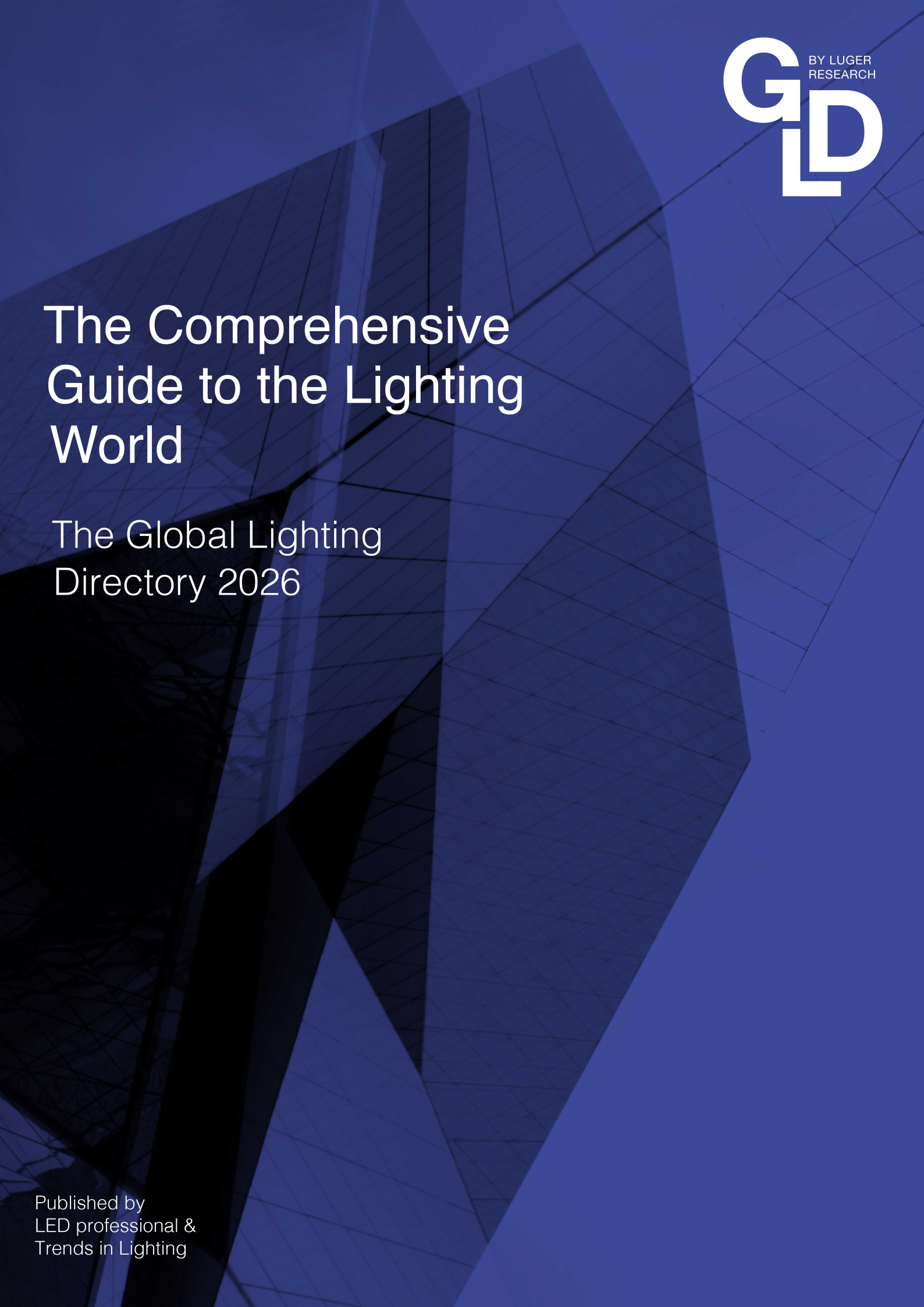

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