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Review

LpR

The Global Information Hub for Lighting Technologies and Design

May/June 2023 | Issue 97

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The Dimensions of Light

Once again, I am pleased to present the latest issue of the LED professional Review (LpR), May/June 2023 issue, number 97.

In this issue, Anton Sonneveld from Broadcom, highlights the topic of phototherapy based on UV-A LED technologies in his commentary. His views skillfully motivate one to focus more on the medical applications of LED technologies for future publications. We were also very excited to have been able to conduct a personal interview at Tridonic headquarters with their CEO, Hugo Rohner. In this interview, he shows how Tridonic is transforming into a company that has put sustainability at the center of its activities. The transformation into eco-design and sustainability is a significant trend of the times, of course, also triggered by essential exogenous factors.

In its cover story, Würth Elektronik addresses the topic of vertical farming with the subject of lighting control and describes its developer kit for RGBW color mixing. Lichtvision Design gives us insights into a project that was completed a few years ago: The Guangzhou International Finance Center in China. Be that as it may, we didn't want to withhold the exceptional façade lighting concept and the impressive building from you. The Good Light Group has created a report with TOP experts, in which they have summarized the effect of good light on people and collected the latest data. The article is a compact outline of the latest scientific findings. The source reference list of the article is beneficial for further studies on this topic. In his scientific contribution, Dr. Thomas Schielke from ERCO takes us into the language of light - Semiotics. Finally, we are pleased to present the Zhaga Awards - Smart City Sensor winners. Congratulations to all winners! These Awards will be essential for developing intelligent lighting systems in cities.

The spectrum of contributions from medicine to HCL, horticulture, and streetlighting to lighting design, gives us a good look at the diversity and the dimensions of light. It remains an exciting topic in many fields!

Have a great read.

Yours Sincerely,

Siegfried Luger

Luger Research e.U., Founder & CEO
LED professional, Trends in Lighting, LpS Digital & Global Lighting Directory
International Solid-State Lighting Alliance (ISA), Member of the Board of Advisors
Member of the Good Light Group and the European Photonics Industry Consortium

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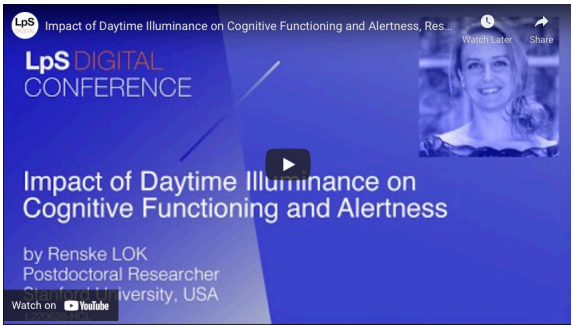

ADVERTISING INDEX

Anton SONNEVELD

Anton SONNEVELD is Business Development Manager for LEDs at Broadcom Inc. for Central & Northern Europe and is part of the European organization. There he has held various positions in Sales and Marketing dedicated to LEDs over the past 15 years.

Broadcom is known for its LED's performance, efficiency and reliability and offers an extensive portfolio of products like high brightness and high power LEDs, PLCC surface-mount LEDs, ChipLEDs, incl. IR & UV LEDs and display backlighting module solutions. These LEDs address a wide range of markets, including electronic signs and signals, industrial applications, solid state lighting and automotive.

Phototherapy and UV-A LED Technology

UV radiations are often linked to well-known risks such as sunburn and premature aging, but they can also be used to treat various medical conditions ranging from skin disorders to psychiatric illnesses. As UV-A is able to penetrate deeper into the human skin, one of the best known benefits is the ability to boost the production of Vitamin D in the human body, which is crucial for calcium and phosphorus absorption.

For such therapy, man-made conventional lamps such as xenon, mercury, and fluorescent lamps have been the main source of UV radiation. However, prolonged exposure to infrared radiation emitted by these lamps may potentially cause undesirable side effects and serious health issues on treated patients.

By adopting LED technology into phototherapy, such health issues and discomfort can be greatly reduced, as LED phototherapy treatment is known to be non-invasive and generates less heat, hence it requires no healing time. In addition, it can deliver the desired spectral bands that are effective for specific treatments. The usage of UV-A LEDs in phototherapy includes:

Skin disorders:
Numerous studies have shown that light treatment with UV-A radiation has successfully treated a number of skin conditions such as psoriasis, atopic dermatitis (eczema), and vitiligo. The most common type of UV-A phototherapy is PUVA combining the use of UV-A radiation and Psoralen, a photosensitizing agent that makes the skin more sensitive to light. Recently, phototherapy with UVA1 (340 nm to 400 nm) is increasingly being used due to its nonerythemogenic effect (redness of skin).

Neonatal jaundice: Reduces the bilirubin level where UV radiation is being absorbed into the skin resulting in the breakdown of bilirubin into compounds that newborns can exert. Newborns are usually treated while covering the eyes or with a Biliblanket (delivering light through fiber optics) covering the infant.

Mood and sleep disorders:
Sleep-related issues such as seasonal affective disorder (SAD) and circadian rhythm sleep disorder (CRSD) can be treated with light therapy by making up for the loss of sunlight exposure in order to reset the biological clock in the human body. This regulates the sleeping pattern and positively affects the mood and emotional conditions of treated patients. Studies have shown that using full spectrum light with UV-A can effectively reduce the depressive behaviors of patients rather than relying on antidepressant medication.

Wound healing:
The combination of UV-A radiation and surgery provides a higher success rate to cure keloid and hypertrophic scars. Studies have shown that UVA1 can effectively inhibit scar formation without damaging the cells.

Pre-cancer: Early-stage cancer such as actinic keratoses can be detected and treated effectively with photodynamic therapy (PDT) which involves UV and photosensitizing agents. This treatment is non-invasive and non-toxic with minimal side effects.

Acne treatment: Near-UVA radiation ranging from 405 nm to 425 nm can eliminate P.acnes bacteria found in the skin which causes acne. Bacteria are eliminated when free radicals are produced during near-UV light absorption by the bacteria to reduce inflammation.

Thus, the advancement and versatility of UV-A LEDs has expanded the applications for both medical and dermatology treatments. ■

A.S.

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THE ORIGINAL BY RÖHM

LightingEurope Elects Executive Board and President

www.lightingeurope.org

The LightingEurope General Assembly elected a new Executive Board for a two-year mandate on 31 March. The role of the LightingEurope Executive Board is to implement LightingEurope's strategy and work program. It is composed of 16 members, equally split between representatives of member national lighting associations and member companies.

The newly appointed Executive Board elected, on that same day, Maurice Maes as President of LightingEurope. Maurice Maes has been the Head of Standards & Regulations in Signify since 2015 and has over 25 years of experience in associations, having served on boards of industry initiatives such as the ZigBee Alliance, LightingEurope and the Global Lighting Association.

Juergen Waldorf, Managing Director of the ZVEI section Lighting and licht.de, was elected Vice-President and Miguel Aguado, Marketing and Technology Manager EMEA at Lutron, was elected Treasurer.

"I am honored to be elected President and look forward to working closely with the Executive Board colleagues and the wider membership to contribute to fit-for-purpose regulations that stimulate smarter, better and more sustainable lighting, bringing even more value from lighting systems to their users," says Maurice Maes.

The Executive Board consists of the following members (by alphabetical order of family name):

- Miguel Aguado, Lutron, UK (Treasurer)
- Alfredo Berges, ANFALUM, Spain
- Bob Bohannon, The LIA, UK
- Lionel Brunet, Syndicat de l'Éclairage, France
- Nathalie Coursière, IGNES, France
- Jean-Marie Croué, Syndicat du Luminaire-GIL, France
- Maurice Maes, SIGNIFY, The Netherlands (President)
- Joerg Minnerup, Trilux, Germany
- Isacco Neri, ASSIL, Italy
- Arnulf Rupp, OPTOTRONIC (OSRAM group), Germany
- Mark Oliver Schreiter, ERCO, Germany
- Wouter Soer, Lumileds, The Netherlands
- Lars Stuehlen, LEDVANCE, Germany
- Carlo Urbinati, ASSOLUCE, Italy
- Klaus Vamberszky, ZUMTOBEL Group, Austria
- Dr. Jürgen Waldorf, ZVEI, Germany (Vice-President)

LightingEurope is the voice of the lighting industry, based in Brussels and representing 30 companies and national associations. Together, these members account for over 1,000 European companies, a majority of which are small or medium-sized. They represent a total European workforce of over 100,000 people and an annual turnover exceeding 20 billion euros.

LightingEurope is committed to promoting efficient lighting that benefits human comfort, safety and well-being, and the environment. LightingEurope advocates a positive business and regulatory environment to foster fair competition and growth for the European lighting industry. ■

Heinrich Thye Appointed as New Secretary General of the Zhaga Consortium

www.zhagastandard.org

The Zhaga Consortium, a global lighting industry organization, is pleased to announce the appointment of Heinrich Thye as its new Secretary General, effective April 1st, 2023. Thye will succeed Dee Denteneer, who has served as Secretary General for the past seven years.

Heinrich Thye is a seasoned business executive with extensive experience in marketing, sales, and management. For 15 years Thye was the Managing Director of IDEE Europe, an international electrical wholesale group and strong partner of the lighting industry. He has a master's degree in engineering and an MBA in business engineering.

"I am excited to join Zhaga as the new Secretary General," said Heinrich Thye. "I look forward to working with the team and the consortium members to further promote the advantages of standardized interfaces of components of LED luminaires and to create value for the lighting industry and the smart city of tomorrow."

Dee Denteneer, who has been instrumental in the growth and development of the Zhaga Consortium, is leaving after 7 years. Under his leadership, the organization has expanded into interface specifications that address interoperability for connected lighting. A result of this direction were the Zhaga Smart City Sensor Awards, where winners were announced last week.

Zhaga has grown into a global consortium with more than 500 members and the purpose to enable new markets for connected and serviceable lighting through interoperability. ■

EIA Projects Will Reduce U.S. Energy-related CO2 Emissions Through 2050

www.eia.gov

U.S. energy-related CO2 emissions drop 25% to 38% below what they were in 2005 by 2030, according to projections from the U.S. Energy Information Administration's (EIA) Annual Energy Outlook 2023 (AEO2023). By the end of the projection period, 2050, U.S. energy-related CO2 emissions are 17% lower in this year's Reference case compared with last year, after EIA accounted for the effects of the Inflation Reduction Act (IRA), energy technology costs and performance updates, a changed macroeconomic outlook, and other factors.

EIA's projected reductions in U.S. energy-related CO2 emissions are driven by increased electrification, higher equipment efficiency, and the deployment of renewables in the electric sector. Emissions reductions are limited, however, by longer-term growth in U.S. transportation and industrial activity.

With policy changes over the last year and continued technology innovation, we expect to see significant shifts in energy production and use over the next 30 years," said EIA Administrator Joe DeCarolis. "The resulting projections for energy-related CO2 emissions are most sensitive to our assumptions regarding economic growth and the cost of zero-carbon generation technology."

The AEO2023 has been published on the EIA website, along with a separate Issues in Focus paper that examines the impacts of the IRA, taking into account uncertainty around some of the policy provisions. In the Reference case, implementation of the IRA results in a 33% reduction in energy-related CO2 emissions by 2030 relative to 2005 compared to a 26% reduction in the No IRA case. Because of the complexity of the IRA and related challenges to modeling some of its provisions, not all of its energy system impacts are represented in AEO2023. Documentation of EIA's IRA-related modeling assumptions is included with this release.

Highlights from AEO2023 include:

Renewable generating capacity grows in all regions of the United States in all AEO2023 cases, supported by growth in installed battery capacity. EIA sees stable growth in U.S. electric power demand through 2050 in all AEO2023 cases because of increasing electrification and ongoing economic growth. Investment in renewable sources such as wind and solar, and the operating cost advantage of those sources, increases the share of zero-carbon electricity generation in EIA's projections. EIA projects growth in

installed battery capacity in all cases to support growth in renewables.

Technological advancements and electrification drive projected decreases to demand-side energy intensity. EIA projects an increase in the deployment of heat pumps, electric vehicles, and electric arc furnaces in the iron and steel industry. In the residential and commercial sectors, higher equipment efficiencies and stricter building codes extend ongoing declines in energy intensity. In the transportation sector, light-duty vehicle fuel efficiency improves due to rising Corporate Average Fuel Economy (CAFE) standards and electric vehicle (EV) sales.

High international demand leads to continued growth in U.S. production, and combined with relatively little growth in domestic consumption, allows the United States to remain a net exporter of petroleum products and natural gas through 2050 in all AEO2023 cases. Despite no significant change in the domestic consumption of petroleum and other liquids through 2040 across most AEO2023 cases, we expect U.S. production to remain at historically high volumes. Domestic natural gas consumption also remains relatively stable, despite a shift in electricity generation towards renewables. Production of natural gas, however, continues to grow in response to international demand for liquefied natural gas.

This year's AEO marks a return of the Administrator's Foreword and a renewed focus on the narrative to contextualize our results, including technical notes that provide a deeper level of explanation around key issues. To better account for future uncertainty, key insights focus on ranges and trends rather than singular projections. ■

Inventronics Acquired OSRAM Digital Systems

www.inventronicsglobal.com

Inventronics, a global leader in reliable and innovative LED driver products, is pleased to announce the successful acquisition of the relevant Digital Systems business in Europe and Asia from ams OSRAM, a global leader in optical solutions. This acquisition demonstrates Inventronics' commitment to providing exceptional technology and value to its global customer base while leading the transformation to cost-effective, intelligent, connected lighting.

The ams OSRAM Europe and Asia Digital Systems business primarily focuses on power supplies, related light modules, software, and connectable components for traditional and LED illumination. These essential components enable smart lighting solutions and digitalization for professional lighting applications. With the acquisition of ams OSRAM's Digital Systems business, Inventronics expands both its regional presence and product portfolio.

Dr. Gernot Steinlesberger, Head of OSRAM Digital Systems Europe and Asia, stated, "We look forward to starting a new chapter with Inventronics. The combined portfolio, market reach and lighting focus, will bring tremendous value to our customers."

Marshall Miles, CEO of Inventronics, expressed his enthusiasm for the acquisition, stating, "We are striving to be the vendor of choice for components supporting the lighting industry, providing the broadest portfolio of innovative, high quality products and services. This transaction demonstrates our commitment to our customers and the lighting market globally."

The ams OSRAM Digital Systems business in Europe and Asia employs around 600 people, is headquartered in Garching near Munich, Germany, with additional operations throughout the territory. Inventronics is a world-class enterprise specializing in the design, manufacture, marketing, and sales of reliable and innovative LED driver products, and a global leader in driving the transformation to cost- effective, intelligent, connected lighting. Inventronics looks forward to integrating these new colleagues into the Inventronics family.

Inventronics is a publicly traded company based in Hangzhou, China, with global operations including manufacturing facilities in China, India, and Mexico, as well as distribution centers in the US and the Netherlands. The company maintains sales offices in major markets worldwide, servicing customers in over 100 countries. ■

LORELUX from Plastic Waste to Resistant Urban Luminaires

www.lorelux.eu

Niteko Illuminazione – renowned Italian manufacturer of custom LED lighting fixtures for outdoor and large areas – has launched Lorelux®, first brand of 100% circular urban luminaires providing a uniquely designed and corrosion-resistant urban lighting that can last for more than 50 years.

Lorelux® luminaire's manufacturing follows the principles of circularity and design's uniqueness in all its stages: from conception to material's choice, to the possibility of recycling the luminaire at the end of its service life. A true revolution in urban lighting thanks to the use of recycled and infinitely recyclable plastic materials, highly innovative for the sector. In fact, Lorelux® luminaires are the first urban luminaires made from recovered polymers deriving from clean industrial waste and from shredded household plastic waste (for example, plastic caps). These sustainable materials, combined with a patented manufacturing solution, make Lorelux® luminaires – acronym for Long Resistant Luminaires – highly durable and resistant to vandalism and corrosion due to atmospheric agents and pollutants. Moreover, LED engine can be easily replaced also at large heights by means of a fast and economical patent pending maintenance system: for indestructible and always upgraded luminaires.

In this way, municipalities can benefit both from a lighting system that is always technologically upgraded and from a green and durable product that is good for the planet. Thanks to the lighting body's manufacturing, using up to 90% of recycled materials, it contributes to cleaning up the planet from harmful waste such as plastic, which is increasingly accumulating in our soils and seas.

"Recycling is the only possible future. We are proud to be the first manufacturer to produce urban luminaires made from discarded materials, thus minimizing waste and applying the virtuous model of circular economy even in a sector where you would usually expect heavy and impacting products," explains Alessandro Deodati, Head of R&D department. "Not only do Lorelux® luminaires come from recovery, but they can also be recycled at the end of their service life and be reused to manufacture a new luminaire, thus closing that perfect circle where nothing is destroyed and everything is reused."

Lorelux® luminaires are exclusive from all points of view. The combination of ductile materials and flexible manufacturing technique – which is environmentally friendly, too – makes it possible to customize the lighting bodies' shapes and colors, and to create unique and bespoke designs for any urban context.

Working together with Lorelux®, architects and lighting designers have the possibility to create luminaires that overcome the creative limits of traditional lighting fixtures, and to obtain out-of-the-ordinary products allowing for the creation of unique and highly valuable projects.

In fact, Lorelux® means limitless creativity and manufacturing speed of the finished piece in just 90 days from the delivery of the technical drawings, even for small batches.

With Lorelux®, creating a new luminaire is fast and easy. The Made in Italy production releases from the timing of the international markets, and the listening to customer's needs leads to an original co-creation that is really accessible to everyone. The result is a network of professionals sharing a common goal: a highly efficient outdoor lighting that is truly sustainable and creative.

"Everyone believes that 100% bespoke luminaires should have a high cost" adds Alessandro Deodati, "Lorelux® clearly shows how outdated this idea is. If you choose the right materials and use an on-site production – giving value to the territory and to the sustainability of both manufacturing and transports – you can completely revolutionize the traditional concept of urban lighting and achieve custom products that are really sustainable from all points of view in a short time." ■

3D-printed Luminaires Set the Bar for Sustainable Design Excellence

www.signify.com

Signify (Euronext: LIGHT), the world leader in lighting, will showcase new additions to its sustainable 3D-printed lighting collection at the world's leading international design fair, Salone del Mobile. The exhibition will feature an exclusive collaboration with innovative textile designer Aleksandra Gaca, and Signify's award-winning Coastal Breeze collection, which is made with 100% recycled fishing nets.

Signify's 3D-printed luminaires will be on display at Masterly – Dutch Design in Milano. Visitors can experience a mesmerizing lighting presentation featuring a stunning tree of lights. A special highlight is a new design with exceptional textures and exclusive finishes, from Aleksandra Gaca. Gaca's innovative woven textiles sit at the intersection of art, design and architecture and match perfectly with the 3D printing technology used to create Philips MyCreation lighting objects.

"As a textile designer, I am really excited about the 3D printing techniques developed by Signify, because they allow me to quickly and easily incorporate my textures into everyday objects within anyone's reach," says Aleksandra Gaca. "I also feel really connected to the company's commitment to sustainability. The Philips MyCreation Coastal Breeze project is a powerful demonstration that the union of design and innovation can give life to a more beautiful world and a more sustainable future."

Three dimensions of sustainability:
Signify continues to push the boundaries of sustainable design with its 3D-printed luminaires that reduce emissions, reduce waste, and contribute to a circular economy. All the 3D-printed luminaires are made with at least 55% recycled or bio-circular materials. A reinvented manufacturing process cuts the number of components by up to 40% and eliminates the need for glue, making it much easier to disassemble and recycle parts for repair and refurbishment. Lighter materials create fewer carbon emissions, and since the products are printed on demand, no unsold stock goes to waste.

Signify's award-winning Coastal Breeze collection will be on display at Salone del Mobile. This special collection is made with 100% recycled fishing nets, transforming waste material into beautiful, functional pieces for the home.

Philips MyCreation: a hallmark of sustainable design:
Signify's 3D printing enterprise is one of its fastest-growing business units, contributing to the company's goal to double its circular revenues to 32% by the end of 2025. In 2023, Signify brought together all 3D-printed professional and consumer collections under the Philips MyCreationbrand. Philips MyCreation now encompasses Lightolier, Shaper Prentalux from Cooper Lighting Solutions, and Philips Tailored Lighting. This single brand guarantees the quality, design excellence, and sustainability that unites the collections.

Salone del Mobile draws over 300,000 visitors per year to experience the best of exclusive design and high-quality products. Signify will be in Sala Donzelli on the first floor of the Dutch Design Pavilion at the Palazzo dei Giuresconsulti. ■

Glamox to Reduce Carbon Footprint of LED Luminaires by Switching to Recycled Aluminum

www.glamox.com

Glamox AS, a leading lighting company, is progressing towards its goal of Net Zero operations by 2030. Glamox announced that it has started to switch from using virgin aluminum to recycled aluminum in manufacturing its LED luminaires. The company has already made the switch for one of its most popular luminaires and is preparing to extend it to other families. The move will further lower the carbon footprint of the company and those customers who purchase the already energy-efficient LED luminaires for use in professional buildings.

Recycled aluminum is created by re-melting scrap metal. The process is less expensive and energy-intensive than creating new aluminum, which is made by the electrolysis of aluminum oxide, which must first be mined from bauxite ore and then fired.

"We've already implemented the plan to shift over to recycled aluminum in the manufacture of a popular luminaire which will result in a 63 percent reduction in the emissions of CO2 equivalents over using new aluminum in these profiles," said Birger Holo, Technical Director, Professional Business Solutions, Glamox. "By adding two new product lines we estimate that we will eliminate a total of 1,000 tons of CO2 equivalents each year, which equals the amount of carbon sequestered by nearly 1,200 acres of forest a year."

The Glamox C35 and C95 LED luminaire ranges are earmarked to be the next products to join the Glamox C80 luminaire range in using recycled aluminum. All three product lines are manufactured in Keila, Estonia. Together they represent around 400,000 products sold yearly, using a combined 300 tons of aluminum.

The company is also progressively eliminating plastic in its packaging, replacing bubble wrap and Styrofoam with materials that are easier to recycle. This has been done for its Glamox C35 and C95 luminaires. Also, it recently launched an Environmental Product Declarations (EPD) generator. Based on international standards, this tool documents the environmental footprint of products taking into account their lifecycle.

"We still have a lot of work ahead of us, but we are committed to helping our customers to reduce their carbon footprint and for us to achieve Net Zero operations by 2030. It's not enough providing energy-efficient LED lighting, we must ensure that every facet of our operations and supply chain minimizes our environmental impact," said Viktor Söderberg, Business Development Director, who heads up the company's sustainability program. ■

IKEA and Little Sun Explore Light Sources Powered by the Sun

www.ikea.com

Most energy resources are limited, expensive and environmentally exhausting. And then there is the sun. Based on a shared belief that thoughtful design can make a difference, Little Sun joined forces with IKEA to develop SAMMANLÄNKAD with the wish to make solar energy available to more people.

In collaboration with IKEA, Little Sun invites people to explore the benefits of a solar-powered life through functional and beautiful lighting. SAMMANLÄNKAD, which means 'connected' in Swedish, features two sun-powered LED lamps designed to awaken interest in solar energy and raise awareness for equitable energy access.

"Design, beauty, and simplicity together make these products something that people will have in their lives, giving them the power to embrace the idea of solar energy powering our future. It's only a small nudge that we can deliver, and many nudges are needed. But we are excited to see how much solar energy we can spread in the world." Felix Hallwachs, Managing Director, Little Sun

The direction for the collection is inspired by Little Sun's unique position at the intersection of design, technology, and impact. SAMMANLÄNKAD is rooted in Little Sun founder Olafur Eliasson's conceptual vision that joins art and science together to make solar energy tangible.

The result of the collaboration is two sun-powered LED products. The first combines lighting and charging, and can be used as either a pendant or table lamp. The light source can be removed from the stand to be used as a flashlight. The smaller portable lamp offers a practical solution for outdoor settings. Coming with a yellow strap, it can be held or hung on a window or backpack during daylight hours for charging. Both lamps are equipped with solar panels and rechargeable batteries.

"It has this heliocentric energy and our planet's orbit around it in the first gyroscope ring at a 23.5-degree angle, which is the axis of the earth in relation to the sun. And the light, a

half-ball, is completed by a mirror to become a full ball, like the sun at its center," said Philipp Käfer, designer for Little Sun. "We wanted to bring the solar energy to the house, to show it in a poetic way for people to literally have this energy floating in their home."

"The collaboration with IKEA supports our mission to raise awareness for energy access and reminds us that we have the potential to co-shape our world." Olafur Eliasson, Artist & founder, Little Sun ■

Refurbishment Tool – Quickly Assists You in Finding the Right LED Solution

www.trilux.com

Due to lamp bans, high energy costs and ambitious sustainability goals, renovating inefficient conventional lighting solutions with LED lights is currently one of the most urgent and economically sensible tasks for companies. But how do customers quickly and easily find the right 1:1 renovation solution for their individual projects? TRILUX provides the answer with the TRILUX REFURBISHMENT TOOL.

Nowadays, most companies are aware of the fact that renovating their outdated lighting is necessary and can no longer be postponed. What most companies are struggling with now, is how to find the right solution for their project, especially regarding the efficiency, applicability and costs. That is why TRILUX developed the refurbishment assistant. This clever online tool supports customers in finding the perfect 1:1 renovation solution for their requirements. A special feature is the intuitive step-by-step process, which quickly presents the user with a suitable solution, even if not all lighting data of the old system is available. After just a few steps, customers can find out which solutions can be used to convert the existing lighting, including the individual savings potential. In addition, the software significantly reduces the planning effort compared to classic product research via online catalogues. The refurbishment assistant thus makes an important contribution to further accelerating the LED transformation.

SIMPLE AND EFFICIENT
THREE-STEP PROCESS WITH INTUITIVE USER GUIDANCE
The right renovation solution is determined in a three-stage process. In the first step, details of the existing system and future room use are queried (feature query). If the conventional luminaire comes from TRILUX, users can alternatively start directly with the TOC, TK or designation of the luminaire, whereupon the corresponding photometric data is automatically transferred to the system. The refurbishment assistant then suggests suitable series and luminaires for the project and immediately indicates the savings potential. At the end of the process, the selected luminaires must be validated again. Customers can save the results, compare them and transfer them to the TRILUX ONE online sales and service portal as an order list.

Thanks to the simple user guidance, the refurbishment tool can be used immediately and intuitively. In addition, TRILUX explains the basic functions of the tool in four short introductory videos. The approximately two-minute video tutorials can be found in the refurbishment section of the website.

TIPS UND TOOLS
EVERYTHING YOU NEED TO KNOW ON ONE SITE
For a transparent and efficient decision-making process, TRILUX has bundled everything around the topic of refurbishment in a separate website area at REFURBISHMENT. In addition to information on the legal framework (lamp ban, RoHS directive), users can find many clever tips and tools, starting with a renovation checklist and concrete calculation examples of practical references in a wide variety of applications. "Renovation affects industrial warehouses and municipal outdoor areas as well as offices, schools and supermarkets," explains graduate physicist Arno Eversmeyer (Lighting Applications department at TRILUX). He continues: "With our extremely broad portfolio, which has been extensively optimized to make it easy to renovate, we have the perfect solution for every case." Interested parties can also quickly and easily acquire the technical and legal know-how required for a refurbishment through the TRILUX AKADEMIE, for example with the digital planner updates. This two-hour online seminar provides cutting-edge expertise for legally compliant lighting planning. ■

Tridonic Launches First Matter-compatible Products for Lighting Controls

www.tridonic.com

What if you could control all your Smart Home or Smart Office devices such as floor lamps, Smart TVs and electronic door locks from a single app, either Apple or Google? A new connectivity protocol has brought us an important step closer to this vision. It's called Matter. Tridonic can now offer its customers the first Matter-compatible products.

Matter, the new open-source communication standard, bridges the gap between a smart ecosystem, such as Apple Home, and intelligent devices from various providers. Matter is the result of a joint initiative involving tech players such as Amazon, Apple, Google, and the Connectivity Standards Alliance (CSA). Today, around 270 companies from a wide range of industries are part of the Matter Alliance, all working to improve interoperability in the smart world.

Tridonic is committed to interoperability in the lighting industry:
Interoperability runs like a thread through Tridonic's research and development activities. As a provider of hardware and software for intelligent lighting, its commitment to the interoperability of lighting technology systems goes back many years. Among other things, Tridonic has played a major role in the development of the DALI-2 standard and has been offering the first LED drivers certified according to Zhaga Book 24 since 2022.

Matter now complements the proven DALI standard for wired lighting systems. With the support of the Matter protocol, Tridonic gives luminaire manufacturers a competitive advantage in smart lighting, enabling them to quickly develop Matter compatible luminaires that can be easily integrated in a wide variety of smart ecosystems – for example in offices, retail stores, hotels, holiday apartments and the high-end residential sector. Thanks to Matter-compatible elements, the entire atmosphere of a room can be set up with just a few clicks on a single device – everything from lighting to air conditioning including smart locks for opening and closing doors.

First wireless Matter drivers and Matter modules for DALI lighting systems:
Tridonic is one of the first manufacturers to offer Matter-compatible products. The following are available:

- Wireless Matter driver: Dimmable 24V constant-voltage driver available in 35W, 60W, 100W and 150W versions
- Active wireless Matter to DALI module: Active module with integrated 10 mA DALI bus supply and one momentary-action switch input
- Passive wireless Matter to DALI module: Passive module that requires a DALI power supply (power consumption: 4 mA), four momentary-action switch input
- Wireless Matter to DALI SR: With strain relief for robust installation and 50 mA integrated DALI power supply

The new Matter-compatible DALI modules can be connected directly to DALI LED drivers already installed in existing luminaires and can then control them. There is no need for any retrofitting work.

Here is a possible Matter use scenario: A smartphone with the respective app of the preferred ecosystem, such as the Apple Home app preinstalled on every iPhone, acts as a remote control and commissioning tool for the smart network. To add a Matter-ready device you point the smartphone's camera at

the QR code on the device. Quick and simple. A smart home device such as the Apple Home Pod mini or a Samsung Wireless Charger serves as the hub for Matter communication. It forwards the commands from the terminal device via a wireless mesh network to a lighting strip system which can "understand" the commands and translate them into the desired lighting mood thanks to the Matter intelligence integrated in the LED driver. Matter can communicate via both WiFi and Thread. Tridonic uses the IP-based Thread wireless protocol as the basis for the wireless mesh network. Compared to classic WiFi, Thread has a lower power consumption even with a large number of network nodes, and offers stable, low-latency data transmission with AES encryption. A simple command such as "Hey Siri, dim the lights in the office to 20 percent" is then all that is needed to control the LED lighting. ■

Casambi Launches Three New Wireless Lighting Control Products with Long-range Capabilities

casambi.com

Global smart lighting control company Casambi announced the launch of three new product variants – CBU-TED-LR, CBU-ASD-LR, and Casambi Xpress-LR – to offer long-range radio modes for robust wireless communication in vast spaces, outdoor applications, and certain complex lighting installations.

In 2022, Casambi introduced a new chip, the CBM-003, which enables new radio modes and longer ranges of up to approximately 200 meters (650 feet) in real-world applications. Based upon Nordic Semiconductor's nRF52840 SoC, this module offers lower energy consumption, greater memory for Flash & RAM, and supports the latest Bluetooth 5 specification to offer long-range and high throughput modes. This has now been incorporated into three Casambi Bluetooth Units.

CBU-ASD-LR: The CBU-ASD-LR is a Bluetooth-controlled, long-range control unit for any type of driver with 0-10V, 1-10V, or DALI dimming interface. This is available with either analog 0-10V (and 1-10V) or digital Standalone DALI control interface. With standalone DALI output, the CBU-ASD-LR acts both as a controller and power supply, making it possible to connect directly to an LED driver with a DALI interface. With this unit, it's possible to implement multi-channel lighting systems with adjustable color (RGB and RGBW) or color temperature (CCT), while keeping the wiring and the number of components to a minimum.

CBU-TED-LR: The CBU-TED-LR is a Bluetooth-controlled, long-range trailing edge dimmer for dimmable incandescent, halogen, LED lamps, and LED control gear. With this unit, any dimmable load can be easily converted to become a part of a Casambi mesh radio network. It can be installed behind a traditional wall switch, inside a luminaire, or into a ceiling outlet box. The CBU-TED-LR can also be converted to a mains-activated sensor device. When acting as a presence sensor, this device provides presence information to the mesh network when it is powered up.

Casambi Xpress-LR: The Casambi Xpress-LR is a Bluetooth-controlled, long-range user interface. This switch can be kept wherever the user needs it, providing direct access to all the important Casambi lighting control functionalities. It offers all the basic functions: Dim up, dim down, change color temperature in steps of 25 Kelvin, change indirect/direct ratio, control individual or luminaire groups, recall scenes and animations. Additionally, smarter functions, such as presets and multipurpose buttons, can be configured in the Casambi App.

'It's with great pleasure that we announce the availability of new long-range variants of our CBUs and wireless switch. If you are new to the idea, these are incredibly good options for introducing Casambi wireless capabilities to luminaires. This is about providing easy-to-deploy solutions for novel hybrid applications – vast sports facilities, parking lots, multi-building campuses, and more robust indoor/outdoor installations' says Kari Mettälä, Casambi CEO.

New network modes: Three radio modes are now offered by Casambi: 'Balanced', 'Better Performance', 'Long Range'. Long-range performance comes from two factors: Higher radio transmission power (now +8dBm instead of +4dBm), and use of a special (defined by Bluetooth 5 specification and supported in Nordic Semiconductor's microcontrollers) hardware feature to encode radio transmissions in an error-resilient way, paying with lower transmission speed for higher sensitivity (effective range) for receiving the signals. ■

New Photodiode Improves Performance in Visible and IR Light Applications

ams-osram.com

ams OSRAM (SIX: AMS), a global leader in optical solutions, has launched the TOPLED® D5140, SFH 2202, a photodiode that offers improved performance compared to existing standard photodiodes, including higher sensitivity to visible light in the green part of the spectrum, and increased linearity.

These improved features enable smart watches, activity trackers and other wearable devices to measure heart rate and blood oxygen saturation (SpO2) more accurately, by substantially reducing the effect of interference from ambient light, and improving the quality of the received optical signal.

Benefiting from various optimizations of the process technology with which the photodiode die is fabricated, the TOPLED® D5140, SFH 2202 achieves 30 times higher linearity in the infrared spectrum than standard photodiodes, according to ams OSRAM internal benchmarking. Laboratory characterization also shows substantially increased sensitivity at the green wavelength used for heart rate measurement in photoplethysmography (PPG) – a technique that tracks the peaks and troughs of light absorption by blood vessels.

When used in PPG systems, the highly linear TOPLED® D5140, SFH 2202 will enable manufacturers of wearable devices to achieve much higher accuracy in SpO2 measurements in conditions exposed to strong or fast-changing ambient light intensity. A typical example of such conditions occurs when the user runs or cycles through a dense

urban area and moves in and out of the shade thrown by tall buildings.

The TOPLED® D5140, SFH 2202's higher sensitivity to green wavelengths improves heart rate measurement by enabling the system to operate with lower LED light intensity, saving power and helping to extend battery run-time, while maintaining highly accurate measurements. The TOPLED® D5140, SFH 2202's specially designed package with black sidewalls minimizes internal cross-talk, further decreasing error in optical measurements and increasing the stability of heart rate measurements.

Florian Lex, Product Marketing Manager at ams OSRAM, said: 'Premium products in the wearable device market add value by providing vital signs measurements that the user can trust. By designing out the photodiode's high non-linearity, which impairs the operation of SpO2 measurement circuits, ams OSRAM is enabling wearable device manufacturers to differentiate their products and secure a higher premium positioning in the competitive market for active lifestyle technology products.'

The TOPLED® D5140, SFH 2202 photodiode is in volume production now. ■

Samsung Display and Ferrari Sign MOU to Bring Samsung OLED to Next-generation Models

displaysolutions.samsung.com

Samsung Display announced that the company has signed a memorandum of understanding (MOU) with Ferrari at Samsung Display's Asan campus in Korea to develop a display solution for implementation in Ferrari's next-generation models. JS Choi, President and CEO of Samsung Display, and Benedetto Vigna, CEO of Ferrari, attended the signing ceremony.

With this MOU, Samsung Display will develop an innovative automotive display solution befitting a luxury supercar brand with world-leading OLED technology in order to support the seamless digital transformation of Ferrari.

Over the past decade, Samsung Display has been leading the technology transition in the premium smartphone market from LCD to OLED. As an industry leader in the premium display market and pioneer of revolutionary OLED technology since 2007, Samsung Display is now actively targeting the automotive display market which is an important technology and business platform.

At CES 2023, Samsung Display unveiled its New Digital Cockpit with a 34-inch slim bezel display and bendable technology that creates 700R curvature during the driving mode.

The lightweight, slim structure and the thin bezel of OLED panels allow for high levels of design freedom and its true black and high-contrast capabilities satisfy the design needs of leading automakers. Moreover, OLED's low power consumption offers even greater benefits, since every watt saved improves the car's efficiency and sustainability.

"In the luxury sector, elevating the client's experience is key," said Benedetto Vigna, CEO of Ferrari. "Through this strategic partnership with Samsung Display for the dedicated development of bespoke OLED technology display solutions, we will make a significant step forwards in the digital environment of our next-generation models."

"Based on our extensive expertise in OLED technology, we are poised to introduce cutting-edge display solutions that meet the Ferrari standard," said JS Choi, President and CEO of Samsung Display. "We are certain that our collaboration with Ferrari will provide an exciting opportunity to apply our strengths to the supercar field and reinforce our position in the automotive OLED market, enabling us to reach ever new heights."

About Samsung Display
Samsung Display Co., Ltd. is an industry leader in providing cutting-edge display solutions around the world. The company diversifies its display markets to not only smartphones, TVs, laptops, and monitors but also smartwatches, VR, game consoles, and automotive applications. Furthermore, it has close partnerships with a variety of global manufacturers. Headquartered in South Korea, with a range of large-scale facilities, Samsung Display has production plants in China, Vietnam, and India, and operates sales offices in nine countries worldwide. Known for its innovation, Samsung Display is leading the foldable display market, enabling the world's first mass-production of OLED, endeavoring to develop next-generation technology such as high image quality QD (Quantum Dot)-OLED, slidable and stretchable panels to provide extraordinary experiences and endless possibilities for consumers. ■

UV-C LEDs: New OSLON® UV 3535 Mid Power Products

ams-osram.com

ams OSRAM (SIX: AMS), a global leader in optical solutions, has introduced the OSLON® UV 3535 series of mid- power UV-C LEDs which meet customers' requirements for longer lifetime, higher output power and easier system integration. The SU CULEP1.VC and SU CULDP1.VC UV-C LEDs in the OSLON® UV 3535 family from ams OSRAM are now available worldwide. Further information about UV-C treatment can be found here.

- New design reduces optical losses and optimizes radiation characteristics delivering outstanding wall plug efficiency
- New open package design with reflector and no cover glass and lens
- Standard 3535 surface-mount footprint and compact size for easy integration into system designs
- 275 nm typical wavelength is ideal for surface, air and water treatment in industrial as well as consumer applications

The OSLON® UV 3535 LEDs combine a compact design with leading efficiency and high quality, making them ideal for use in consumer or industrial applications such as water purification or air conditioning systems. These products show a typical output power of 40 mW at a drive current of 185 mA for the SU CULDP1.VC, and 75 mW at 350 mA for the SU CULEP1.VC.

The new package design with no cover glass and an integrated reflector improves the output by reducing optical losses and leads to a comparably high wall plug efficiency of 3.7%. The reflector collects the die's emissions and directs the light forward with a viewing angle of 120°. A standard 3.5 mm x 3.5 mm footprint and the absence of cover glass and lens give system designers the flexibility to apply a standard UV-C lens and to optimize the light output for their application.

A further advantage of the new OSLON® products SU CULDP1.VC and SU CULEP1.VC is an excellent, application dependent, lifetime. The package also includes an ESD protection device and a transparent dielectric coating as a protective element, contributing to the robustness of the LED.

Pia Weinmann, Senior Product Manager for UV-C at ams OSRAM, said: 'Manufacturers of UV disinfection equipment are competing to provide the most value to customers by producing the required disinfection dose with fewer and longer-lasting emitters. The OSLON® UV 3535 products offer a new competitive edge with their increased output power and lifetime.'

Technology innovation produces performance breakthrough The enhanced performance of the OSLON® UV 3535 LEDs is the result of innovations in package design and semiconductor technology. The new open package design is robust, compact and flexible for use in applications that require medium to high UV-C output power.

The AlGaN-based flip chip is a more reliable radiation source than traditional UV-C sources and provides flexibility in terms of wavelength,

output power and switching. The products are part of a strong performance roadmap to further enhance our position in the fast developing UV-C market.

The SU CULEP1.VC and SU CULDP1.VC UV-C LEDs in the OSLON® UV 3535 family from ams OSRAM are now available worldwide. ■

UV or not UV – The Benefits of UV LEDs

https://www.avnet.com

New Highly Efficient UV Optics for the UV-C Range from Asahi Rubber

www.lumitronix.com

The Japanese optics manufacturer Asahi Rubber recently introduced new UV optics especially for the UV-C range (280 nm). The silicone lenses named AL-10M-DUV280 (for LEDs of a size of 3.5 x 3.5 mm) and AL-20M-DUV280 (for LEDs of a size of 6.8 x 6.8 mm) were measured with the UV-C LEDs of the type NCSU334B from Nichia and subjected to an endurance test of 15000 hours, whereby hardly any loss of brightness and no damage could be detected. This underlines the high quality of the optics, whose light transmission is 90%.

The UV lenses AL-10M-DUV280 and AL-20M-DUV280 have a radiation angle of 10 and 20 degrees respectively. Other radiation angles are conceivable. The Japanese company is currently testing whether the good test results can also be reproduced at shorter wavelengths. The UV optics from Asahi Rubber can be used in various applications such as water treatment, air purification, sterilization of medical instruments and other areas. The highly efficient lenses are distributed in Europe only by the Swabian LED expert Lumitronix. ■

Avicena Partners with ams OSRAM – Ultra-low Energy Chip-to-Chip Interconnects

avicena.tech

AvicenaTech Corp., a privately held company in Sunnyvale, CA, has partnered with ams OSRAM to develop high-volume manufacturing of GaN microLED arrays for its industry-leading LightBundle™ communication architecture.

The need for next generation computing power is here, driven by strong AI/ML and HPC application demand – for products like ChatGPT, DALL-E, autonomous vehicle training, and many others. Attempts to scale current architectures are running headlong into physical limits leading to slower throughput growth, power-hungry and hard to cool systems. The Avicena LightBundle architecture breaks new ground by unlocking the performance of xPUs, memory and sensors – removing key constraints of bandwidth and proximity while simultaneously offering an order-of-magnitude reduction in power consumption.

"Avicena's LightBundle technology provides an opportunity for GaN microLEDs to impact numerous key applications including HPC, AI/ML, sensors, automotive and aerospace. As a global leader in GaN LEDs, we are excited to partner with Avicena to transform these very large and important markets."

— ROBERT FEURLE, EXECUTIVE VICE PRESIDENT AND MANAGING DIRECTOR, OS BUSINESS UNIT AT AMS OSRAM:
"We acquired our fab from Nanosys in October to accelerate our development efforts and support low-volume prototype manufacturing," says Bardia Pezeshki, founder and CEO of Avicena. "However, we are addressing very sizeable markets requiring high-volume manufacturing. We are very pleased to partner with one of world's top GaN LED companies to provide a path to satisfy the expected high volumes required by our customers, including hyperscale datacenter operators and the world's leading IC companies."

"Avicena's LightBundle technology provides an opportunity for GaN microLEDs to impact numerous key applications including HPC, AI/ML, sensors, automotive and aerospace," says Robert Feurle, Executive Vice President and Managing Director, OS Business Unit at ams OSRAM. "As a global leader in GaN LEDs, we are excited to partner with Avicena to transform these very large and important markets."

About the Technology:
Today's high-performance ICs use SerDes-based electrical links to achieve adequate IO density. However, the power consumption and bandwidth density of these electrical links degrade quickly with length. Conventional optical communications technologies developed for networking applications have been impractical for inter-processor and processor-memory interconnects due to their low bandwidth density, high power consumption, and high cost. Moreover, co-packaging existing laser sources with hot ASICs does not fit well for reliability reasons unless external laser sources (ELS) are used which increases complexity and cost.

Avicena's LightBundle™ links use densely packed arrays of GaN microLEDs to create highly parallel optical interconnects with typical throughputs of > 1Tb/s at energies of < 1 pJ/bit. A LightBundle cable uses a highly multicore multimode fiber to connect a GaN microLED transmitter array to a matching array silicon photodetectors (PDs). Arrays of hundreds or thousands of LightBundle's microLEDs and PDs are easily integrated with standard CMOS ICs, enabling the closest integration of optical interconnects with

electrical circuits. In addition to high energy efficiency and high bandwidth density, these LightBundle links also exhibit low latency since the modulation format of the individual links is simple NRZ instead of PAM4 which is common in many modern optical links but has the disadvantage of higher power consumption and additional latency.

The parallel nature of LightBundle™ is well matched to parallel chiplet interfaces like UCIe, OpenHBI, and BoW, and can also be used to extend the reach of compute interconnects like PCIe/CXL, HBM/DDR/GDDR memory links, as well as various inter-processor interconnects like NVLink with low power and low latency.

About Avicena:
Avicena Tech Corp. is a privately held company located in Sunnyvale, CA, developing LightBundle, a next generation computing architecture for AI/ML, HPC, sensors, 5G wireless and aerospace applications. This unique, flexible ultra-low energy technology is based on microLEDs, offering both very high bandwidth and low latency. Now, system designers can disaggregate functions like compute and memory and radically grow system throughput. Avicena's technology is a key building block in the evolution of networking and computing that will reduce the energy impact on our planet. ■

DALI Lighting Awards 2022

www.dali-alliance.org

The DALI Alliance, the global industry organization for DALI lighting control, has revealed the winners of its prestigious DALI Lighting Awards 2022.

The standard of entries within each of the eight categories was exceptionally high, and the awards recognize the best use of DALI lighting control applications and solutions around the globe. The international judging panel of lighting designers, lighting magazine editors, and representatives from global lighting organizations picked eight projects as well-deserved winners. Further information about all the winners and commended projects is available on our website at www.dali-alliance.org/awards2022.

The winner in the Architectural & Entertainment category is Tridonic Middle East, for its work on the Expo 2000 entry portals in Dubai, UAE. The lighting system used dynamic color mixing to provide the desired effects in the vast portals, which are 21m tall, 30m long, and 10.5m wide. DALI was used due to its advanced dimming and daylight sensing features, interoperability, and its ability to reduce maintenance costs.

The Healthcare & Education award went to Delmatic, for its work at University College London (UCL) Hospital in London, UK. DALI lighting management systems extend throughout the hospital's 34,500m2 building, which comprises six floors above ground and five below. The energy-efficient DALI system manages and monitors around 17,500 DALI assets, and incorporates comprehensive DALI emergency light testing and monitoring.

Synapse Wireless triumphed in the Industrial category for its work on the Uline Store C6 project in Ontario, California. Lighting for the 1 million square foot warehouse is all controlled from a single lighting dashboard with lights responding to commands in less than a second. DALI was chosen due to the rich features of the D4i LED drivers, which provide asset management and power monitoring. In turn this allows the customer to achieve energy rebates and meet strict energy codes.

Delmatic also won the Infrastructure category for its work on the Elizabeth Line, a new 118km high-speed rail network in London, UK. This is Europe's largest infrastructure project, and uses more than 35,000 DALI assets to illuminate the stations. DALI optimizes efficiency, safety and aesthetics, while providing the flexibility and versatility needed to meet the stringent and complex lighting requirements of the project.

The winner of the Outdoor category is Signify for its street lighting renewal project in Algeciras, Spain. A total of 5,600 light points have been updated throughout the city, and technicians can now remotely control Zhaga-D4i luminaires from multiple manufacturers with a single control system. The new LED lighting system has enabled the city to cut its energy usage by more than 50%, a reduction of 1261 tons of CO2 per year and a saving of almost half a million euros.

Sunricher won the Residential category for its work on the Taiziwan High-end Building in Shenzhen, China. The building has 33 floors and a total of 158 households, and uses a DALI lighting scheme connected with a KNX bus control system for intelligent building control. DALI can individually control or flexibly group different lighting units on the DALI bus. DALI was chosen for its easy management, straightforward installation, and accurate, stable and smooth dimming control.

Delmatic completed its triple success with the Retail & Hospitality award, for a project at Battersea Power Station in London, UK. Delmatic's DALI-2 lighting system integrates control of normal, specialist and emergency lighting across the project. Lighting scenarios can be configured to precisely suit the individual requirements within the various spaces. DALI was chosen due to its flexibility, energy efficiency, emergency lighting capabilities, and dimming and color control.

Finally, the Workspaces category was won by Bluebottle, for its work on the 83 Pirie Street offices in Adelaide, Australia. This involved around 9,000 DALI devices in the 22-level office tower, with DALI used for the control of all light fittings. DALI was selected due to its flexibility and ease of wiring; bringing all assets onto the DALI bus greatly reduced the wiring complexity, and offered cost savings over traditional bus systems. ■

Direct Current (DC) Power Solutions for LED Lighting Systems

www.acuitybrands.com

Our built environment plays a crucial role in determining the quality of energy we consume. As the nation invests in grid modernization and resiliency, there is a growing emphasis on electrification, renewable energy integration, and carbon reduction. With this, Direct Current (DC) power is key to easily connecting our buildings to renewable resources and energy storage batteries.

While Alternating Current (AC) has traditionally dominated our built environment, the use of DC power is rapidly expanding. From renewable energy sources and electric vehicles to mobile devices and IT networks, DC power is already prevalent and continuing to grow. Converting AC to DC power results in efficiency losses and potential failure points for connected devices and systems. However, direct DC power connection to renewable energy sources, combined with DC-powered building systems, has been proven to generate significant energy savings compared to AC-powered buildings. Recognizing the potential of DC power, the US Green Building Council has introduced a LEED® credit for Direct Current Power Systems and consideration for DC-powered systems under its LEED Zero certification.

Acuity Brands' innovative DC2DC architecture provides a distributed DC power solution for LED lighting systems, revolutionizing their efficiency and sustainability. By eliminating the need to convert AC to DC power at the luminaire, the architecture reduces energy losses and enhances the reliability of lighting systems. This not only lowers maintenance and operation costs but also contributes to overall energy savings and sustainability goals. The DC2DC architecture is ideal for new construction spaces like classrooms, where both energy efficiency and occupant comfort and well-being are critical factors. It allows for up to 16 lighting zones or up to 8 lighting zones with tunable white, which promotes an intellectually stimulating and comfortable environment, aligned with key classroom activities.

Energizes lighting design for student and teacher well-being: The DC2DC architecture's control cabling and DC powered LED drivers provide native support for tunable white applications enabling the creation of scenes and modes that can be aligned with key activities during the day.

Empowers flexible lighting control design and "flex space" configuration: Luminaires can be individually controlled or grouped in zones, and installation time can be further reduced by leveraging embedded occupancy and daylight sensors within luminaires. Classroom spaces can be reconfigured, and lighting control zones customized, without the need and cost of rewiring.

Reduces materials and installation hours and facilitates maintenance: Utilization of Class 2 low voltage DC wiring eliminates the need for power packs, junction boxes, and conduit to luminaires, providing reductions of both materials and related installation hours, and contributing to a reduction in construction carbon footprint. The DCHUB is a single point of AC to DC power conversion and luminaire control interface, reducing points of maintenance.

Integrates for a unified building approach: The DC2DC architecture can be used within a hybrid implementation of DC and AC powered lighting systems within one building. It is part of a unified platform through nLight networked controls, enabling building-wide control and lighting strategies. ■

NICHIA Stages Roadshow to Celebrate the Commercialization of High Brightness Blue LED

www.nichia.co.jp/en/

NICHIA, the world's largest LED manufacturer and inventor of the high-brightness blue and white LED, announced an extensive international roadshow. As part of the 30th-anniversary of the high brightness blue LED pioneered by NICHIA, a series of must-attend events for customers, partners and influential lighting professionals will be staged across Europe including dedicated roadshow meetings in Germany, Spain, Italy and other European locations.

The roadshow started on 9 May in Frankfurt am Main area in Nichia's office in Kronberg, Germany, with specific business representatives and invited partners in attendance. The tour continues in other European cities with specific events scheduled in Barcelona on 31 May, Hechingen on 21 June, and Milan on 28 June.

Nichia, together with key local European partners, will deliver an immersive experience to key customers by telling the story of high brightness blue LEDs. Besides interactive workshops, roundtable discussions and conference-style presentations with an expert panel of speakers, the events will also allow luminaire manufacturers, lighting designers and Nichia's representatives and sales partners to network, observe product demonstrations and discuss Nichia's world-leading innovations and current lighting trends in person.

The invention of the high brightness blue LED has contributed to many significant advances in Solid State Lighting. Nichia has pushed the boundaries of its technology further over the past 30 years with continuous product innovation. Presentations in the roadshow will focus on a range of key lighting applications including the use of high efficacy, high color quality and sustainable lighting in retail stores.

Case studies will also be presented such as how spectrum and color tunable lighting technologies boost the well-being of occupants in health and hospitality venues as well as office workspaces. There will be a "light experience" space where visitors to the roadshow can experience the latest technological innovations in the field of LED and Human Centric Lighting.

Dr. Ulf Meiners, Managing Director, NICHIA Europe GmbH, said: "The objective of this roadshow is to introduce our class-leading technologies and products to our customers and provide a highly engaging experience. We will not only introduce the latest products but also have technical experts on hand to educate attendees face-to-face."

"We always strive to communicate directly with our customers – they shape our future, and our purpose is to help them succeed in realizing their designs and meeting functional requirements. The team are looking forward to hitting the road, forging closer ties with our key stakeholders and meeting even more customers face-to-face." ■

Webinar: Mimicking Daylight Indoors – Why, What, How?

www.led-professional.com

The Good Light Group, together with the Society for Light Treatment and Biological Rhythms (SLTBR), the Daylight Academy (DLA), the International Association of Lighting Designers (IALD), and Luger Research (LR), are organizing and presenting the "Mimicking Daylight Indoors – Why, What, How?" lectures on May 16th, 2023 from 04:00 PM - 05:30 PM (CEST). The webinar explains the need for daylight and how we can use this knowledge in lighting designs.

Lecture: "Daylight – See Me, Feel Me, Touch Me, Heal Me!" by Professor Yvonne de Kort, Technical University Eindhoven, The Netherlands. Our technological tools to create indoor electric light are ever advancing, and yet in virtually every context there seems to be nothing better than "the real thing". In my presentation I will review the scientific evidence for the importance of daylight and sunlight indoors for human health and wellbeing, and the different mechanisms through which these effects (may) emerge. We hope this may inspire architects and engineers to design for even better daylight access and perhaps even better electric lighting solutions.

Lecture: "Daylight in Buildings – How Much We Need and Get" by Johannes Zauner, PhD, Munich University of Applied Sciences, Germany. Designing spaces with optimal daylight levels is crucial for maintaining a healthy circadian rhythm. However, the typical indoor environment falls short of recommended (day)light levels for optimal health. In this talk, the speaker will showcase real-world projects that successfully optimized daylight levels during the design phase and integrated artificial lighting to boost light levels during winter. Attendees will gain insights into why quantitative daylight optimization at the very beginning of a project saves money and leads to better interior spaces. ■

More Sustainable Lighting Solutions – Hugo ROHNER, Chief Executive Officer, Tridonic

Hugo ROHNER:
"Sustainability has always been a fascinating topic for me. It is something that Tridonic focuses on and it makes a difference."

Tridonic, a company of the Zumtobel Group, was founded in 1956 in Dornbirn, Austria. For over 60 years, the company has been a driving force in the development of professional lighting solutions. Today, Tridonic is a world-leading provider of lighting technology for professional applications in offices, retail, hotels and gastronomy, education, industry, outdoor lighting sectors, and much more.

www.tridonic.com

LED professional: **We are delighted to have the opportunity to conduct this interview with you. To start, can you give us a review of your career?**

Hugo ROHNER: I grew up in St. Gallen, Switzerland, where I live today. I got my Master's Degree in Business Science from the University of St. Gallen in 2000. I spent a few years as a management consultant before joining a company involved in security technology as head of the controlling department. Then I had what you could call a classical 'finance career' over the next ten years. That led me to Germany and the US before becoming the CEO of SKIDATA, an Austrian access control company located in Salzburg. My start at Tridonic was in May 2020, and this date also marks my entry into the lighting industry.

LED professional: **Now let's talk about Tridonic. Could you briefly tell us about the company's history?**

Hugo ROHNER: Tridonic represents the original business of Zumtobel, starting in 1956 with developing and producing magnetic ballasts. Since then, Tridonic has always been there to make light work. Our specialization in electronics for lighting led us early on to digital technology. In 1991, we already brought digitally dimmable ballasts to the market. The technology behind it served as the basis for the worldwide DALI standard[1], which became a daily business for the entire lighting industry. We had early LED activities from 2007, although we must admit that our business with LED only took off later.

After the LEDification period, we stepped very quickly into connectivity. Today our system solutions are designed for connectivity applications. At the same time, we provide standard products with drivers and light sources. Currently, we are in our next evolution phase, which is sustainability. We can build on many years of ecological orientation within our company and successfully implement measures, which we will now strategically combine and consistently expand.

LED professional: **Could you explain how Tridonic is integrated in the Zumtobel Group.**

Hugo ROHNER: We are a proud member of the Zumtobel Group[2], but we are independent in that we do most of our business – more than 80% - outside of the Zumtobel Group. The Tridonic research department is entirely separate. Since our products go into luminaires, and Zumtobel is one of the companies making luminaires; obviously, we also sell to competitors of the Zumtobel Group, something that we have been doing for many years. Tridonic products were necessary to start up the Zumtobel Group, and the Zumtobel Group quickly realized that this was something for everyone in the market. We have worked within the Zumtobel Group as an independent company serving customers worldwide for many years.

LED professional: **What are the major product groups Tridonic offers to the market?**

Hugo ROHNER: Our main business is drivers[3], whether they are regular drivers or the emergency version. That makes up more than half of our business. Then we have quite a significant LED module[4] business. The modules match perfectly with our drivers and allow our customers to have a complete technological delivery from us. Then we have controls, which include sensors, and many other things, which is a robust third group. With the intelligence going into the systems, software becomes much more critical. The software allows control and adding features. But we consider the software part of everything we do, and it's generally integrated into complete systems.

LED professional: **The product groups can be sold independently, but are there also packages?**

Hugo ROHNER: The best way to look at that is with the Human Centric Lighting for everything related to modules. We pair these modules with the correct drivers. If a client wants a package, we will happily provide that, including the modules, drivers, sensors, and emergency units, fitting perfectly together.

[1] DALI Alliance https://www.dali-alliance.org

[2] Zumtobel Group https://z.lighting/en/

[3] Tridonic LED Drivers https://www.tridonic.com/en/int/products/led-drivers

[4] Tridonic LED Modules https://www.tridonic.com/en/int/products/led-modules

LED professional: Where is Tridonic located globally?

Hugo ROHNER: The headquarters is in Dornbirn[5] and has an adjacent factory. The largest factory is in Nis, Serbia, and the second is in Shenzhen, China. Furthermore, a Spennymoor, UK factory specializes in sensors and emergency gears. In all of these locations, we also have specific R&D centers. In addition to that, our R&D center for software is in Porto, Portugal. Although our main business is in Europe, we are well placed in China and Australia, the Emirates, South Africa, Turkey, and the US.

Our Chinese factory focuses on products mainly for the Asian market. The Dornbirn factory focuses on premium product lines – more advanced products. And Nis is for the mass market in Europe. Almost all standard LED models are produced in Nis.

(left, middle) LED modules from Tridonic's Activating Light family support well-being and concentration at work thanks to their special color spectrum.
(right) The new premium driver from the GEN4 platform with its 220 W output is designed for use in harsh environments, especially in industrial applications.

LED professional: How important is cooperation with other business and technology partners?

Hugo ROHNER: We are specialized in energy efficiency for drivers and modules, including advanced sensors and controls. We cooperate with companies in technology fields such as cameras or sensors that measure parameters that the lighting industry traditionally hasn't been interested in – like air quality.

It could be an almost final product that we integrate, or it could be an idea that we develop together with a partner.

[5]Tridonic GmbH & Co KG, Färbergasse 15, 6851 Dornbirn, Austria

There is a lot of knowledge out there that our customers can benefit from, and even though Tridonic has a significant size, we know we will never be able to do everything ourselves. We can't be specialists in everything, so we like concentrating on what we do best and getting other inputs from the outside. For example, we brought our latest ASIC on the market one and a half years ago. Developing specific ICs with partners shows how we collaborated closely with companies specializing in crucial technologies.

LED professional: Does Tridonic work in the Artificial Intelligence (AI) field for lighting solutions?

Hugo ROHNER: There are many use cases for AI. The most obvious one is if you look at how energy is used in buildings. We can use AI to help us understand better when light is required and at what level. We strongly invest in understanding drivers under stress to do preventative maintenance. And we are using AI to become better, ourselves.

LED professional: We also want to congratulate you on your recent DALI lighting award.

Hugo ROHNER: Thank you very much. We are extremely proud. The "Best in Category Architectural Lighting Award" was for a project we did with customers in Dubai. It was for the entrance portals of the Dubai Expo in 2021. It was about creating a particular lighting atmosphere for these entry portals. They used our DALI drivers and created a lighting scene via tunable white. The judges were impressed by the simple but highly effective lighting design of the structure and the exemplary use of DALI tunable-white control. It shows that the Tridonic collaboration with our customers works very well.

LED professional: Why did Tridonic focus on sustainability maybe more than others?

Hugo ROHNER: Sustainability is part of Tridonic's DNA. For example, we pioneered the Environmental Product Declaration EPD, which we have been issuing since 1998. They record the impact of a product on the environment during its entire life cycle: Starting with the extraction of raw materials, through production, transport, installation and operation, through to disposal. We want to be one of the players who lead the lighting industry to sustainable structures - actively and as thought leaders. The topic may seem new to Tridonic, but in fact we already have some experience and expertise in the area of sustainability. However, it is typical that we first build up our know-how, implement methods and when everything works, we also talk about it. This is also true for implementing the cradle to cradle concept. We are not the first in our industry to talk about it, but as you say, probably the first to implement.

We have now combined our activities, plans and goals into our Sustainable Tridonic strategy and are tackling issues such as circular economy even more strongly and systematically. We should not procrastinate when it comes to protecting our planet.

LED professional: Sustainability and eco-design seem to be highly important for Tridonic.

Hugo ROHNER: The whole topic of sustainability has become more critical over the past couple of years, but Tridonic has always had this base DNA. Before it was even required, Tridonic had EPD for all our products. We decided two and a half years ago to focus more on reusing material at the end of the product's life. That topic has always fascinated me; I recognized it could make a difference.

We built a separate team to ensure focus and involved all departments to get traction. We started with LED modules that are produced in Nis. Having certifiable products is an enormous step – and having them certified is the next step. The certification is essential since we create most of our goods in Europe. It shows that for us, sustainability is a core message. Ultimately, we want to be able to give our customers all of the basics for a green luminaire.

LED professional: What was necessary to change or adapt during that process?

Hugo ROHNER: Especially materials that had an issue when it came to being recycled. How could we change them, adapt them and understand them? How could we work with our suppliers in that the materials they use correspond with how we want to reuse them? It's a com-

plete understanding of the value chain. And, of course, our way of thinking also had to change. We had to decide what was essential and what was vital.

LED professional: Are there still RFPs and RFQs that ask for an eco-design product?

Hugo ROHNER: There are a lot. The question is, how do they measure it? Also, eco design does not have the same relevance in every country yet. But we've had a couple of customers that have contacted us and asked if we could help them with drivers and other products and how we did things in the field of eco-design. Talking to our customers, we have learned that they need to have greener products that are sustainable so that they win the RFQs they are facing. Cities especially want to know what the CO_2 footprint is and how recycling works. So there is a slight push in that direction by end customers. And it will get stronger.

LED professional: Let's take a deeper look back into the development of the lighting sector. How would you summarize the last decade of the lighting world?

Hugo ROHNER: Nowadays, in professional lighting, LED is standard. Conventional and energy intensive products are step by step banned in the EU which gives a clear guideline with the direction to energy efficiency and, of course, CO_2 reduction. Based on this groundwork, connectivity is now on the agenda. With the help of connectivity, we can make lighting even more efficient and can also use and control light more precisely.

And beyond lighting we see that via connectivity our industry is moving closer to other trades and services. For example, in the connection to building management systems or building information systems as well as smart cities. This is because lighting has omni presence with power supply and serves as a backbone for a smart infrastructure indoor and outdoor. Coming back to lighting application, we had enormous progress in managing lighting color temperature and control light, in general, during the last decade.

Looking forward I think we will discover and shape a new role for light in buildings and outdoor applications. New Ecosystems will be derived and new collaborations will be established. The lighting industry is finding, shaping, embracing and expanding this new role.

Tridonic thinks of itself as a thought leader and already builds new ecosystems – a current example is the Connectivity Standards Alliance, CSA, where together with big players we participate in establishing the new connectivity protocol "Matter"[6]. This is a cooperation with partners beyond lighting.

LED professional: Today, we talk about some significant lighting trends, namely Human Centric Lighting, Sustainability with Circular Economy, Intelligent/Data-Controlled Lighting, and Energy Efficient Lighting Solutions. Which trends are most important for Tridonic?

Hugo ROHNER: For us, digitization is the overarching theme that supports activities to improve sustainability as well as the implementation of a circular economy. In addition, digitization, is of course, at the forefront of all system solutions for smart buildings and smart cities, both as a requirement for us and as a means used, and as a prerequisite for connectivity.

At Tridonic, we have set ourselves the goal of gearing our activities towards mitigating the consequences of climate change and tackling far-reaching change processes and putting our technological expertise at the service of sustainability. We want to rethink production completely new: circular economy is currently implemented by following the cradle to cradle (C2C) concept. The basic idea of C2C is modelled on nature, which, as we know, produces no waste. The goal of the C2C concept is to close the cycle of resource use.

The other points such as energy efficiency and data management have been part of our daily agenda for some time and continue to play a major role. Software is playing an increasingly important role, both in production and as embedded software in our controls devices and as user apps for our customers and end customers out in the field. Apps make the sophisticated lighting systems easy to use. All this pays off on the following factors:

- Lighting must serve human beings and their well-being must be the base.
- Efficiency of lighting systems has improved a lot and should also go without saying


CERTIFIED
cradle to cradle
BRONZE

Tridonic GmbH & Co KG

has successfully achieved Cradle to Cradle Certified® Bronze for the product(s) under the name:

CLE, LLE and QLE LED Modules

CLE, LLE and QLE LED Modules manufactured at Tridonic SRB d.o.o.

Certification Number
5527

Standard Version
3.1

Lead Assessment Body
EPEA GmbH - Part of Drees & Sommer

Material Health Assessment Body
EPEA GmbH - Part of Drees & Sommer

Effective Date
01 August 2022

Expiration Date
30 June 2024

President & CEO
Cradle to Cradle Products Innovation Institute

See the Cradle to Cradle Certified Product Registry at www.c2ccertified.org for additional details
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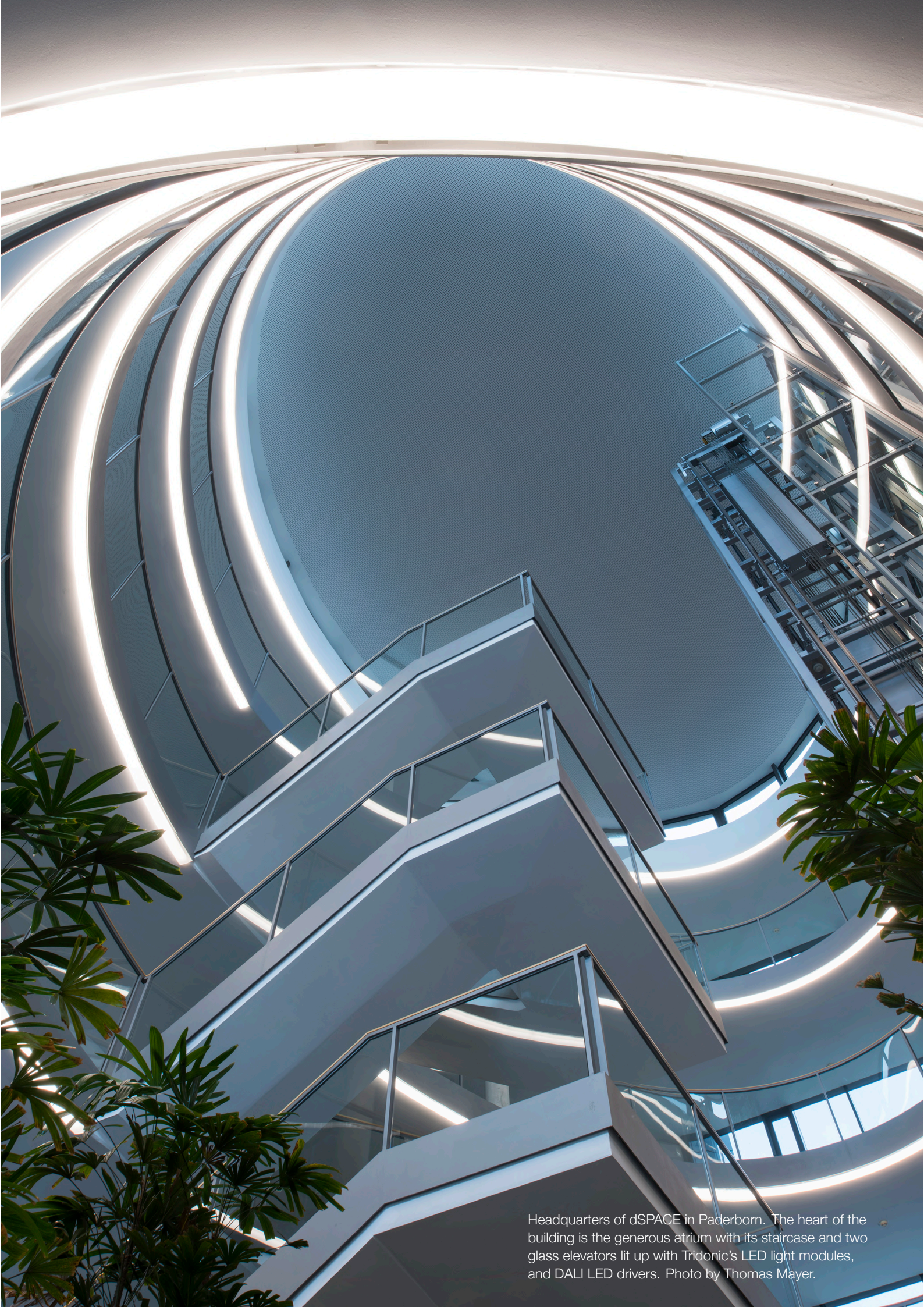
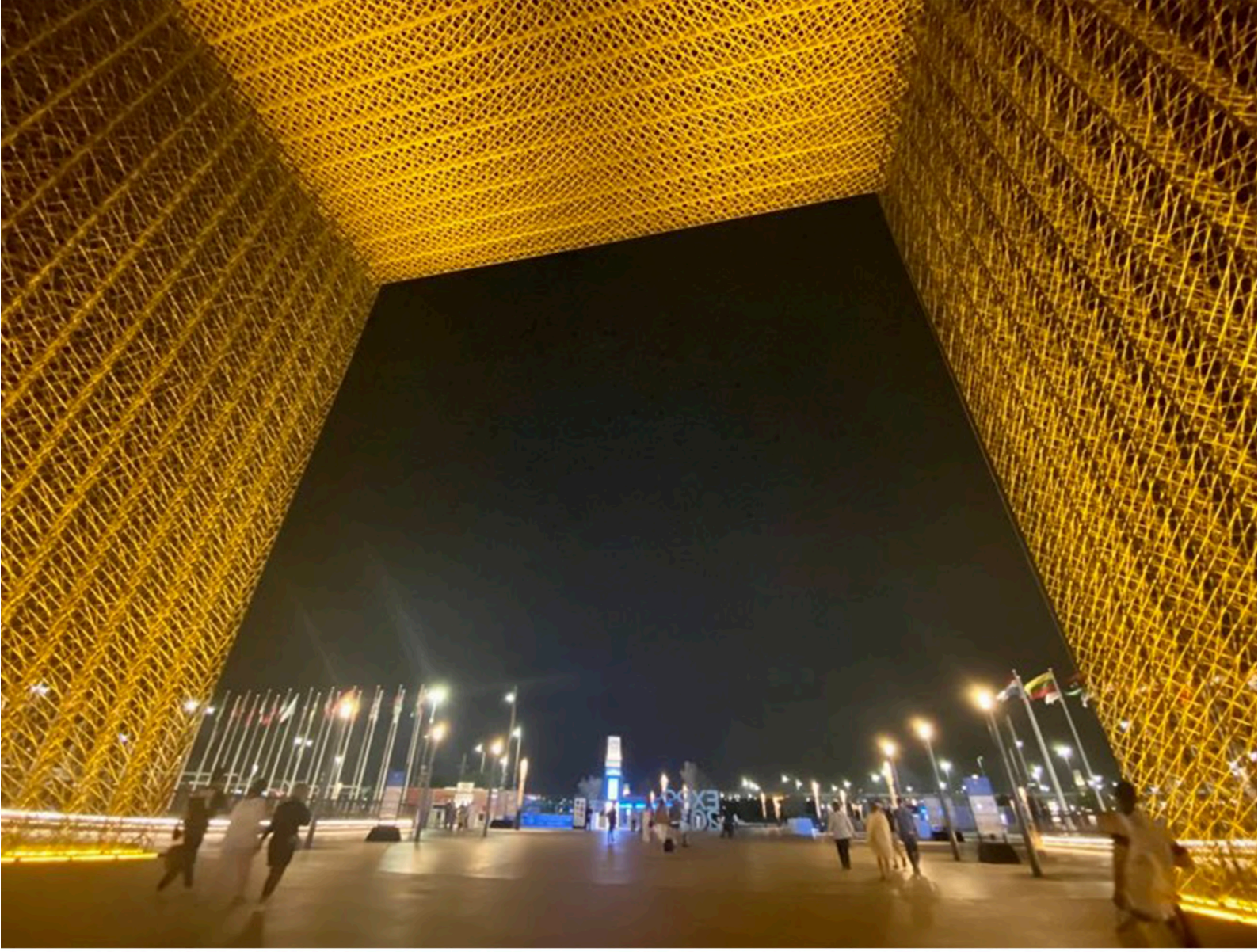
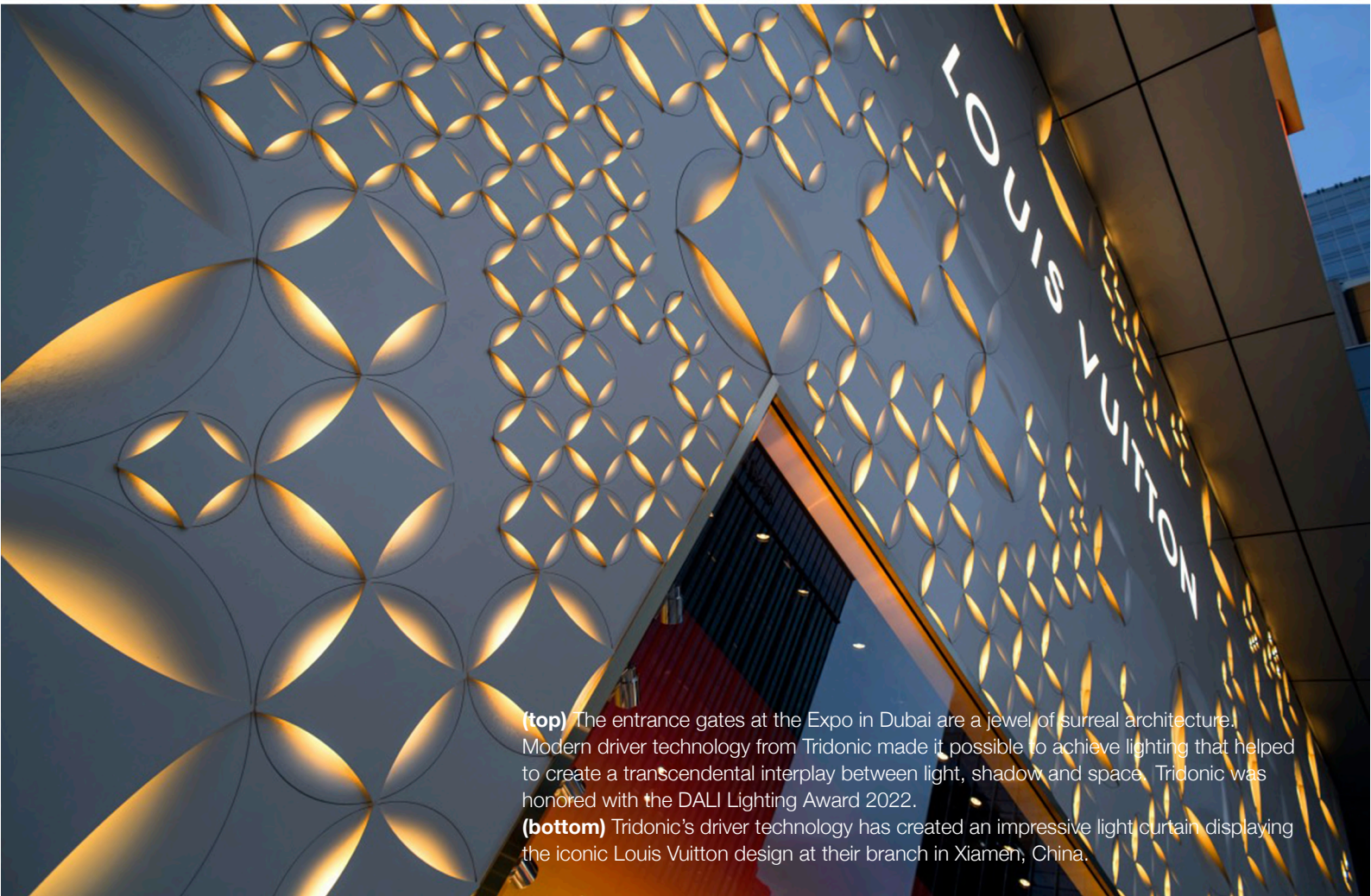
[6] Connectivity Standards Alliance https://csa-iot.org/all-solutions/matter/

Tridonic supplied more than 5,000 LED drivers to provide light-on-demand in the terminal of the new Beijing Daxing airport.



Headquarters of dSPACE in Paderborn. The heart of the building is the generous atrium with its staircase and two glass elevators lit up with Tridonic's LED light modules, and DALI LED drivers. Photo by Thomas Mayer.





(top) The entrance gates at the Expo in Dubai are a jewel of surreal architecture. Modern driver technology from Tridonic made it possible to achieve lighting that helped to create a transcendental interplay between light, shadow and space. Tridonic was honored with the DALI Lighting Award 2022.
(bottom) Tridonic's driver technology has created an impressive light curtain displaying the iconic Louis Vuitton design at their branch in Xiamen, China.

Discussion with Hugo ROHNER, CEO of Tridonic, in the offices at the headquarters in Dornbirn, Austria.

LED professional: Intelligent lighting, connected lighting and data management are also getting more important. How does Tridonic deal with these developments?

Hugo ROHNER: I fully agree when you say these points are getting more important. Of course, our daily business that brings us the resources to invest in new technologies is also very important. This means we must take care for further developing, improving, producing and delivering standard drivers and modules but at the same time being active and gaining know-how in intelligent lighting and data management for smart buildings and smart cities.

We are successful with new lighting management systems indoor and outdoor and had some great projects with new partners – which of course take long-term engagement. Along with this we expand our software development. Our competence center in Porto has developed excellently and has taken a crucial role in our R&D. We put a lot of effort in understanding the pain points of our customers, installers and end users. This is key to successful projects.

LED professional: Where do you see Tridonic in 5 years?

Hugo ROHNER: We will keep our role as a reliable and trustworthy partner for our luminaire manufacturer customers – not only with products but also with support for new technologies, trends and business developments.

- Our concept of sustainability will be proven.
- Tridonic will be a constitutive partner in new ecosystems.
- We will have increased knowledge as a company to be technology leader further-on.
- Digitization will be integrated in our daily business.

LED professional: How do you manage Tridonic, the people and the teams?

Hugo ROHNER: The critical point is to listen to people and ensure they are central to our actions. The power of Tridonic is its products and its people. The products are a deviation from what the people can do. So that's very, very important. Looking at a company like Tridonic that produces worldwide also means balancing the cultures. This means helping people from different cultures to communicate effectively with their colleagues.

LED professional: Thank you very much for the detailed interview, and we wish you, your team, and Tridonic continued success!

Hugo ROHNER: It was great talking to you. Thank you very much. ■

About Tridonic

In the 2021/22 business year, Tridonic generated sales of Euro 365 million. 1,869 highly skilled employees and a worldwide sales presence in over 70 countries reflect the company's commitment to the development and deployment of new, smart and connected lighting systems.

For additional information please visit https://www.tridonic.com.

TRIDONIC

SILVER 2023 ecovadis Sustainability Rating

Tridonic has been awarded the EcoVadis Silver Medal for sustainability activities. Its overall rating places Tridonic in the top four percent of companies in the lighting industry.

Lighting Control for Food Production

Alexander GERFER, Johann WALDHERR, and Harun ÖZGÜR from Würth Elektronik eiSos

Vertical farming is an approach to water and space-saving production in the face of growing food demand and dwindling agricultural land. This requires efficient lighting, which can be easily implemented with the Lighting Development Kit from Würth Elektronik eiSos.

AUTHORS

Alexander GERFER is Chief Technology Officer at Würth Elektronik eiSos. (top)
Johann WALDHERR is Business Development Manager for Horticulture LEDs at Würth Elektronik eiSos. (middle)
Harun ÖZGÜR is Executive and Head of eiPal Optoelectronics & Additive Manufacturing at Würth Elektronik eiSos. (bottom)

Edited by Gerhard Stelzer.

Humanity is facing numerous challenges. By 2050, the world's population is expected to rise to nearly ten billion people. At the same time, extreme weather phenomena such as prolonged droughts, severe storms with hail or flooding are increasing as effects of climate change. Soil surface sealing is leading to loss of agricultural land, and resources such as water and nutrients can be in short supply. New solutions are needed to ensure food security in the future.

Controlled Environmental Agriculture (CEA) is one such solution that is helping to supplement traditional agriculture. Indoor Vertical Farming is a form of this cultivation method in which plants are cultivated under optimal conditions. Horticulture LEDs provide light in the exact wavelengths that the plants need. By cultivating in several levels one above the other, it is possible to achieve more yield in the same area and save space (**Figure 1**).

Closed water and nutrient cycles also make better use of resources. Cultivation in the middle of the city allows harvesting at the right time, which results in a higher nutrient content of the plants. This also results in significantly shorter transport distances. In this way, CO_2 can be reduced and transport losses avoided. Vertical farming enables cultivation anywhere in the world, is independent of weather conditions and ensures the same plant quality everywhere. There are many factors that influence vertical farming, including temperature, irrigation, CO_2, nutrient availability, humidity and light. Indoor vertical farming was first made possible by LEDs.

Driving Innovation in Vertical Farming

Würth Elektronik not only offers horticulture LEDs, but also actively advances their most beneficial applications. Besides having our own plant scientists doing research, the team also provides numerous tools for developers. Various application notes provide a good primary biological and electrical knowledge overview of basic plant lighting topics. An important tool is the "Horticulator", a module of the online simulation tool REDEXPERT. With it, Würth Elektronik provides support in calculating your own light spectra and selecting the right LEDs for the individual applications. The Lighting Development Kit helps developers with lighting control.

Lighting Development Kit

The Lighting Development Kit provides a simple solution for mixing RGBW colors for different lighting situations or enhancing plant growth with the Horticulture Panel. Additionally, it includes a "Sunshine Panel" for indoor lighting in the spirit of Human Centric Lighting. The MagI³C multi-color LED driver can power all panels. With four MagI³C LED Step-Down High-Current modules as the core, it is possible to control the color by the intensity of each of the four LED channels individually to meet the requirements of the application.

Control is provided via an app for iOS and Android to control the reference design via Bluetooth® LE. The board includes an EMI filter to meet the limits of the EN55015 standard for conducted lighting and the CISPR32 standard for radiated EMC (tested with 1 m output cable length) even when dimming the LED channels.

Lighting Curtain Design

The Lighting Development Kit is the starting point for many product developments. With the help of the Lighting Development Kit, a type of light curtain (**Figure 2**) was developed with the company Agile Solutions. This light curtain was equipped with Würth Horticulture Midpower LEDs of the WL-SMTW series and white LEDs of the SWTP series. LEDs with peak wavelength 450 nm, 660 nm, 730 nm and white LEDs with CCT 5000 K are used.

Figure 1: Indoor Vertical Farming demonstration facilities: space and resource-saving crop production with optimized artificial light and individual lighting recipes. (Source: Würth Elektronik eiSos)

Figure 2: Light curtain with Würth Elektronik Horticulture Midpower LEDs of the WL-SMTW series and white LEDs of the SWTP series: a microcontroller enables flexible and dynamic light mixing. (Source: Agile Solutions)

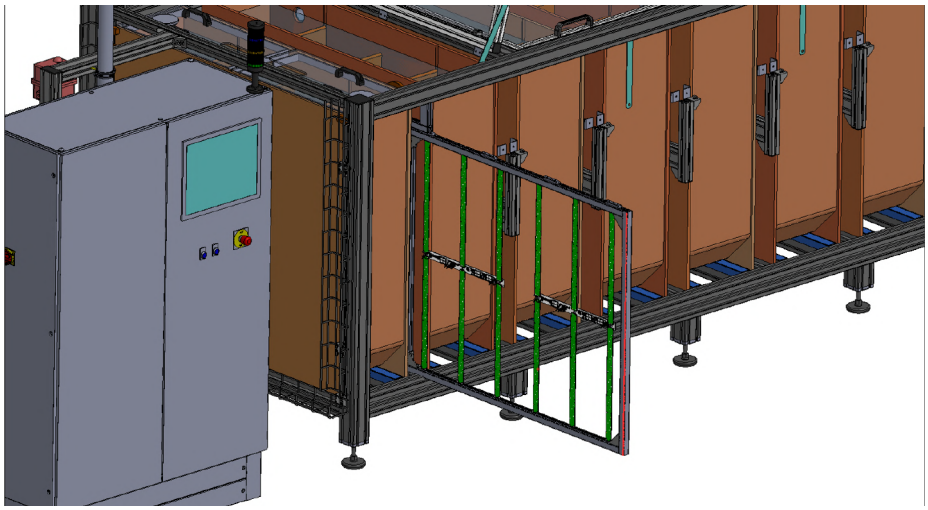


Figure 3: Algae reactor with optimized LED lighting: The very high-purity algae produced here are valuable sources of protein and provide secondary plant compounds used as additives in the cosmetics and pharmaceutical industries. (Source: Alganetics)

The individual LED colors can be controlled separately and are continuously dimmable from 0 to 100%. Due to the microcontroller control, a flexible mixing and creation of light recipes is possible, in order to respond to quality parameters of the plant, (e.g. better rooting, more biomass, higher secondary substance content, etc.). In addition, dynamic lighting is made possible over the duration of the entire vegetation period. Due to the intelligent power electronics, the efficiency could be increased by 20% compared to conventionally controlled LED systems. The illumination area is $1.35\,m^2$ per curtain. The areal distribution of the LEDs allows a very homogeneous illumination of the target area at a small distance, which enables a uniform plant quality.

The Potential of Algae

This light curtain is very applicable in the field of vertical farming, but it is also used in other applications of plant lighting. One example is the algae reactor from the company Alganetics (**Figure 3**). The developed lighting enables the production of microalgae with a very high purity content. The algae produced can be used as protein sources in human and animal nutrition. Secondary plant compounds from the algae also serve as additives in the cosmetics and pharmaceutical industries.

Another example of the use of the Lighting Development Kit is the start-up Organifarms. Here, the Sunshine PCB was used to develop a lighting concept that enables the start-up's harvesting robot (**Figure 4**) to harvest around the clock. This compensates for poor lighting conditions so that the robot's camera system can distinguish ripe from unripe fruit.

The Lighting Development Kit also served as the basis for the development of two luminaires by Engel Lighting. Both luminaires (**Figure 5**, **Figure 6**) are equipped with the Horticulture High Power LEDs of the WL-SMDC series and offer different spectral ranges from UV to infrared. The Line luminaire is mainly used in vertical farming and achieves PPE (Photosynthetic Photon Efficacy) values of up to $2.8\,\mu mol/J$. At a distance of $30\,cm$, PPFD (Photosynthetic Photon Flux Density) values of $450\,\mu mol/m^2s$ can be achieved. The Optimus luminaire is mainly used in the greenhouse sector. It achieves PPE values of up to $3.1\,\mu mol/J$ and PPFD values, at a distance of $30\,cm$, of up to $1260\,\mu mol/m^2s$. The modular expandable LED plant lights can be dimmed continuously during operation.

Figure 4: BERRY harvesting robot: With its LED lighting, the machine detects ripe fruit even under unfavorable lighting conditions. (Source: Organifarms)

Figure 5: Modular lighting system for plant optimization from Engel Lighting: Horticulture High Power LEDs of the WL-SMDC series deliver different spectral ranges from UV to infrared. (Source: Engel Lighting)

Figure 6: Modular lighting system for plant optimization from Engel Lighting in practical use. (Source: Engel Lighting)

Research and Support

The Development Kit is also used at Würth Elektronik itself, for example in the "HortiRack" developed for internal research purposes. The HortiRack is an indoor greenhouse for experiments on sustainable food production. The plant scientists in the optoelectronics team use it to study the effects of various impact spectra on plant development. "Microgreens", herbs and various leafy vegetables are grown in the HortiRack. Research is being conducted on dynamic light spectra to increase the quality parameters of plants.

At **Würth Elektronik**, we feel responsible for proactively helping to shape the future through the development and use of new technologies. This is achieved through intensive partnerships with medium-sized companies, corporations and start-ups. With the Lighting Development Kit, biological know-how and the right network, the company helps developers find solutions for the "farm" of tomorrow. ■

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www.we-online.com

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Shaping Leading Edge Technologies

by Alexander GERFER

At Würth Elektronik we are forward thinkers and act responsibly. We want not only to sell as much as possible today, but also to turn leading edge ideas and tomorrow's projects into reality. Our customers receive services that extend far beyond mere sales advice. We support start-ups and their ideas, thus helping to shape the future.

You may be asking yourself, how can a manufacturer of electronic and electromechanical components really make a mark on the future? The answer is: by being interested in the applications and uses of our products. In 2008, Würth Elektronik began setting up its LED division, and began marketing them in 2011. In 2018 we reached another milestone by launching a product that paved the way for a lasting commitment: our first LEDs that emit light at wavelengths of 450 nm, 730 nm and 660 nm. Deep Blue, Far Red and Hyper Red are Horticulture LEDs. The light in these wavelengths play a major role for photosynthesis, with the spectrum of the frequencies having a direct effect on the growth of plants. We are putting a lot of research into this, and offering tools and control layouts that enable plant lighting using light recipes. It is a field with huge potential. With the right light recipes and LED lights, plant growth can be increased without compromising taste or nutrient content. This all can be done within a smaller space and saving up to 95% water and 70% energy. Vertical farming is a future technology and based on our collaborative basic research, we can already provide the required equipment.

Controlled Environmental Agriculture is an important building block for securing food supplies in the future. Plants are fed in a targeted way, and the environmental impact is furthermore minimized by using closed systems with integrated water treatment. We already have exact knowledge of how many nutrients individual plants need and can precisely dose both the nutrients and the lighting in the greenhouse to optimize growth and nutrient content. In this way we can achieve maximum yields with minimum energy input. Horticulture LEDs are a key technology for vertical gardening, but only the entry product into a gigantic emerging market. Here we cooperate with partners who offer and sell plant lights.

We work with established manufacturers of agricultural technologies as well as start-up companies like Organifarms. Based in Constance in southern Germany, Organifarms has developed a harvesting robot called BERRY, which recognizes and harvests ripe strawberries. We have designed lighting technology that enables the harvesting robot to reliably recognize ripe fruits, even in difficult lighting conditions. This product will soon be ready for the market.

Alexander GERFER, Chief Technology Officer at Würth Elektronik eiSos.

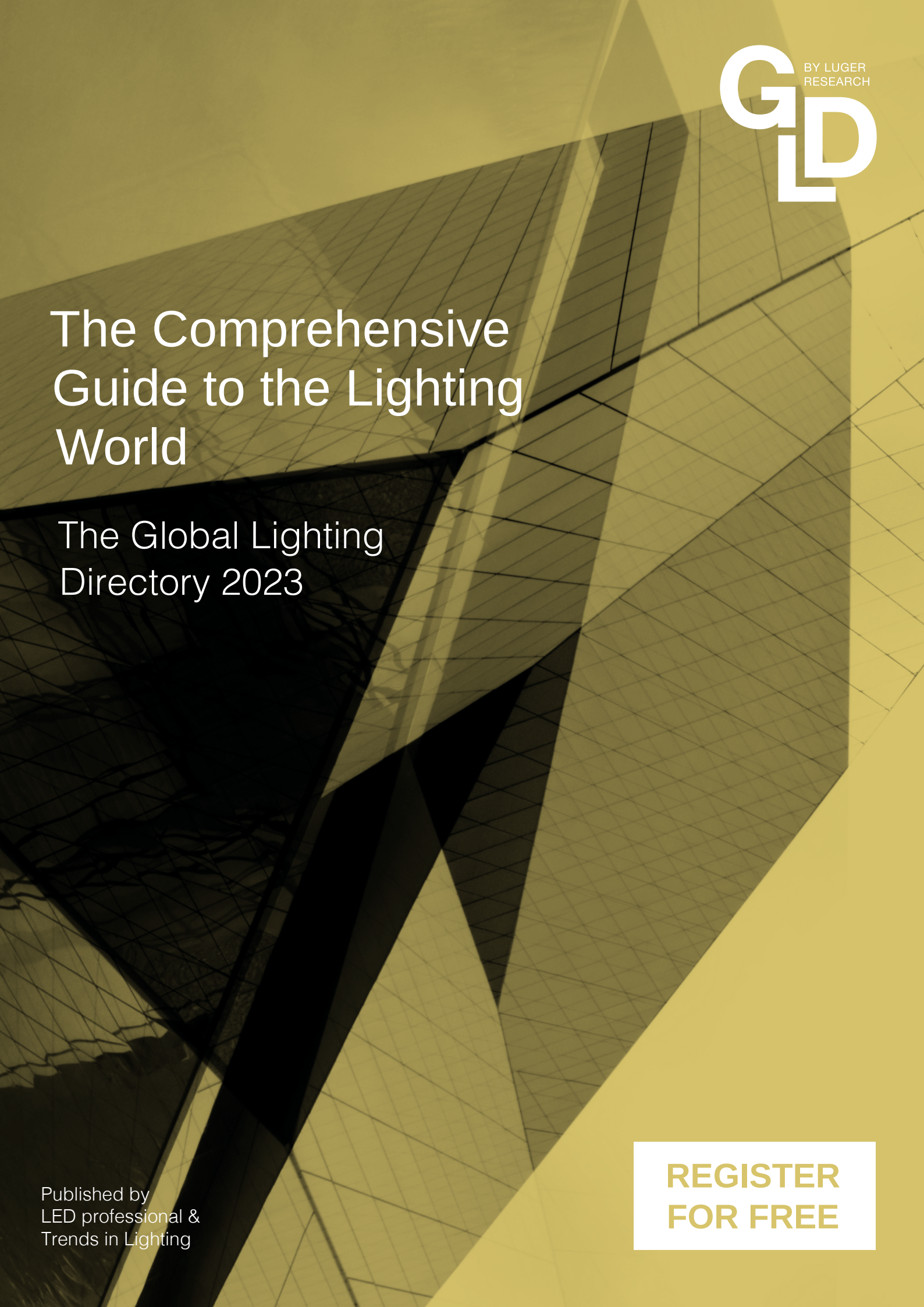
The length of product time-to-market obviously varies with the complexity of each project, but based on our experience and industry contacts, we can significantly reduce this time factor. Competition, like everywhere in the high-tech sector, is fierce, but our research activities, our many years of experience and our connections to universities and future technology leaders provide us with a good footing.

Just as lighting solutions for buildings are relevant to key areas such as Smart Building, Horticulture LEDs open up good opportunities for smart solutions for the agriculture sector. We already deliver radio modules and sensors for related IoT solutions, for instance.

You could say that not only do our Horticulture LEDs supply plants with the exact amount of light they need, but they have also illuminated a road towards the future for us. We are living out our passion for sustainable technologies and for partnerships with innovative companies in this field. ■

Alexander Gerfer is Chief Technology Officer for one of Europe's largest manufacturers of electronic and electromechanical components. Headquartered in Waldenburg, Germany, Würth Elektronik employs around 8,200 people and has manufacturing, logistics, quality and administrative sites in 50 countries. In 2022, the Würth Elektronik Group generated sales of 1.33 billion Euros.

Gerfer is a graduate engineer (FH) for electrical engineering and a trained radio and television technician, who has been with Würth Elektronik since 1997, beginning his career as a technical sales representative. He has been instrumental in establishing the company's research and development, product, quality and supply chain management divisions.



BY LUGER RESEARCH

The Comprehensive Guide to the Lighting World

The Global Lighting Directory 2023

Published by
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Guangzhou International Finance Center (IFC)

Lichtvision Design

Guangzhou, formerly Canton, is one of China's largest cities and has a population of over 15 million. It has grown rapidly in recent years and many of the city's districts have been re-planned around dramatic urban set pieces, of which Zhujiang New Town is one. The Guangzhou International Finance Center was envisaged as one of a pair of towers creating a spectacular gateway to the business district on this central boulevard. It differs from many other tall buildings in the purity and elegance of its form, free from distractions and informed by technology rather than symbolism.

General Scope

The IFC Guangzhou with a height of 439m is the 24th highest building in the world and number 14 in China. Lichtvision developed a lighting solution which aimed to feature the very characteristic diagonal framework structure behind the glass façade. As this structure is not visible during the day due to the reflective material properties of the curtain wall, this effect would only be revealed during the night. As the tower is mainly used for office and hospitality, lighting equipment had to be placed to facilitate maintenance and accessibility from the outside.

At the same time adherence to glare control was of top priority. In no circumstance, was façade lighting allowed to shine into the interiors, causing potential light nuisance. Therefore façade elements with integrated LED modules were developed. The modules allow for dynamic scenes as well as color change for special events. The standard, every day setting, is set at monochrome white and static for a subtle accentuation of the architecture at night.

Architecture

Following an international design competition, WilkinsonEyre was selected to design this 439m tower in Guangzhou, one of China's tallest buildings. With 103 storeys, the tower has a mixture of uses including office space and a luxury Four Seasons hotel with a top-floor restaurant and bar. At ground level, the tower connects with a substantial podium complex containing a luxury brand retail mall, conference center and high-quality serviced apartments.

The tower and podium connect below ground to further retail spaces and a transport hub, with a retail loop encouraging connections to a landscaped central axis. The tower's tapering, crystalline form acts as a landmark on Guangzhou Zhujiang New Town's main axis, linking the commercial district in the north with the Pearl River to the south. The tower employs a diagrid structure, the world's tallest, visually expressed through the building's transparent envelope. Its triangular plan responds to the need for efficient internal space layouts and excellent environmental performance.

As a global brand, Four Seasons demanded spectacular accommodation of the highest quality, so WilkinsonEyre created a 33-storey hotel atrium, clad in sparkling glass, which is tall enough to house London's St Paul's Cathedral. The building was named the 2011 Best Tall Building Asia/Australasia by the Council on Tall Buildings and Urban Habitat. In 2012, the tower was awarded the RIBA Lubetkin Prize, for the best building by a British architect outside of the UK.

https://www.lichtvision.com/en

Lichtvision on LinkedIn

LICHTVISION DESIGN

Guangzhou IFC

Typology: High Rise Hospitality, Commercial, Mixed Use
Scope of Work: Artificial Lighting Facade
Start & Completion: 2012
Location: Guangzhou, China
Client/Owner: Chow Tai Fook Enterprises, China
Tenant/User: Various
Architect: Wilkinson Eyre Architects
Awards: CTBUH 10 Year Award of Excellence 2020, RIBA Lubetkin Prize 2012, CTBUH Best Tall Building Asia/Australasia 2011
Images: Jonathan Leijonhufvud

Project Contact & Links
shanghai@lichtvision.com
wilkinsoneyre.com

Façade elements with integrated LED modules were developed for IFC. The modules allow for dynamic scenes as well as color change for special events. The standard, every day setting, is set at monochrome white and static for a subtle accentuation of the architecture at night.

The IFC Guangzhou with a height of 439m is the 24th highest building in the world.

The Power of Good Light Indoors: Boosting Sleep, Alertness, Mood and Productivity

Jan W. DENNEMAN, Marina C. GIMÉNEZ, Bruno M.J. SMETS, Roger SEXTON, Marijke C.M. GORDIJN | Good Light Group

Good indoor lighting is essential for enhancing healthy bodily rhythms, sleep quality, alertness, mood and workplace productivity. Current practices and recommendations for indoor lighting, however, prioritize vision over health, leading to disruptions in our biological clock and alertness. Limited exposure to natural daylight also contributes to this problem. Scientific recommendations for people following regular daytime schedules call for higher light levels during the day and lower levels in the evening and night. Adopting these good lighting recommendations in norms and regulations will lead to improved indoor lighting and overall well-being for individuals as well as having a significant socioeconomic impact.

The Dark Side of Indoor Lighting: How It's Disturbing Our Biological Clock

In modern times people spend up to 90% of their time indoors [1], resulting in limited exposure to natural daylight. Unfortunately, indoor lighting practices mainly focus on providing good visual and aesthetic experiences and low energy consumption with little consideration for the health aspects of light [2]. As a result, indoor light intensity is too low during the day and too high in the evening and at night. This interferes with the natural regulation of the biological clock causing disruptions in many areas like our sleep-wake cycle and alertness.

Because people spend so much time indoors, indoor lighting should promote the natural regulation of the biological clock and support our sleep-wake cycle, alertness and mood, in addition to providing adequate illumination for visual tasks and ambiance. The field of knowledge on the health effects of light is mainly based on chronobiology. Chronobiologists investigate 24h rhythms, the biological clock and how adaptations of the clock to the environmental light-dark cycle are instrumental for health and well-being. This field received the Nobel Prize in Physiology or Medicine in 2017 [3]. Now is the time to implement the insights into daily practice. Recent scientific recommendations [4,5] propose that indoor light levels, necessary for proper adjustment of the biological clock and supporting alertness, should be two to five times higher during the day and much lower in the evening than is currently the case in working and home environments. The technicalities of these recommendations are available in international standards [6], but they are not yet included in norms or regulations.

Good light indoors [7] provides the right light intensities with the right spectrum, at the right time of day. Implementing regulations for good indoor lighting can support overall health and well-being.

Light indoors is too dim during the day and too bright in the evening and at night for a healthy and happy life.

Shedding Light on Better Sleep

Sleep is crucial for overall health and well-being, but up to 20% of the population may experience insufficient or disrupted sleep, leading to daytime sleepiness and other negative effects [8].

Good light exposure plays a vital role in regulating the body's biological clock and can improve sleep quality for example by reducing the time needed to fall asleep, increasing deep restorative sleep and increasing the likelihood of waking up feeling more rested in the morning [9]. The improved sleep quality may, in turn, lead to better cognitive function, memory, learning, athletic performance, physical coordination and a lower risk of accidents, injuries, and occupational errors [8,10].

On the other hand, sleep deprivation has been linked to an increased risk of chronic conditions such as obesity, diabetes, and cardiovascular disease [8].

Unlocking the power of good light can significantly improve sleep quality and promote overall health and wellbeing.

Light Up the Day to Boost Alertness and Mood

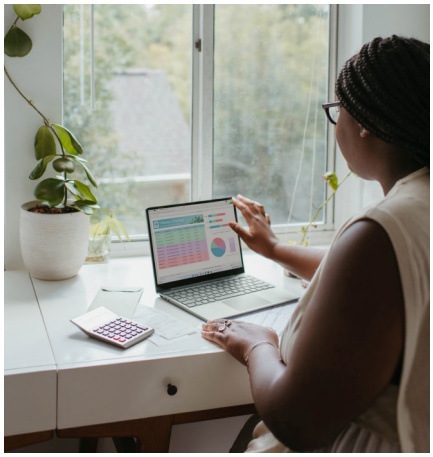
Although a clear dose response curve [11,12] for immediate effects of daytime light on alertness is not yet established, it is clear that sitting in relative darkness makes you sleepy. Increasing light intensity in an attractive way [13] can have an immediate alerting effect on the human body, leading to increased alertness, attention, and cognitive performance [10,14,15]. It can help reduce fatigue, improve mood, and boost mental acuity, making it an invaluable tool in workplaces where focus and productivity are essential.

Studies have shown that good light exposure can also enhance well-being, alleviate symptoms of depression and anxiety and increase positive emotions. In fact, bright light therapy is a highly effective treatment for seasonal affective disorder **[16]** (SAD) and related depressive symptoms. If applied early in the development of symptoms, studies have shown that it may prevent the full-blown development of a serious depressive episode **[17]**.

By harnessing the power of good light indoors, we can unlock a whole new level of mental and emotional vitality.

Bright Idea for Individuals and Society

Investing in good indoor lighting can improve individual health and well-being and has the potential to lower healthcare costs and boost workplace productivity.
Good lighting can reduce the cost of sick leave (absenteeism) and presenteeism, potentially amounting to up to $410 billion per year **[18]**, or $550 per capita for the five major OECD countries.



Optimizing indoor lighting promotes health and well-being of individuals, enhances productivity, reduces healthcare costs and benefits society economically.

While the long-term economic impact of good light on health and well-being is yet to be determined, investing in good indoor lighting can definitely benefit individuals, companies, and governments. ■

AUTHORS

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The Language of Lighting: Applying Semiotics in the Evaluation of Lighting Design

Dr. Thomas SCHIELKE, Architect and Lighting Design Trainer, ERCO

Architectural lighting provides optimum visibility for tasks but illuminations convey meanings as well. Though many studies analyze technical dimensions of lighting, research on the meaning is rare. Therefore, this article discusses semiotics as a methodology for lighting design within the design process and critically reflects the appearance of light and architecture. The semiotic discourse starts with terminology and presents models of architectural signs. The history of architectural semiotics serves as a background for the transfer to lighting and leads to an understanding of recent debates. The relevance of semiotics for lighting design is shown in three aspects: Firstly, the influence on the lighting design process; secondly, how physical characteristics of light intensity, distribution, and spectrum are interpreted as signs; and, thirdly, the evaluation of different lighting design tasks like daylight, lamp and luminaire design, interior and exterior lighting, as well as media façades. A critique of architectural and lighting semiotics reveals the methodological limitations of the linguistic concept. It can be concluded that semiotics provides a useful instrument to identify the meaning, which helps to improve the quality of lighting design. The semiotic matrix offers a differentiated view of relationships based on the aspects of sign, object, and interpretant with relation to light characteristics, illuminated buildings, and architectural lighting in general.

1. Introduction

Semiotics is a method to study the meaning of signs and therefore represents an interesting approach to analyze sign systems like architecture. The semiotics of architecture has emerged as a branch of semiotics for visual communication and allows the interpretation of the building as a sign and the user as a receiver. Similarly, windows, luminaires, and lighting pattern in the space embody signs. Consequently, the transfer of semiotics to lighting design offers an opportunity to enhance the discussion of the quality of lighting. This strategy can be beneficial for a more comprehensive evaluation of architectural lighting regarding research, education, and design. Such a view is especially relevant for lighting situations that appear technically correct but where users experience problems in meeting their expectations and understanding their meaning.

Semiotics studies complex systems of signs and their meaning as part of a communication between sender and receiver [71]. Three dimensions of semiotics indicate the scope: syntax as the grammar, semantics as the relationship between signs and their meaning, and pragmatics as the language within the social context (**Figure 1**).

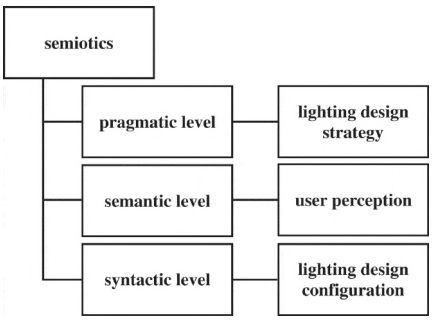

Figure 1: Dimensions of semiotics and lighting design.

Semiotics has mainly been influenced by linguistics and was later applied to aesthetics and visual communication like architecture, painting, or film. Light is examined as a code and a unit of information that produces an identity as result of a linguistic outcome. Within this perspective, light in architecture is used as a social construct, where contrastive and fluid identities emerge [107]. When the relationship between architecture and light is not reduced to conveying only the meaning and function but also understood as an influence on our behavior, we even assign a rhetoric role [37].

The impact of light for generating an identity is particularly interesting for clients who strive for representation and a narrative component for their corporate design [40]. The latter is of high interest for the retail environment, urban design, and marketing. Eye-catching animations on media façades are just one form of architectural expression that use light to communicate a message to people. On a small scale, semiotics for lighting can help to understand the interest in symbolism like the retro designed Edison light bulbs with light emitting diode (LED) technology. In the future, the rising LiFi technology will add another dimension to the semiotic analysis of architectural lighting, where the spectrum, light distribution, and luminaire form will influence not only the meaning but also the content, which the beam sends to users [25].

Using sign theory for architectural lighting offers methodological impulses for different research strategies in architecture: qualitative research, logical argumentation, case studies, and interpretive–historical research according to the categories by Groat and Wang [32]. On the one hand, focus on the qualitative aspects of lighting enhances individual well-being by including social and communicative aspects as well

as aesthetic judgement, whereas, on the other hand, quality improves architecture with the aspects of style and composition when referring to Veitch's definition of lighting quality [104]. Environmental studies have developed an information processing model to evaluate qualities where the factor legibility indicates a link to semiotics even if it has not been explicitly discussed yet [45,58]. The logical argumentation is particularly relevant in an educational context, as part of the design process, and in the critique of illuminated projects, where, for instance, the arrangement of the different units such as light source, luminaires, light distribution, and architectural elements are analyzed (**Figure 2**) [50].

Concerning case studies, semiotics can help to identify complex systems of how lighting technology can be applied and the generated image and user experience combined. It could offer input to increase interest in the psychological effects in identifying the way in which lighting can benefit a desirable outcome [12]. Current research on the illumination hierarchy that expresses visual significance of the content of spaces appears to be relevant for a semiotic perspective [59]. The importance of the interpretative–historical research became obvious in studies that examined cultural phenomena with changes of meaning through time or relationships between different fields such as art, retail, and lighting [69,86].

When semiotics is applied to lighting it can be used as a tool to overcome the crisis in methodology of design and naïve functionalism and point out interpretational pluralities by placing man in the center. Thereby semiotics could provide an impulse for the quantitative interpretation of light, which has been criticized by the recent human-centric light movement, among others [10]. A qualitative method like semiotics can be added to quantitative research in order to adequately prepare it or to explain it afterwards [47].

Architectural semiotics presents a branch of semiotics for visual communication, which is related to aesthetics, objects, and space. In architecture, the semiotic approach became very popular with the onset of postmodernism, where designers criticized the primacy of function by using dominating forms as meaningful entities or alternatively by deconstruction to reveal morphological elements [53]. These specific buildings range from explicit representations through their shape and construction, like the Binoculars Building in Los Angeles, to metaphorical applications of the linguistic concept by Eisenman [20]. The recent emergence of iconic landmark buildings—for instance, the Guggenheim Museum in Bilbao leading to the so-called Bilbao effect—exemplifies the topicality of architecture as a sign [43]. In a similar way, the rising interest of builders to include a media façade shows the interest of creating a specific identity with light [40]. Additionally, architectural photography has reinforced the trend for pictoriality and architects' interest in creating attractive images [83].

Figure 2: Semiotic design layers for architectural lighting: Space, texture, light, and luminaires. Rendering layers: Axel Groß. Image © ERCO.

Introducing various semiotic theories in this article offers the chance to explore different perspectives for lighting tasks—for example, to understand the meaning of a specific lighting installation, the design rules that create a structure of light for buildings, and the historical or cultural context—which has an impact on the perception of an illuminated space. The theories also provide the possibility to select simple or complex models to analyze solutions.

In this article, the semiotic discourse for light starts with models of architectural signs. The history of architectural semiotics serves as a background for the transfer to lighting and leads to an understanding of recent debates. Options to use semiotics for lighting are illustrated regarding the design process, the meaning of photometric parameters, and lighting design tasks ranging from the light source up to urban design issues. A critique of architectural and lighting semiotics reveals the methodological limitations of the linguistic concept.

2. Models of the Architectural Sign

Semiotics does not just have one unifying theory but has different models to interpret the relation between sign and the interpreter, which influences the analysis. For the architectural sign, the behavioristic, dyadic, glossematic, and triadic sign models play a central role [71].

2.1 Morris's Behavioristic Model

The behaviorist model goes back to Morris and was written by Koenig (Koenig 1964). The architectural sign is considered a preparatory stimulus where specific behaviors result as a response [71]. Nöth exemplified this with learning building: The denotata of a school are the children who study there. The significatum of this building is the fact that these children go to school **Figure 3**.

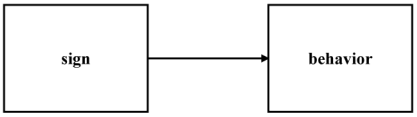

Figure 3: Behavioristic model according to Morris.

2.2. Saussure's Dyadic Model

The model of Saussure with the sign as the unit of the signifier in the sense of sign body and signified as meaning was incorporated by De Fusco into his semiotic analysis of architecture, in which he interpreted architecture as a mass medium [18,87]. He illustrated this aspect, among other things, with the development of large

department stores and museum buildings, which became centers of communication. De Fusco referred to Saussure's terminology of "signifier" and "signified" when he introduced his categories of outer and inner space, where the inner space embodied the essence and imagination of architecture (**Figure 4**).

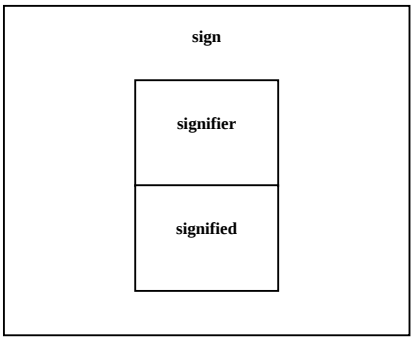

Figure 4: Dyadic model according to de Saussure.

The perception of a built project serves as an illustration: The Institut du Monde Arabe in Paris: The actual building with the diaphragms to filter daylight embodies the signifier. The architecture and daylight design signifies a hinge between the Arabic and European culture as between tradition and modernity. The façade details appear as homage to Arabic culture with the modern interpretation of mashrabiya as traditional Arabic screen, whereas the general form does not quote typical Arabic forms like mosques but rather refers to rational geometries. The detailing of the diaphragms with the characteristic apertures also refers to the tradition of photographic development in France. In addition, the motorization of the diaphragms epitomizes modern high-tech design.

2.3. Hjelmslev's Glossematic Model

In addition to the behavioral model of Morris and the dyadic approach of Saussure, Nöth identified the glossematic model of Hjelmslev, which Eco **[23]** further developed. Eco saw a weakness in the triangular model, because one cannot differentiate between the signifier as a material sign bearer and the object of the signs because both units refer to the same physical reality. His differentiation from "denotation" and "connotation" was based on the content and expression of substance and form (**Figure 5**).

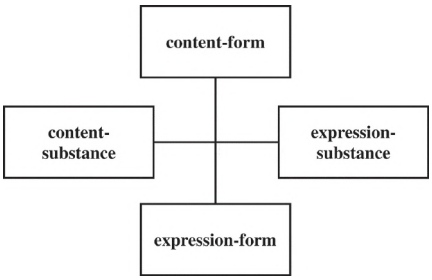

Figure 5: Glossematic model according to Eco.

The units of expression, morphemes, had the units of content, the semene, as a counterpart. The semene is divided into architectural function, either in the denotative physical functions or in the connotative socio-anthropological functions. Concerning architectural lighting, a glazed entrance hall provides natural light in the physical dimension and at the same time represents transparency and openness on a connotative level. The morphemes as elements of expression are divided into a comparable form. This means that one can use the semantic component "luxurious" with a morphological component such as "valuable glass crystals."

2.4. Peirce's Triadic Sign Model

The fourth model for Nöth was the model of Peirce, consisting of sign, object, and interpreter. If you transfer this tripartite model to the New Yorker Empire State Building with its color coding at the top of the building to inform about holidays and events, then the building would represent the object. The changing architectural lighting program with colored light can be considered as a sign and the citizens and tourists of Manhattan represent the interpretant.

The relation of the sign to the three poles was accordingly the reference to the sign, object, and interpretant (**Figure 6**) **[8]**. The sign reference was divided into the qualisign as a sensible appearance of the sign (for example, color); the sinsign, which was location and time dependent as a real existing character; and the legisign, which was not bound to a singular appearance. The object reference was in turn divided into the icon, which mimicked its object as a character; the index, which had a direct relationship to the object as location and time dependent; and the symbol, which was arbitrary to the object but can be based on cultural assumption. The interpretant reference consisted of the rhema, which offered a qualitative possibility; the dicent, which really existed and could therefore be true or false; and, finally, the argument for a legitimate context.

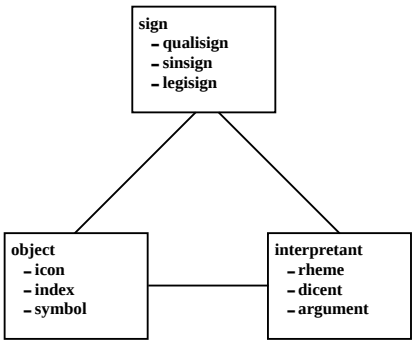

Figure 6: Triadic sign model according to Peirce.

The model of Peirce also allows a transfer to architectural lighting, illustrated in **Table 1**, and can be applied to a project like the Yas Viceroy Hotel with its media façade **[90]**. The colored light of the media façade serves as the qualisign. The specific grid of the media façade in Abu Dhabi corresponds to the sinsign and the general meaning of media facades the legisign. The object reference can be differentiated into the icon with the design program for marketing; for example, with the aspects specificity and exclusivity. The uniqueness as meaning of Yas Viceroy media façade forms the index. The specialty of media façades corresponds to the symbol and derives from the fact that media façades are only used in singular cases and thereby generate a strong contrast when compared to conventionally illuminated facades. The qualitative evaluation of colored light and dynamics in general represents the rheme, whereas the dicent refers to the tourist's opinion of whether the media facade of the Yas Viceroy Hotel looks exceptional and exclusive. The argument deals with the aspect of which extent media facades are a special feature.

	Lighting (sign)	Design program (object)	Viewer (interpretant)
Light characteristics (reference to a ground)	Luminance distribution and color (qualisign)	Image (icon)	Evaluation of luminance distribution and color (rheme)
Architectural lighting of building (reference to a correlate)	C of building (sinsign)	Image of building (index)	Judgment true/false for image in relation to luminance distribution and color (dicent)
Architectural lighting in general (reference to an interpretant)	C in general (legisign)	Image in general (symbol)	Evaluation of architectural lighting in general (argument)

Table 1: Semiotic matrix for architectural lighting based on Peirce's classes of signs.

3. History of Architectural Semiotics

The semiotics of architecture originated as a sideline from semiotics in the 1960s, which focused on the meaning of buildings based on architecture history and theory with early titles like "Meaning in Architecture" [44] and "The Language of Architecture" [75]. At the end of the 1960s, architectural semiotics became an independent field of semiotics [71]. For Nöth the architectural semiotics covered the construction from the single building up to urban design as a sign system and systematically described it as a code. Thereby, it established a contrast for him in relation to the asemantic nature of architecture, which interpreted the architecture exclusively in its functionality.

Barthes was one of the first who applied the ideas of semiotics to visual images and later developed a high interest in urban design, which became visible in his 1964 essay of the Eiffel Tower as an iconic center and functioned as a signifier independent of any specific referent [4]. Norberg-Schulz, influenced by Morris's interpretation of semiotics, invented a phenomenological approach with four levels of "existential space": geography and landscape, urban level, and "the thing" [33]. He observed the relationship between the man-made world and natural world through a three-point process of visualization, complementation, and symbolization. His theory involved a reductive approach with three categories for the landscape and the man-made world with romantic, cosmic, and classical archetypes.

The publications "Learning from Las Vegas: The Forgotten Symbolism of Architectural Form" [105] and "The Language of Post-Modern Architecture" [42] have been very influential in the semiotic context. Jencks revealed how architecture can be regarded as a sign from a metaphor to a cliché. In his view, architectural elements like windows and columns can be regarded as "words" and identified as a reuse of symbolic signs linked to a specific meaning. For instance, a problem with the meaning becomes noticeable when purist transparent architecture with ribbon windows is transformed into conventional signs of homes by the residents with added shutters and more window mullions due to the perceived lack of shelter and protection. The rules for combining the various words of windows and walls are interpreted as syntax, whereas the semantics describe the relationship of the elements and their meaning.

According to Preziosi, the functions of architecture were divided into six points: (1) referential function of the architectural context, (2) aesthetic function via the architectural design, (3) metacodal function as architectural allusions or quotations, (4) phatic function in the sense of a territorial aspect of a building, (5) expressive function as self-representation of the builder, and (6) conative function in terms of user-related aspects of architecture [71,76]. To exemplify the different functions above the corner window at the Fallingwater building from 1939 serves as a daylight detail. Frank Lloyd Wright said in an interview,

The corner-window is indicative of an idea conceived early in my work, that the box was a Fascist symbol, and the architecture of freedom and democracy needed something beside the box. So, I started out to destroy the box as a building. Well, the corner-window came in as all the comprehension that ever was given to that act of destruction of the box. The light came in where it had never come before, vision went out. And you had screens instead of walls—here the walls vanished as walls, and the box vanished as a box [22].

The architectural context of the project consists of a natural environment. The special aesthetics of the window derive from the dematerialized corner, which was solid in the architecture and windows were only positioned next to the corner support. The meta-architectural function lies in the political dimension, where the architect used a certain design to mediate freedom and democracy with a window instead of planning a closed volume. The territorial perspective results from the topography of the waterfall at the house and the spectacular view of the landscape through the window. As an owner of a department store in the heavily steel-dominated city of Pittsburgh, the client looked for a compensation of his industrial environment with his holiday home surrounded by unspoilt nature. The client's openness toward modern art and design, the choice of architect, and the realization of a visionary building for that time clearly demonstrate an architectural self-representation with an expressive orientation. The connotative function for the residents finally lies, on the one hand, in a unique window, which was later published worldwide, and, on the other hand, in the individual associations with the residents' view.

Mitchell intensified the discussion of languages of architectural form and their specifications by means of formal grammars [64]. His view was based on Chomsky's theories of language. He described the classical order of architecture with linguistic theory for analyzing sentence structures.

Unfortunately, this strategy did not consider the perspective of meaning.

4. Architectural Semiotics Since 2000

With the critique of postmodernism, the debate about architectural semiotics has almost vanished. In contrast to the theories of the 1960s to the 1980s, the newer approaches do not interpret architecture as language or as a model of verbal speech. Most of the critique regards architectural semiotics as one aspect of a comprehensive architectural theory. The review of recent literature begins with three books where Baumberger deals with semantics, Schumacher with syntax, and Delitz with pragmatics, followed by recent papers.

Baumberger transferred Goodman's architectural symbol system, which primarily described the notation system of drawings and plans, to general architecture like buildings and urban structures [5,30]. Baumberger explored the semantic dimension very analytically when he related the architectural signs to possible meaning by using Goodman's terms of "denotation," "exemplification," "expression," and "complex reference." Thereby, Baumberger identified direct and indirect relations of buildings or building parts precisely and, for instance, divided references into stylistic, typological, local, and cultural aspects.

Schumacher's system was developed as an extension of Luhmann's theories, where he added architecture as an independent social system [56,95]. Schumacher's interest in contemporary architecture became visible in adding innovation to utility and beauty as elements of the double code of architecture. With this framework, he introduced and tried to justify parametricism as an upcoming universal style, which he designed in collaboration with Zaha Hadid. He argued that in the period of classic modern architecture, the indexical relation referred mostly to constructive and technical features. As a consequence, the iconic and symbolic relation was neglected. For Schumacher, a semiotic system was necessary within the design process so that new architectural forms could be read and understood by society.

In her theory, Delitz worked with a very tight constellation between architecture and society and thereby concentrated on the pragmatic perspective of architecture [19].

She introduced society as an imaginary institution, where symbols were used as a form of expression and the architecture played a central role in the generation of self-presentation.

Semiotics also offered the possibility to examine the aspect of style [102]. For Tschertov, for example, syntax included continuity, homogeneity, symmetry, and dimensionality in the architectural code. Furthermore, the semantic forms of expression implied movement or development.

Iconic buildings like the Guggenheim Museum act as signature architecture and therefore the creation and reception of architecture requires a pictoriality, argued Ullrich [103]. She referred to Peirce to point out differentiate levels of iconicity, when analyzing quotes: image, diagram, metaphor. In particular, media façades use the building surface for emotional pictures, which, when electronically controlled, emanate prerecorded repetitive patterns or can generate live or interactive content and thereby create a changing appearance of the building [34].

Semiotics also has relevance for architectural conservation [78]. Preservationist processes change not only the appearance and physical features of a building but also its meaning. These measures are merely neutral but can entail modifications and even distortions of the original meanings. The quality of interventions can be analyzed in regard to epistemological and symbol-theoretical aspects. Three aspects were important for Capdevilla: (1) The preservationist measurements should avoid misunderstanding by accepting that they are not neutral but present interpretations of a symbol. (2) It is better to preserve a maximum of meanings instead of doing a selection. (3) Preservation should keep a plurality of meanings for an open interpretation in the future.

5. Semiotics and Lighting

The background of architectural semiotics provides a useful overview of several models and present discussions that can be applied to lighting design. Similar to architecture, light is used as a medium to generate an atmosphere. In addition to the functional aspect of visibility, it conveys a meaning. Studying the syntax—the grammar of how light elements can be combined—could enhance the design process. The semantic dimension raises awareness for the illuminated buildings as signs and what they stand for. Finally, a pragmatic perspective would complement the system to especially evaluate its interpretation in a social context. The different styles to illuminate a building find their equivalent in the different languages in the world.

Relevant academic literature about how semiotics and lighting could benefit from each other is still rare with a few exceptions. A first step toward semiotics started when architectural lighting was interpreted beyond visibility and focused on the meaning with aspects like addressing a mood or expressing intended use to complement structure or even modify the appearance of a space [60]. A close interplay of language and vision with a relation of text and image was applied to daylight observations and combined with a phenomenological method influenced by Norberg-Schulz [74]. With this point of view, the character of light is explained not by historical influences or technology but by sensuous experience. An explicit connection between electrical lighting and semiotics was drawn by Ruxton as a perspective to assess lighting beyond technology [84]. A more detailed semiotic analysis was introduced for architectural lighting and particularly the retail environment and media façades with experiments and a model based on Peirce that links the different views of the sign, object, and interpretant [90,91].

In addition to the architectural context, publications about semiotics and stage lighting and visual arts exist. Semiotics became useful for analyzing stage lighting and the communication between the performer and the audience and to identify lighting signs associated with productions [66]. For instance, the image of the moon represents an indexical sign pointing to the fixture that is projecting it. Examining light and shadow for modern visual arts and in early cinema benefits from a semiotic analysis as well [85].

Firstly, the various options to apply semiotics for daylight and lighting design are subsequently shown for the design process; secondly, how the basic light characteristics have a meaning in a general context; and, thirdly, specific design tasks are presented with the above semiotic models and theories based on specific projects.

5.1. Semiotics for Lighting Research

Semiotics provides a valuable addition to prevalent quantitative-orientated research strategies. It could help to detect significant factors for respective experiments and to classify the results. Qualitative studies would benefit from finely nuanced views of multiple semiotic theories. Especially for complex research questions like human-centric lighting, semiotics would raise an awareness for multiple parameters and social components. When utilizing case studies as a research method, semiotics offers a helpful matrix to relate lighting as a sign, the viewer as interpretant, and the light characteristics and architecture in general as an object. Interpretative–historical research projects would also benefit from this perspective. Similarly, the user as an interpretant would be beneficial for postoccupancy research.

5.2. Semiotics for Lighting Education

Educators can apply semiotics in various ways for teaching architectural lighting. Studying vocabulary and typologies serve as a basis to understanding existing situations as part of site visits or history and transferring the knowledge to design tasks. Learning a vocabulary of window types and the production of compositions has been a standard practice for architectural education [64]. The size, form, and proportion of a window in relation to the whole façade communicate a symbolic dimension; for example, a large horizontal window represents a modern style in contrast to small vertical windows [15]. Vernacular windows are not only a function of the daylight situation but are readable as social and aesthetic statements [2]. Typologies of daylight patterns allow architects to develop a precise language for their composition and help to compare design solutions [80]. These multiple views enhance students' competence for a comprehensive evaluation of competition results and stimulate the exchange of interdisciplinary groups within complex projects. The quality of communication, like visualization, is another relevant factor for education and depends upon the media and the applied technique used [88,39,82].

5.3. Semiotics for Lighting Design

Semiotics can be relevant during the design process while analyzing a project, comparing designs, and visualizing. This viewpoint can be applied to daylight and illumination. Daylight openings and luminaires as tools possess an iconic quality but the generated light pattern in combination with different photometric parameters create specific lighting effects as well.

Pioneers of architectural and stage lighting defined functions of lighting beyond visibility early on. Stanley McCandless regarded communicating a mood with a dramatic effect as one of his four lighting functions for the stage [61]. Influenced by McCandless, Richard Kelly defined three distinct functions of lighting "focal glow," "ambi-

ent luminescence" and "play of brilliants," which were based on daylight phenomena and linked to electrical lighting techniques to generate specific moods [48]. The simplification of the lighting designer's approach represented an effective communication strategy in the dialogue with clients to identify the desired mood, although the reduction of categories did not necessarily lead into a restricting factor as Kelly's versatile design language showed [70]. The luminaire itself can be interpreted as an icon of a specific style and conveys a historical message [27].

5.3.1. Lighting design process

The methodology of semiotics can also be applied for the general collaborative design work within a lighting design office and with the architect. The design thinking is regarded in semiotic terms as a complex of signs with three components: a virtual building, an envelope of consideration, and a network of meanings [63]. A semiotic approach is useful for identifying complex environmental patterns within the analysis and helps to evaluate alternative concepts within the design phase. In addition to the oral and written communication of lighting design, semiotics enhances the understanding of visualizations. Drawings, diagrammatic representation, or computer-generated images represent a product of an ideological framework of a society and require a careful application [79].

5.3.2. Photometric parameters

The basic physical characteristics of light intensity, light distribution, and spectrum are introduced as carriers of meanings in a general context. The light intensity with dark and bright light is used as a sign to convey an atmosphere for night and day. The connotation for darkness ranges from feeling unsafe, for example, in hardly illuminated streetscapes up to fascination for magical exhibition where several exhibits are kept concealed [55]. The interest in shadow can be linked to local culture as well, as Tanizaki revealed in the case for Japan [100]. In contrast, brightness is a sign to create the image of day, activity, transparency, and openness, with the risk of uncomfortable glare when too bright; for instance, as used with luminaires that have no cutoff. Daylight-filled atria are a sign for the bright design strategy as well.

The parameters of diffuse and directed light are closely connected to a cloudy sky and direct sunlight, respectively. They can be regarded as a medium to communicate either a soft atmosphere; for instance, with the signs of diffuse luminous ceilings in museums or rich in contrast mood with clear glass roofs for direct sunlight (**Figure 7**) [50].

The spectrum will be discussed with regard to color temperature and colored light. Low color temperature reveals a similarity to fire or candlelight, whereas high color temperatures show a close link to daylight. The former can be found in restaurants and hotels for a cozy atmosphere, whereas the cooler light color is more often used as additional lighting to daylight in offices [50]. When color was taken into account, studies showed that cool material colors such as blue or green were associated with a tranquil effect in contrast to warm material colors like orange and red, which appeared stimulating [3,7,16]. Associations for colored lighting were linked to natural light with the blue cast of twilight or the orange shift of the sunset and thereby colored light would act as a signifier for the respective atmospheres [58]. The meaning of colors can also be closely connected to local traditions, like the reflectance of daylight on gold or red surfaces in Japan [73]. The use of cross-cultural color schemes needs to be carefully evaluated, because both sim-

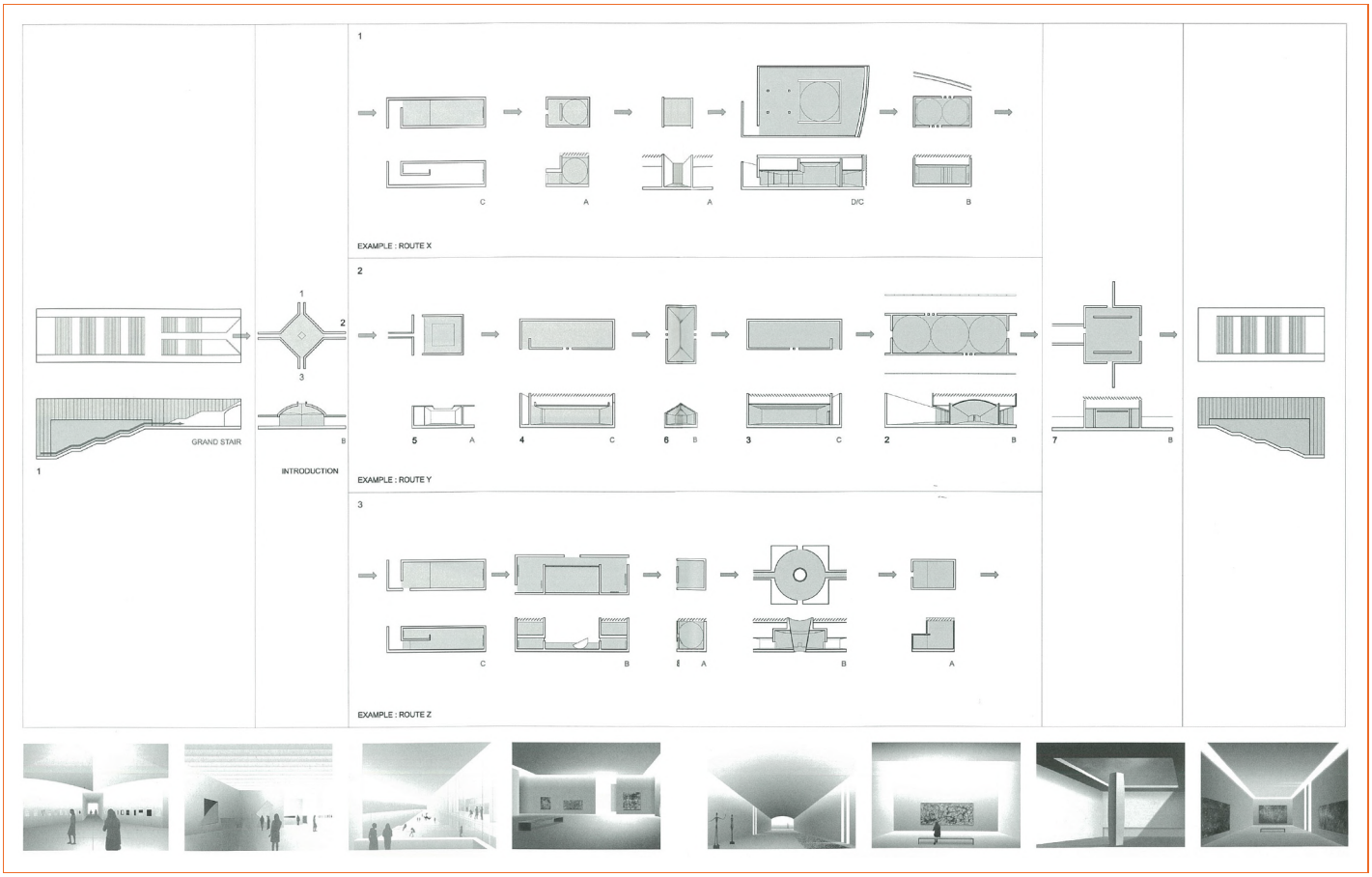

Figure 7: Spatial diagram for three routes through the museum. Illustration of daylight openings in ground plan, section and perspectives for the Fondation d'Art Contemporain François Pinault, Paris (France). 2001. Architect: Tadao Ando. Image © a+u (Ando 2002).

ilarities and dissimilarities occur for color meaning associations between different countries [51,57].

5.4. Lighting Design Tasks

Due to the fact that the types of projects vary widely, several semiotic issues become relevant. The examples will be illustrated with specific applications ranging from single installations up to urban design projects in the context of spectrum, light distribution, and luminaire form. They will be discussed in regards to style, the symbolic meaning, the role of the interpreter, and changes in context over time.

5.4.1. Daylight: Parametric language

The relevance of Schumacher's notion for parametricism becomes visible in the use of diagrammatic grammar to translate algorithmic rules for daylight design solutions. The complex honeycomb-inspired shading system for the Al-Bahr Towers (**Figure 8**) in Abu Dhabi designed by AHR responds kinetically to the sun's movement and generates a distinct identity for the client, involving a strong pictoriality that Ullrich discussed [46].

Figure 8: Al Bahr Towers, Abu Dhabi, United Arab Emirates, 2012. Architecture: AHR. Image © Christian Richters.

The communication of the design was accompanied by a so-called code—the abbreviation for construction, operation, and design execution. The pattern design quotes the mashrabiya as a traditional and local Islamic façade detail. But with parametric modeling and control software, the solar screen evolves into a dynamic daylight façade. From a pattern point of view, the Al-Bahr Towers screen represents a large-scale quote of Jean Nouvel's Institut Du Monde Arabe in Paris with its small-scale light-sensitive diaphragms but with an automated design process.

5.4.2. Lamp design: Signifier for price perception

The emergence of LED technology, which was accompanied by new forms for lamps and luminaires, has triggered a discussion about style and social context involving semiotics as well. The pixel aesthetic of LEDs has indicated innovative design. One part of this transformation is due to the changing perception of light sources when compared to the larger high-pressure discharge lamps, tungsten lamps, or older linear fluorescent lamps. Nevertheless, the rising usage of LED technology was accompanied by an increase in retro design mimicking vintage Edison filament light bulbs. This retro design can be assigned to a social environment and works as a signifier in the sense of Saussure's model for a price level in stores; for example, in Brooklyn to indicate upscale shops (Campanella 2017).

5.4.3. Luminaire design: Genius loci

When looking for a contemporary expression in order to achieve a specific new identity for the client, the designer starts to question the traditional design language of luminaires. Historical concert halls like the Neo-Baroque Palais Garnier for the Paris Opera had a central decorative and round chandelier in their main halls [93]. For the main hall of the opera in Oslo, the designers quote a round form in combination with sparkling hand-cast glass bars, but the overall form is a large linear layout that can be found in modernist abstract paintings (**Figure 9**) [97]. Further on, the detailed single crystals appear like an ice sculpture and thereby emphasize a link to the local environment of glaciers—an aspect that Norberg-Schulz discussed with the terms "geography" and "landscape" as part of his genius loci concept. The round cool form on the ceiling is a metaphor as it generates a connection to the moon.

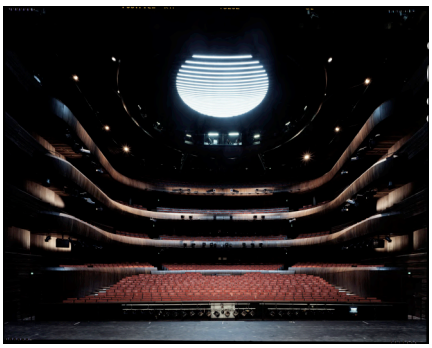

Figure 9: Main Hall at Norwegian National Opera and Ballet with chandelier, Oslo, Norway, 2008. Architecture: Snøhetta. Photo by Helene Binet. Image © Helene Binet.

5.4.4. Luminaire design: Direct quote

In contrast to the Oslo concert hall with a regional reinterpretation of chandeliers, direct quotes can, for instance, relate to culture, religion, or nature. The Kingfisher Mall in Redditch contains a strong symbolic dimension with a sun-like element (**Figure 10**).

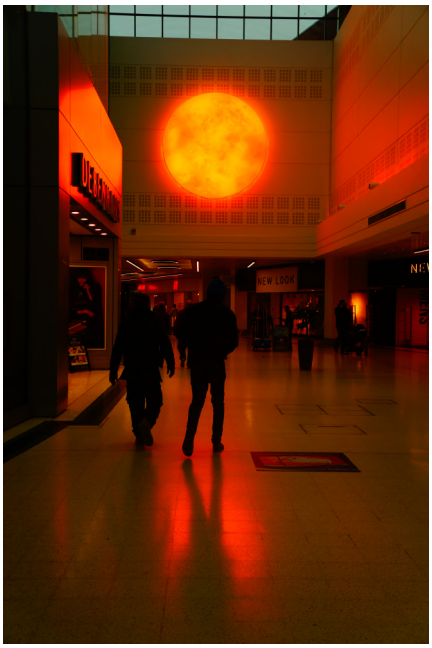

Figure 10: Kingfisher Mall, Redditch, UK, 2016. Lighting Design: Elektra lighting. Image © Elektra lighting.

Figure 11: Olafur Eliasson: The Weather Project, 2003. Monofrequency light, foil, haze machine, mirror foil, scaffold. Installation view: Tate Modern, London, 2003. © Olafur Eliasson. Photo by Andrew Dunkley and Marcus Leith. Courtesy the artist; neugerriemschneider, Berlin; Tanya Bonakdar Gallery, New York.

The orange circle below the ceiling at the end of a long hall evokes the association of a sunset when compared to nature and emanates an intense pictoriality like Ullrich argued. With the widely published "The Weather Project" installation by Olafur Eliasson at the Tate Modern in London (**Figure 11**), the orange circle appears like a quote of the artistic predecessor [60].

Considering that the artist himself quoted the natural sun, we find a quote of the first quote in the mall. The central upper position at the end of a long hall also creates an homage to Gothic church architecture with the characteristic luminous rose windows. The iconic orange image of both projects appears to be similar, though the details are different. Eliasson used a semicircle illuminated with monofrequency lights that he mirrored and a haze machine diffused the image. In contrast, Elektra Lighting avoided a single pure color and printed a graphic panel on the front for the sun at the mall. The two orange and red light colors in combination with light control lead to an animated surface.

The desire to quote daylight is visible in numerous projects. Numerous installations refer to the natural sky to enable a natural atmosphere for the interior, but often they achieve this only on the level of a static image on the ceiling. Dynamic ceiling images with changing patterns and colors are the exception, like the Condé Nast Cafeteria in New York completed in 2006, and often they still generate only diffuse light in contrast to direct sunlight. This means that on an image level we could detect a close relationship to nature for the ceiling, whereas with regard to the light effect in the space the relationship is not given due to lacking direct light.

5.4.5. Light art: Minimalism

The use of few architectural and lighting elements forms a reaction to a design environment that employs a multitude of signs such as those used in the baroque period. This minimalistic perspective was typical for the California "Light and Space" movement, which focused on perceptual phenomena in the 1960s. Light and dark, sunlight and shadow, time and space were central elements of the artworks **[13]**. Artists like Robert Irwin, James Turrell, and Douglas Wheeler used natural as well as electrical lighting for their ascetic spaces.

The influence of this movement is also visible in the works of artists like Olafur Eliasson or architects like Tadao Ando, Peter Zumthor, and John Pawson, where minimal interventions with daylight create impressive experiences. Regarding illumination, the concept of minimalism is apparent in a design approach where only the light is visible and not the luminaires that were used. Decorative luminaires as surface or pendant mounted are avoided in favor of concealed details like recessed luminaires or wallslot lighting. However, critics remark that the meaning of minimalism has shifted from an art-historical movement into a signifier of a global elite Chayka 2016 **[14]**.

5.4.6. Retail lighting: Indirect quote

Indirect quotes offer retail brands the chance to define their corporate design on an abstract, general level and thereby avoid a specific image that might look less attractive to some clients. The fashion retail showrooms by Jil Sander refer to American minimalism and the minimalistic light art of James Turrell Wagner 2017. The preference for translucence, invisible light sources and rendering volumes with light lines to create floating surfaces was introduced by the architect Gabellini Sheppard in the Jil Sander flagship showroom in Paris in 1993 (**Figure 12**) and later implemented in numerous showrooms worldwide and included in a corporate style guide. With this architectural lighting design scheme, the German fashion label pays homage to the American light artist and intensifies its simplistic brand image by forming a link to minimal art. Due to the fact that no specific art project with reference to form, material, and light was quoted in the Jil Sander showroom as Turrell's Wedgework series emphasizing walls, the author would regard the reference in the Paris showroom, located at 52 Avenue Montaigne, as an indirect quote, although Turrell's minimalism according to Ullrich is a metaphor. Indirect quotes enable stores to add a brand image on a conceptual level with regard to cultural, economic, ecological, and social contexts.

Figure 12: Jil Sander boutique, 52 Avenue Montaigne, Paris, France, 1993. Architecture: Gabellini Sheppard. Photo by Paul Warchol. Image © Paul Warchol.

5.4.7. Façade lighting: Modification in preservation

Illuminating historic buildings with modern lighting technology faces the challenge of linking a client's desire for a more attractive marketing image with respect for conservative historians who attempt to preserve the original meaning. Therefore, increasing the intensity of lighting for visitors establishes a stark contrast to dimly illuminated spaces signifying an unchanged and neutral appearance. The Rookery building, designed by Daniel Burnham and John Wellborn Root, was completed in 1888 and designated a historic landmark in Chicago in 1970 as an early high-rise building with a steel frame. A central light court provided daylight for the offices. Electric lamps were available for illuminating buildings, but the architects assessed the technology as unreliable and therefore did not illuminate the building exterior (Evitts Dickinson 2012). The building underwent several renovations, including changes of interior luminaires and reopening of the light court ceiling, before exterior lighting was added in 2011 (**Figure 13**) **[77]**.

Figure 13: The Rookery, Chicago, Illinois, 2011. Architecture: Daniel Burnham and John Wellborn Root, 1888. Lighting design: Office for Visual Interaction. Photo by Adam Daniels. Image © Adam Daniels Photography.

A strict preservationist attitude would not have permitted illuminating the façade, because it would have broken up the original night appearance of the building. In contrast, the use of a steel frame at that time indicated that the architects expressed a high interest in the latest available technology. Therefore, the lighting designers from the Office for Visual Interaction considered contemporary lighting tools and sensitively lit all of the window frames of the brick façade with grazing light using sophisticated LED technology. Floodlighting and bright spotlights were regarded as inadequate lighting tools for the complex surface details. Of course, luminaires could not be directly fixed to the terra-cotta surface because of the building's historical landmark status. The new façade illumination is not a neutral response due to its historical background as Capdevilla remarked, but it keeps the uniformity of the building by including all window frames while the front surface is not lit in order to provide a link with the original nonlit exterior lighting.

A similar situation occurred for Carnegie Hall in New York, where the façade was illuminated for the first time after 125 years. The design for the landmark by Kugler Ning Lighting included illuminated window frames as well, but additional areas using grazing light for the entrance and first floor, as well as light for the cornice, have created a more festive image.

5.4.8. Media facades: Semantic shift across time

The field of media facades is another example where semiotics presents a valuable asset to evaluate the design and could help to develop readable design solutions for citizens. For example, the Hongkong and Shanghai Bank (HSBC) Headquarters by Norman Foster vividly illustrates the change of lighting over time in the digital age of LEDs and screen technology **[92]**. The original open layout with its exposed steel structure generated a powerful corporate identity for the bank (**Figure 14**).

Figure 14: Hong Kong and Shanghai Bank Headquarters, Hong Kong, in 1986. Architects: Foster + Partners. Lighting design: Claude and Danielle Engle Lighting. Photographer: Ian Lambot. Image © ERCO, www.erco.com.

However, the restrained atmosphere of white architectural lighting with two color temperatures and the lack of distinctive façade lighting had lost its attractiveness two decades after its opening in 1986. The colorful and dynamic relighting presents a remarkable example of how an architectur icon has shifted from a productivist ideology toward a scenographic image — a temporal dimension that Bonta discussed **[28]**. To the Western observer, the multicolored light language may give off a playful impression, but to the local culture the transformation evokes grandiosity.

In 2003, the façade illumination changed from a discreet glow from within into colorful light lines and bright search lights to create a beacon of light for the Hong Kong skyline. Since 2004, the Hong Kong Tourism Commission has tried to become a benchmark for city marketing in Asia with the largest sound and light show in the world, called “Symphony of Lights.” With globalization, rising economic competition, and political changes, the city has looked to tourism to increase business and to mark a strong, modern, and dynamic identity. Nevertheless, the first façade lighting update did not cover the newer expectation of higher visibility and more explicit messages of brand communication. For that reason, the façade lighting was amplified with a media wall for the 150th HSBC anniversary in 2015 (**Figure 15**). Synchronized with the façade lighting, the media walls offer a very flexible infrastructure for independent content or echoing the effects of the architectural lighting on screen or vice versa. Erected originally on the ground of a British colony as a distinctive British high-tech office tower, localized with a feng shui expert, the HSBC building now resides on an autonomous territory of China. The search for a new identity, significantly influenced by globalization, has led to a new luminous mask to conceal a tough and cold finance building. This colorful overlay of pattern, made of light, has turned the HSBC into an obvious dualism: during the daytime, it conveys the cool rational image of productivism, but at night the explicit scenography demonstrates a soft emotional character.

Figure 15: Hong Kong and Shanghai Bank Headquarters, Hong Kong, in 2015. Architects: Foster + Partners. Photographer: Simon McCartney. Image © illumination Physics.

5.4.9. Street lighting: Psychological message

On a larger scale, many cities have updated their lighting installation for energy efficiency. Though from an engineering perspective the installations were comparable to or better than the older high-pressure sodium lamps in terms of illumination level, lighting distribution, energy consumption, and lifetime, the effect of one minor change was significantly underestimated. The local residents perceived the change to a cooler color temperature as less romantic **[99]**. The response revealed a strong symbolic power of the color temperature, which was also linked to different regions like Los Angeles as a modern city tolerating a cooler color temperature in contrast to the ancient origin of Rome requiring a more romantic, warmer light. In another city the residents called the new LED street lighting “zombie lights” and “prison lighting,” for example, due to a combination of high brightness and cool color temperature **[9]**. A semiotic analysis with the semiotic model of Peirce could help to identify the role of the interpreter to prepare a holistic, user-friendly design.

5.4.10. Light for branding: Urban identity

The term “light” has also been turned into a tool for urban self-representation and thereby into marketing communication as well. This strategy is visible in hotel names with illuminated signage on top of the building, like the Nordic Light Hotel in Stockholm, or for large-scale urban marketing with the term “city of light,” like Paris, Eindhoven, or Lüdenscheid—either associated with a long history of electric lighting going back to the Exposition Universelle of 1889 or with local lighting manufacturers like Philips or ERCO. The worldwide light festivals represent a temporary version for city marketing where cities use light to create awareness and use light to define their identity **[40]**.

5.4.11. Urban lighting: Images triggering sustainability

Despite the interest in light festivals and representative outdoor illumination, the rising awareness of light pollution has led to a countereffect where regions regard darkness as an important value and have started to establish dark sky parks in order to communicate their sustainable orientation **[1,24]**. The growing number of satellite images of cities at night and the publication of respective reports have developed into important visual media to inform a wide audience about light pollution **[52]**. The change in visualizations of light from street-view photos to satellite images symbolizes a shift in the social context from local to global. Later, intense street lighting, captured on a large scale with satellite images, triggered discussions regarding politics and economics with the mutually profitable relationship between politicians, electrical

Figure 16: #WeLiveHere2017 Community light project, Waterloo, Sydney, Australia, 2017, www.welivehere2017.com.au. Image by Jessica Hromas. © Jessica Hromas for #WeLiveHere2017.

distributors, and energy suppliers—a social dimension that Delitz emphasized and that had been pointed out, for example, in the highways in Belgium [94].

5.4.12. Urban lighting: Rhetoric for political activism

The symbolic power of light and architecture has been used increasingly in recent years by various groups to engage the public and relates to the behavioristic semiotic model. Illumination with colors or projections with images and text were temporarily applied mainly to landmark buildings. The design ranged from abstract to figurative imagery and the fields of interest included environment, health, and social issues as well as politics. Iconic design solutions were used to ensure a wide response for mass communication in printed and social media.

The annual Earth Hour has turned into a global event to raise awareness of energy consumption and light pollution [108]. With its 1-h duration for turning off the illumination, the effect can be regarded as symbolic and not as a significant influence on the total lighting energy consumption.

Famous landmarks like the Eiffel Tower play an important role to gain widespread attention. In contrast, artists considered projected animations of endangered species for their environmental campaign on the Empire State Building [81]. Again, the selection of a building with a global status was essential for press communication.

To focus on health issues like the World AIDS Day, text projections on several buildings were used to create awareness [65]. Alternatively, the campaign against autism was more abstract and used blue light on World Autism Awareness Day [98].

In opposition to the general projections onto façades, an art project in Sydney activated residents of two 30-story residential buildings to create an architectural light sculpture with light from within (**Figure 16**) [35]. All participants received a color-changing luminaire for their window with a remote control to individually express their mood using constant color or strobe or flash. The protest was targeted against the demolition and privatization for a large inner-city real estate development and gained international press publicity.

Political initiatives address issues like economy and terrorism. During the Occupy Wall Street movement, activists utilized text projection to summarize the protest of a march [41]. Later, the New York art-activist collective "The Illuminator" used a van for optimum mobility for various events, which raised and lowered a projector through the roof and applied software that also allowed writing on buildings in light in real time. Light installations to commemorate tragic attacks by terrorists started with the "Tribute to Light" in New York in memory of the people killed on September 11, 2001 [68]. The twin beams reached up into the sky and became an annual event. The worldwide terror threats led to global acts of solidarity and sympathy after terror attacks—for example, after incidents in Paris in 2015 and Brussels and Berlin in 2016—where international landmarks were highlighted with the color code of the respective nation [72].

6. Limitations

The main critic against interpreting architecture as language lies in the aspect that architecture does not fulfill the two basic requirements for language: Parts of buildings do not create a vocabulary that creates certain meanings based on lexical rules and neither do syntactic rules exist for the way in which the meaning of complete buildings results from their parts [6]. The aspect of light as a medium additionally raises the argument that light can only be perceived via a reflective surface and therefore does not represent an independent language.

6.1. Limitations for Architectural Semiotics

Critiques against architectural semiotics have been published by several authors. One problem of a linguistic view of architecture began with the different assumptions about the nature of language [96]. Many writers mixed language with style, argued Scruton. Furthermore, he differentiated natural and intentional signs and concluded that architectural signs are rather natural but a code is not necessarily involved. It is also important to critically reflect on the perspective of the discourse, because interpretations can vary, depending on whether the analysis has a historical or stylistic focus or alternatively a functional or typological emphasis [11]. For instance, when one depicts problems in the building type or in certain façade details, the typological or morphological similarities would be more important than historical links.

The analogy between architecture and language is tempting for the issue of meaning in architecture, but several criteria for language proved architecture to be non-linguistic [21]. Due to the opposition of form and content in combination with architecture as a field where the form appears to be paramount, one could detect attempts to isolate the content. This tendency marked a shift toward a discourse in an aesthetic of form rather than a semiotic discussion [67].

Another reaction to very abstract semiotic analyses was the introduction of socio-semiotics, where the connotative codes were interpreted as products produced by groups and classes connected with urban life [31]. One example is the legacy of Lynch, with his publication of the five features of paths, edges, districts, nodes, and landmarks as urban reference points, which reduced the use of urban environment to the activity of movement and did not consider the role of ideology according to Gottdiener and Lagopoulos. This urban view is particularly relevant for creating urban lighting and the creation of master plans.

For Harries, the fascination between linguistics and architecture was linked with the crisis of modern architecture, where meaning had been lost and critics had looked for more complex reflections [36]. He questioned whether objects could send an intentional message. For instance, if we call a cloud a sign of rain, it seems inappropriate to assume that this cloud wants to tell us something. Transferred to lighting, this would mean that we understand the sun as a sign of light. In the context of ancient Egypt, the sun was regarded as a sign linked to the solar deity Ra and could consequently be interpreted as a sign, but within modern natural sciences this intention of the sun is not given.

Furthermore, Harries warned that the use of words like “language,” “syntax,” and “grammar” could confuse more than they are able to explain. In a language, specific words can replace each other in a sentence whereas others cannot. For example, a window frame within a wall could be filled with stained glass or with simple transparent glass. This would be equivalent to introducing a word from another language. Filling the window frame with a brick wall would generate architectural nonsense, but we could imagine that a deconstructive or postmodern architect could attempt to do such construction. Certain brands, for example, break the role of good visibility in their stores in order to offer customers an abnormal mysterious appearance within a dark space [90].

Additionally, Harries referred to Eco when he mentioned that objects must communicate or denote their function and that this needs to be supported by existing codification. This aspect becomes apparent when new elements like light control interfaces are introduced with a radical new look. As a result, in his critique of symbols, Harries preferred to speak about architecture as representation and to ascribe a pictorial function. He exemplified this perspective with the medieval church and the use of gold and especially illuminated with flickering candles. The shimmering gold was a metaphorical device related to passages from the Bible and should transport the faithful from this world into “the True Light” [36]. The stained glass window was another metaphorical device for Harries. Here Harries indicated that we consider such language of light today as merely metaphorical, but for the medieval artist’s worldview, light was spiritual and the bridge to the sacred sphere.

Due to the linguistic- and image-orientated concepts of the sign theories by Ferdinand de Saussure, Charles S. Peirce, Nelson Goodman, and Umberto Eco, Gleiter suggested extending the semiotic model with phenomenology [29]. For him, architectural signs included three aspects: pictorial, phenomenological, and performative. From a distance, a window may appear as a pictorial sign. Being close to a window, it may appear as a real window for looking out and that it can be opened. If a person actually looks out of the window or opens it, a shift from the phenomenological aspect toward the performative begins.

6.2. Limitations for Lighting Design Semiotics

In general, the critique regarding architectural semiotics cannot be removed for architectural lighting, and some arguments have already been illustrated in terms of light. But due to the fact that we see only reflected light, the aspect of light is inherent to our observation of architectural forms, contours, textures, and materials. However, the dimension of either daylight or illumination is seldom addressed. It appears that the image of light emerges as another layer on the architectural surface. However, the rays of sunlight do not stop at the surface, but they are reflected and thereby influence the appearance of other areas as well. A discussion of light as a language independent from architecture seems absurd. But a semiotic perspective can help to identify the two elements of light and architecture and to describe their relationship; for example, as a unity, contrast, transformation, or exaggeration. For instance, a space with designed white walls generates a unity with reference to material and color. Considering downlights with their characteristic scallop pattern on the upper part of walls dissolves the unity, whereas a uniform lighting distribution of wallwashers enhances the spatial unity [89].

Hill responded to the issue of reflectivity on surfaces as well when he criticized Scruton’s arguments with realistic and nonrealistic subcategories [38]. When seeing physical objects like façade constructions creating patterns of bright light and shadow, one could assign a realistic seeing in Scruton’s terms. But the case is more problematic when the overall space is considered and we see a quality of calm and clarity of the light and raise the question of whether this should be regarded as nonrealistic seeing according to Scruton. Hill suggested solving this problem by interpreting light as reflectivity on surfaces. In the first step, the individual surfaces would be construed as realistic seeing, which would be equivalent with Scruton’s realistic perception. In the second step, the light in the space would be understood as an imaginative object, which would relate to the nonrealistic perception. An option for Hill was the idea that a space has characteristics, one of which is the quality of light. According to Hill, light moves people. He illustrated this with John Soane’s architecture and argued that the aesthetic perception does not derive from manipulating surfaces with color, decoration, and mirrors.
From a linguistic point of view, with morphemes as the minimal distinctive unit of grammar, light could be considered as a bound morpheme, which is linked to the architectural element. It requires architecture to alter the meaning [17]. In this way light becomes a derivational affix. This means that as an affix it cannot exist without the morpheme of the respective architectural element, but as an affix it builds a new word in combination with the architectural unit and carries a new meaning.

Critique with regard to communication theory and light was brought forward by McLuhan, who said that light is not a medium and electric light is pure information, unless it is used to spell out some verbal advertisement or name [62]. This statement was developed from his understanding that a society is influenced more by the media used than the topics within this medium. However, this intense focus on the medium also implies that the content and social dimension of media are

neglected. It is obvious from the different above-mentioned case studies that the content of the medium light has a substantial effect and is relevant for the resulting reactions by people and society.

7. Conclusion

Applying semiotics directs the focus on the quality of lighting design. Considering the meaning of light within the design process leads to more sustainable solutions with an optimization beyond the widely discussed economic and performance factors like efficiency or visibility. Semiotics can serve as a tool to understand architecture and lighting regarding their signifying dimension and to identify the meaning. This view is based on the concept that lighting conveys a meaning next to the function of visibility and safety.
The strength of the semiotic method lies in the ability to analyze complex systems of signs that lighting designers deal with: light sources, luminaires, integration in architecture, and illuminated interior spaces, up to urban design. This approach offers a variety of perspectives to imagine and analyze the structural rules of the lighting design composition, the relationship between the light-filled space and the meaning, and how people respond to light.

Theories of architectural semiotics offer a valuable background for transferring the method to architectural lighting design. The semiotic matrix offers a differentiated view of relationships based on the aspects of sign, object, and interpreter in relation to light characteristics, illuminated building, and architectural lighting in general. Depending on the research problem, the emphasis of the semiotic approach is adjustable. Academics have pointed out several aspects where the applications of semiotics could lead to problems; for instance, when semiotics bases everything on signs or words and moves away from perception without using words like the phenomenological perspective with emotion and presence. A semiotic analysis considering only light without architecture is short-sighted as well. However, the critique does not question the use of semiotics for architecture and light in general but focuses on structural details.

Addressing the meaning of light could also benefit the debate about human-centric lighting and its search to include the usefulness of lighting. With this methodological potential, semiotics deserves a larger recognition not only within the lighting research community but also for practitioners, educators, and critics. ■

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Additionally, he has taught lighting design at different universities and was invited for lectures at institutions like Harvard GSD, MIT, Columbia GSAPP and ETHZ. His dissertation at the University of Technology in Darmstadt, Germany, has analysed architectural lighting. His research interests focus on qualitative lighting design. Thereby, he examines the way in which light can be used to interpret architecture and to express a semantic quality. Further, he explores the development of contemporary light patterns, technologies and visualisation techniques to detect historical influences and to critically discuss the progress of light and architecture. His column “Light Matters” on ArchDaily reveals various perspectives of architectural lighting.

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Recognizing Excellence in Smart City Sensors

Zhaga Consortium[1]

The Zhaga Smart City Sensor Awards recognize the most innovative, streetlight-compatible smart city sensors already on the market and encourage the development of new ones.

Smart cities depend on data – data that is often collected using sensors. In fact, many cities are already using sensors to monitor traffic, measure air pollution, forecast weather and detect noise levels.

But this is only the tip of the iceberg of what these sensors are capable of. To leverage their full power, they must be completely integrated into a city's existing infrastructure.

Enter the humble streetlight.

"When it comes to smart city sensing tasks, nothing beats the streetlight," says Francesco Martini, Chair of the Zhaga Steering Committee. "Already ubiquitous in most cities, the streetlight not only offers a strategic location for smart sensors, it's also a secure piece of powered infrastructure available at a low cost."

Francesco MARTINI, Chair of the Zhaga Steering Committee

With over 500 members, Zhaga is the global lighting industry consortium with the mission of standardizing the interfaces of components of LED luminaires – including streetlight sensors. It does this through its specifications, which Zhaga refers to as Books.

Each book defines the interface of one or more components of an LED luminaire. All sensor/communication modules and luminaires designed and certified in accordance with a Zhaga Book are guaranteed to work together as intended, even if they come from different manufacturers. Taken together, the interface specifications established by Zhaga Books enable an interoperable ecosystem of luminaires and components.

"When it comes to smart city sensing tasks, nothing beats the streetlight."

FRANCESCO MARTINI

The Backbone of Data-Driven Smart Cities

Entitled 'Smart Interface Between Outdoor Luminaires and Sensing/Communication Modules', Zhaga Book 18 standardizes the interface between luminaires and sensors that can be installed on streetlights. "Streetlights are regularly positioned, secure, powered and in a great location for many sensing tasks and for communications," explains Martini. "Zhaga's Book 18 takes this further by standardizing the mechanical interface, intra-luminaire communication protocol and power budget for a control device."

The Book was developed based on a liaison between the Zhaga Consortium and the DALI Alliance (DiiA), the owners of the DALI lighting protocol and D4i, which standardizes the communication between the sensors and the luminaires.

"Zhaga Book 18 creates the ecosystem of products needed to future-proof luminaires, while the Zhaga-D4i certification provides the trust companies need to get there," adds Martini. "By putting them together, we've elevated the streetlight from mere lamp to the backbone of tomorrow's data-driven smart cities."

[1]**Zhaga Consortium**
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Jury Members of the Zhaga Smart City Sensor Awards (left to right):
Kevin FITZMAURICE, Principal of Smart Services at Georgia Power
Paul BAGINSKI, Head of Lighting Services at Dortmund Energy Company
Graham MAWER, PgM of the SSROC Streetlighting Improvement Program in Sydney
Christophe ORCEAU, Chairman of the TALQ Consortium Steering Committee
Carl BLOOMFIELD, VP of Commercial Infrastructure and Industry Regulations at Intertek
Ted DROST, Global Technical Leader at DEKRA

ZHAGA Consortium

In 2021, the Zhaga Consortium published the third edition of Book 18. This new edition allows for architectures that combine an ANSI C136.41 dimming receptacle with a Zhaga receptacle next to the architectures previously specified in the prior edition.

"Zhaga Book 18 creates the ecosystem of products needed to future-proof luminaires."

FRANCESCO MARTINI

"This is good news for those parts of the world that are more comfortable with ANSI/NEMA-based lighting controls who still want to add Zhaga-D4i based smart city sensors to their streetlights," notes Kevin Fitzmaurice, Principal of Smart Services at Georgia Power.

An Idea is Born

With over 200 families of Zhaga-D4i luminaires from over 50 manufacturers already certified, it has become the most cost-effective way for deploying smart sensors. As a result, more cities than ever are now leveraging the power of streetlight-compatible smart city sensors. One of those cities is Dortmund, Germany. Over the course of the next two years, the city plans to change about 11,000 streetlight fittings to D4i certified luminaires.

Meanwhile, in Sydney, Australia, a large group of local governments intended to design 62,000 hybrid Zhaga-D4i certified streetlights to be the backbone of its planned smart city infrastructure. However, before this could happen, the group first needed a range of innovative, low cost Zhaga-based sensors with compelling capabilities. So, they decided to approach the Zhaga Consortium to see what could be done to promote the creation and development of Zhaga-D4i innovative smart city sensors.

"We quickly realized this was an opportunity not only to support the Sydney region, but to recognize the most innovative, streetlight-compatible smart city sensors already on the market and encourage the development of new ones," says Martini.

The outcome was the inaugural Zhaga Smart City Sensor Awards.

Winners

Launched in September 2022, the Awards recognize excellence in smart city sensors designed to be installed on streetlights using the Zhaga Book 18 standard and that are suitable for Zhaga-D4i certification. "The Smart City Sensor Awards are a great way to help identify excellence in sensors," says Graham Mawer, Program Manager of the SSROC Street Lighting Improvement Programme in Sydney, who also served on the Awards' jury panel.

Companies, academic institutions, and individuals from around the world were encouraged to submit their smart city sensors for consideration in one or more category, including mobility, climate, pollutants, sound, lighting controls, multi-sensors, innovation and research.

All submitted sensors had to meet the physical, electrical, and connectivity requirements of Zhaga Book 18 Edition 3. This included the ability to comply with D4i requirements for luminaire-mounted control devices. Sensors could be designed to communicate directly with an external IoT communications network or via the DALI bus in the luminaire (and ultimately via a luminaire-mounted lighting control). Sensors had to be either an available product suitable for Zhaga-D4i certification or, if new, a working prototype needed to be available for demonstration.

Judged by a panel of smart city and sensor experts, including city officials, utility companies and industry associations, the jury evaluated qualifying submissions coming from sensor manufacturers. After careful consideration, the jury awarded four solutions from four categories.

■

A Game-Changing Sensor to Measure Traffic Density and Patterns

TRIDONIC | SensorX

Based on the Zhaga-D4i standard, this game-changing image-based sensor is designed to accurately measure traffic density and patterns in real time. The sensor provides data that urban planners can use to mitigate, for example, road congestion, while also optimizing the use of roads, bridges and tunnels. It can even be used to generate street lighting based on traffic density.

"Thanks to the application controller logic, SensorX will be able to send commands, via the DALI line, directly to the driver –

Tridonic's SensorX

Eduardo PEREIRA, Product Manager Outdoor Controls at Tridonic

a feature that enables several benefits, including energy savings, reduced light pollution and increased safety," says Eduardo Pereira, Product Manager Outdoor Controls and continues, "At Tridonic, we are thrilled and proud to accept the Zhaga smart city sensors award in the mobility category. This recognition is a testament to our commitment to delivering innovative and sustainable lighting solutions that enable smart cities to become more livable, efficient and resilient."
Other use cases include advanced presence detection and parking lot management. As to the former, because the sensor can recognize different road users, when it detects a pedestrian crossing the street, it can send commands to adjacent luminaires to warn oncoming vehicles.

"This new Tridonic sensor is a real game changer for street lighting and traffic measurement."

EDUARDO PEREIRA

For parking lot managers, SensorX will offer a flexible solution that can be integrated into the lighting infrastructure. Not only will this allow users to add, remove or change the parking lot spaces on demand, it will

enable increased flexibility and lower costs compared to the magnetic counterpart. SensorX is being developed using artificial intelligence with edge deployment, meaning that the images acquired by the sensor are processed in the sensor itself and only the result of the analysis is sent via the DALI bus. This means no picture of video ever leaves the sensor at any time during operation, thus fulfilling data protection requirements. According to Pereira, when released in October 2023, the SensorX will revolutionize the market. "Camera systems are expensive, bulky and require special mounting systems," he says. "With the help of the Zhaga interface, SensorX changes everything, making the installation and integration into streetlighting infrastructure almost effortless."

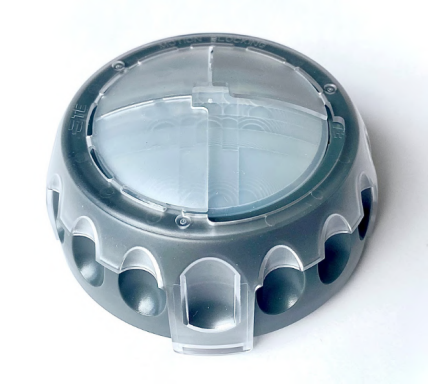
www.tridonic.com

■

An Innovative Motion Sensor

TE Connectivity | LUMAWISE Motion Sensor

In the Adaptive Lighting Control category, which includes motion detection and other sensors that control lighting levels, TE Connectivity was awarded for its LUMAWISE Motion product.



TE Connectivity's LUMAWISE Motion Sensor

Jonathan CATCHPOLE, System Architect at TE Connectivity

The American-Swiss company designs and manufacturers sensor and connectivity solutions.
"LUMAWISE Motion is a motion sensor designed specifically for street lighting," explains Jonathan Catchpole, System Architect at TE Connectivity. "The pluggable device enables energy savings by dimming or even turning off a luminaire without compromising the sensor's safety and security benefits of reacting to motion and bringing the luminaire back to full brightness."

"With LUMAWISE Motion, you don't have to choose between efficiency and safety, it lets you have both."

JONATHAN CATCHPOLE

The sensor will fit into the Zhaga-D4i ecosystem, which Catchpole says is the new standard for smart cities. It can work as a standalone control device, in combination with Zhaga-D4i photocell, or, for even greater levels of control, as a communication node.

According to Catchpole, some organizations are choosing to turn outdoor lighting off during low use times. "While doing so may improve efficiency, it compromises safety and security, which is the main purpose of outdoor lighting," he says. "With LUMAWISE Motion, you don't have to choose between efficiency and safety, it lets you have both."

"Zhaga-D4i ecosystem being completed with smart city sensors."

JONATHAN CATCHPOLE

Other benefits include a compact design that doesn't distract from the aesthetics of the modern luminaire and the ability for an installer to easily secure the sensor with one hand while working below the luminaire. "TE Connectivity is excited to receive this Zhaga Award for LUMAWISE Motion. The Zhaga Awards isn't just about bring end users and manufacturers closer together, but is a symbol of the Zhaga-D4i ecosystem being completed with smart city sensors," Catchpole concludes.

www.te.com

■

An Adaptive Lighting Control / Multi Sensor Crossover

Citylight.net | CNODE IOT AMR IoT Sensor

Citylight.net, who designs smart IoT luminaire controllers, was also awarded in the Adaptive Lighting Control category for its CNODE IOT AMR IoT sensor. The versatile and convenient all-in-one outdoor luminaire controller provides advanced lighting control for a range of outdoor lighting applications. The sensor, which is commercially available, features built-in cellular technologies such as LTE, with fallback to 3G and 2G, providing global coverage without the need for a gateway infrastructure.

Citylight.net's CNODE IOT AMR IoT Sensor

Reinis KULA, Founder of Citylight.net

One of the CNODE IOT AMR sensor's key differentiators is its support for the Wireless MBus 868MHz OMS automated meter reading protocol – a wireless protocol used by the utility meter industry.

According to Citylight.net founder Reinis Kula, with this feature, utility companies can read water, heat, gas or electricity meter data from a distance of up to 600m of the luminaire controller. "This means multiple municipal utility companies can simultaneously read meters and share the costs for one cellular communication channel," he says. "Remote meter data reading also reduces maintenance costs, improves services and provides on-time data for utility companies."

The sensor enables detailed driver data readout and control, making it ideal for areas where precise lighting control is required. The CNODE IOT AMR also features a Zhaga Book 18 physical interface, ensuring fast and reliable connection with the luminaire and making it easy to install and maintain. Moreover, the built-in GPS receiver provides automatic commissioning on the luminaire during setup and eliminates the need for manual labor.

"With this wireless feature, utility companies can read water, heat, gas or electricity meter data from a distance of up to 600m."

REINIS KULA

"The CNODE IOT AMR sensor offers a range of compelling benefits for those looking to streamline their outdoor lighting control and utility management needs, making it an ideal solution for smart city applications. In name of all Citylight.net team I would like to extend our sincere thanks to the Zhaga Consortium for organising the Smart City Sensor Awards and for recognizing our product CNODE IOT AMR smart outdoor luminaire controller and Wireless MBus gateway as the winner in the Innovation category. This award is a great honor and a validation of our team's hard work and dedication to developing innovative solutions for smart cities. We appreciate the opportunity to participate in this event and look forward to continued collaboration with the Zhaga Consortium in the future.," adds Kula.

www.citylight.net

■

An Outdoor Multi Sensor to Support Different Smart City Applications

Signify | Philips Outdoor Multi Sensor LRI8135

In the Multi Sensor category, which covers sensors that combine two or more functionalities, the award went to Signify for its Philips Outdoor Multi Sensor (OMS) LRI8135. The OMS connects to streetlight luminaires via the Zhaga Book 18 (edition 3) socket interface.

Intended for use in Zhaga-D4i certified outdoor luminaires, the OMS includes several

Signify's Philips Outdoor Multi Sensor LRI8135

Maria Luisa MARTINEZ CESPEDES, Global Product Manager Sensor (Public) at Signify

sensors to support different smart city applications. For example, it can serve as a radar motion sensor to automatically increase light levels, as a light sensor to enable dusk-to-dawn operations, or as noise and temperature sensors to monitor ambient conditions near the light pole.

"The main benefits of the Philips OMS are increased safety, reduced crime and significant energy savings – by as much as 30%," says Signify's global product manager sensor (public), Maria Luisa Martinez Cespedes. "The data collected can also contribute towards more efficient maintenance schedules."

The multi sensor can be used either standalone or in combination with Signify's CT nodes that connect the luminaire to the Interact City lighting management system. In a stand-alone deployment, the device can be used for dusk-to-dawn light control or light on demand applications in which the light level is increased when activity is detected. The neighboring luminaires can be controlled through an internal mesh network. In an Interact City connected deployment, the device can also be used to flag unsafe light pole conditions (for example due to crash).

"The Philips OMS is a future-proofed system that can easily be updated with the latest software versions," continues Martinez Cespedes. Besides light on demand, ambient noise and temperature monitoring, the OMS features some additional safety notification use cases. For instance, tilt sensors and impact sensors can be set at specific thresholds in the Interact City application. If the set value is exceeded, it generates safety alerts to signal a potential danger, crash or maintenance issue. The same holds true for the noise sensor.

"The OMS provides reliable detection of vehicles, cyclists, and pedestrians and light levels that can be adjusted as needed."

MARIA LUISA MARTINEZ CESPEDES

"The housing of the Outdoor Multi Sensor can be rotated, making it possible to fine-tune the motion detection area for every use case," adds Martinez Cespedes. "As such, the OMS provides reliable detection of vehicles, cyclists, and pedestrians and light levels that can be adjusted as needed. We are delighted to have won a Zhaga Sensor Award for our Zhaga-D4i certified, Philips Outdoor Multisensor, which is designed to support many smart city applications."

Launched in 2021, the OMS is already being used in many projects.

www.signify.com

■

Defining the Smart City of Tomorrow

"The Zhaga Smart Sensor Award is another step towards the transfer of knowledge gained from smart lighting in the past decade to a variety of other smart city applications," concludes Martini. "Not only do each of our winners celebrate the innovative solutions on the market today, they also challenge other manufacturers, innovators and researchers to create the next generation of sensors that will define the smart city of tomorrow." ■

ZHAGA Consortium

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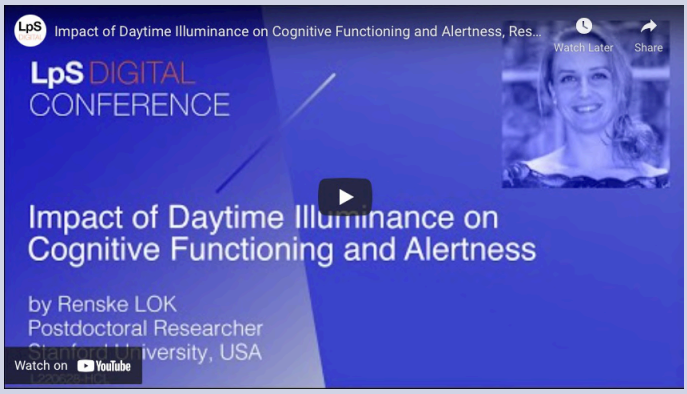

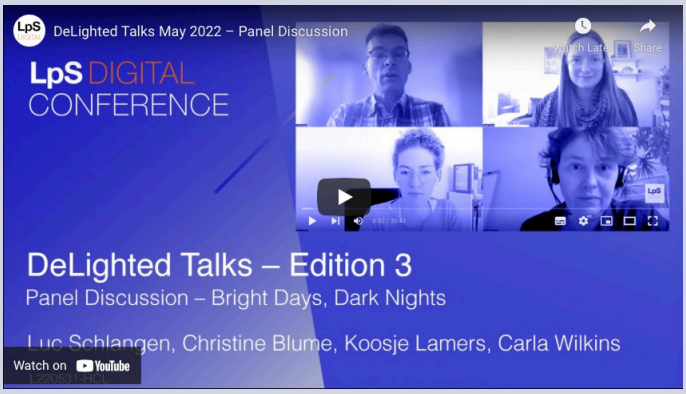

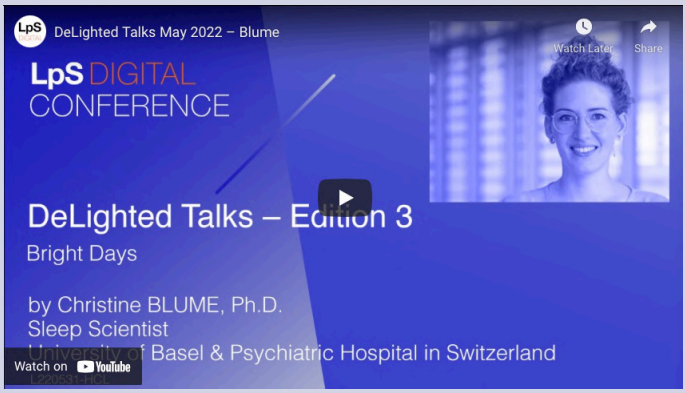

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