TALQ White Paper

Managing Artificial Light at Night (ALAN)

How Interoperable Smart Street Lighting Systems Enable More Sustainable Cities

June 2026

TALQ Consortium

About TALQ

The TALQ Consortium has developed a global standard protocol to enable Central Management Software to configure, control, command and monitor multiple Outdoor Device Networks from various suppliers through an easy-to-integrate RESTful/JSON protocol. TALQ is open to industry members to join and participate in the evolution of the TALQ Protocol.

TALQ also provides a Partner Program for cities, municipalities, utilities and consultants to contribute to the future of Smart City. To learn more about the consortium, our members and partners, please visit www.talq-consortium.org

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About this document

This white paper explains the importance of managing artificial lighting at night to benefit the environment, biodiversity, and achieve energy savings. The TALQ Smart City Protocol can play a key role in allowing cities to control their own impact. For any further explanation of the contents of this document, or in case of any perceived inconsistency or ambiguity of interpretation, please contact the TALQ Consortium:

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1 EXECUTIVE SUMMARY

Artificial Light at Night (ALAN) is an increasingly recognised challenge for cities worldwide. While public lighting remains essential for safety, mobility, and economic activity, growing evidence shows that excessive or poorly managed lighting can have unintended consequences. These include negative impacts on ecosystems, energy consumption, and overall urban efficiency.

A growing number of cities and municipalities are therefore re-evaluating how outdoor lighting is planned, operated, and integrated into broader urban systems. The objective is not to reduce lighting indiscriminately, but to use light more intelligently – **providing the right light, at the right place, at the right time.**

Recent advances in smart street lighting technologies offer practical pathways to address ALAN. Adaptive lighting – enabled by **dimming, scheduling, and sensor-based control** – allows cities to dynamically adjust lighting levels based on real-time conditions such as traffic, weather, or time of night. Additionally intelligent technology allows also to **control the light spectrum and colour temperature of the light**, as different species have different light spectral sensitivity. Taking all these aspects into account helps to balance safety requirements with environmental and energy considerations.

However, technology alone is not sufficient. Many cities face fragmented infrastructures composed of systems from multiple vendors, often operating in silos. This can limit flexibility, increase costs, and restrict the ability to implement ALAN reduction strategies.

In this context**, interoperability emerges as a key enabler**. Open, standardised interfaces allow different systems in smart cities – such as lighting, traffic management and environmental sensing – to communicate and operate together. This creates the foundation for more coordinated, data-driven urban services.

The TALQ Smart City Protocol plays a role within this ecosystem by enabling interoperability between Central Management Software (CMS) and outdoor device networks (ODN) managing field devices across different manufacturers. By supporting multi-vendor integration and facilitating data exchange, TALQ helps cities to implement **adaptive lighting strategies at scale**, avoid vendor lock-in, and future-proof their infrastructure investments.

Practical applications already demonstrate the potential of such approaches. Cities are increasingly using adaptive lighting to reduce light levels during low-traffic periods, adjust illumination based on environmental conditions, and support biodiversity – for example, by limiting lighting during wildlife-sensitive periods such as bird migration or turtle hatching seasons.

Looking ahead, regulatory frameworks and sustainability goals are expected to further increase the importance of managing ALAN. At the same time, the continued evolution of smart city technologies will provide new opportunities to integrate lighting into broader urban systems.

2 Outdoor Lighting the Modern City – At What Cost?

2.1 Why outdoor lighting matters

Public lighting is a fundamental component of modern urban infrastructure. It supports road safety, enhances public security, enables economic activity after dark, and contributes to the overall quality of life in cities and communities worldwide. From major metropolitan areas to smaller municipalities, outdoor lighting plays a vital role in shaping how public spaces are used and perceived.

Over the past two decades, street lighting has undergone a significant technological transformation. The transition from conventional lighting technologies to energy-efficient LEDs is enabling substantial reductions in energy consumption and maintenance costs. At the same time, the emergence of smart lighting systems – featuring remote control, monitoring, and automation – has opened new possibilities for managing lighting more dynamically and efficiently.

These developments have brought clear benefits. Cities today are better equipped than ever to provide reliable, cost-effective, and adaptable lighting services. However, they have also partly contributed to a steady increase in the amount, intensity, and spatial reach of artificial light at night.

2.2 What is ALAN

Artificial Light at Night (ALAN) refers to the presence of human-made light in outdoor environments during natural dark periods. It encompasses a wide range of lighting sources, including street lighting, architectural illumination, commercial signage, sports facilities, and residential outdoor lighting.

The main sources of ALAN in urban contexts include:

- Street and roadway lighting
- Public space and architectural lighting
- Commercial and advertising lighting
- Industrial and infrastructure lighting
- Residential outdoor lighting

The growth of ALAN is driven by several factors, including urbanisation, increased economic activity at night, and the widespread adoption of LED lighting, which – while energy-efficient – has also made it easier and more cost-effective to install higher levels of illumination.

At the same time, awareness of ALAN as a critical issue has grown. Scientific research and policy discussions increasingly recognise that artificial lighting, when not carefully managed, can have broader implications beyond its intended purpose.

2.3 What are the adverse effects of ALAN

The attention for and intensity of ALAN has increased in recent decades, and both is expected to grow further. Therefore, cities and municipalities must take possible side effects of ALAN into consideration for their investment decisions.

Public lighting systems are intended for illumination and safety but can also have adverse effects, such as:

- **Energy waste and emissions**:
  Excessive light at night consumes unnecessary energy. This leads to avoidable carbon emissions and higher costs for cities.
- **Light trespass and glare:**
  Overly bright or poorly shielded luminaires cause glare. Misdirected light might spill into private homes and gardens.
- **Skyglow and loss of the night sky:**
  Upward or scattered light creates a bright dome over towns and cities. Stars become much harder to see, affecting both astronomy and the natural character of the night.
- **Disruption of ecosystems and biodiversity**
  Many species depend on natural darkness for navigation, feeding, and reproduction.

One of the most widely documented effects of ALAN is the last one of the list above, its impact on ecosystems and biodiversity. Many species have evolved in environments governed by natural light-dark cycles. Artificial lighting can disrupt these cycles, affecting behaviour, reproduction, and survival.

Cities are therefore increasingly exploring ways to reduce unnecessary light exposure without compromising safety or comfort. So today, the focus should shift from 'more light' to 'adopted and purposeful light' – an approach that is increasingly supported by advances in smart and connected lighting technologies.

3 HOW CAN LIGHTING CONTROL SYSTEMS HELP REDUCING THE NEGATIVE ASPECTS OF ALAN

3.1 Benefits of an adaptive outdoor lighting control system

Traditionally, outdoor lighting systems have operated in a largely static manner. Streetlights were typically switched on and off at fixed times or based on simple daylight sensors or fix timetables, with little or no variation in light levels throughout the night. This approach prioritised simplicity and reliability but often resulted in over-lighting during periods of low activity.

The introduction of LED technology marked an important step forward, not only in terms of energy efficiency but also in enabling intelligent controllability. Unlike conventional light sources, LEDs can be dimmed and adjusted without compromising performance or lifespan. This capability has paved the way for more flexible and responsive lighting strategies.

Building on this foundation, smart outdoor lighting systems now allow cities to move from static to adaptive lighting. These systems typically include connected luminaires, communication networks, and Central Management Software (CMS), enabling operators to monitor and control lighting infrastructure remotely and in real time.

Key capabilities of adaptive public lighting include:

- **Dynamic dimming**: Adjusting light levels based on predefined profiles or real-time conditions.
- **Scheduling and event-based control**: Tailoring lighting behaviour to time of night, day of week, seasonal patterns, or single events.
- **Zonal management:** Applying different lighting strategies to different areas depending on usage and context.
- **Sensor-based control**: Responding dynamically to additional inputs such as traffic flow, pedestrian presence, or environmental conditions.
- **Purpose-driven variations of light spectrum**: Adopt light spectrum and colour temperature according to defined requirements.
- **Supporting biodiversity** throughout the year: Seasonal adjustments for wildlife protection, coastal protection scenarios, habitat-sensitive zoning to limit ecological disruption.

Dimming the light level does not only reduce the light level but also reduces the undesired parts of the light spectrum emitted. In general, blue light is considered less favourable, that is why outdoor lighting often uses light sources with lower colour temperature (Tc). Lower colour temperature LEDs have less blue light in their spectrum. When dimming these lights, the emission of all wavelengths of the light source are reduced, which is good for all species. Summarised: dimming can avoid discussions regarding which light source spectrum to use and saves also on energy.

In case the colour of the light sources can be varied, even better solutions for people and environment can be realised. For example, in a use case in which people must be able to see fast moving objects, such as in sports or in busy traffic, a light source of 4000 K is recommended. But later in the evening, when there is less traffic or the sport game has ended, the light level can be lowered (dimmed) and colour can be reduced to e.g. 2700 K.

This evolution and greater flexibility enable cities to align lighting more closely with actual needs. For example, light levels can be reduced during low-traffic periods while maintaining higher illumination where and when it is required for safety.

Reducing unnecessary lighting through adaptive strategies can help cities to:

- Lower energy consumption,
- reduce operational costs,
- contribute to climate targets and sustainability commitments, and
- last but not least: reduce adverse ALAN effects.

Intelligent outdoor lighting systems increase a city’s ability to optimise operations across its entire lighting network. It is important to emphasise again that the objective is not to-switch-off lighting or reduce lighting levels in general but to provide the appropriate level of lighting where and when it is needed, while minimising unnecessary emissions and impacts. In short: the reason to implement an adaptive lighting control system is gaining the flexibility to create the right light at the right moment in time.

3.2 Reasons to choose a system with a TALQ Standard interface.

Investments in street lighting are costly. Additionally, lighting infrastructures are frequently composed of components from multiple vendors, deployed over long timeframes and based on different technologies. As a result, cities found themselves trying to manage a collection of disconnected or loosely integrated solutions.

To solve these issues several major lighting industry players decided in 2012 to found the TALQ Consortium. Since the beginning the scope was to define a standard interface protocol for increasing interoperability in outdoor lighting. Over time the consortium has evolved to become the ideal framework for achieving compatibility between different smart street lighting solutions but also other smart city applications, like waste management, parking solutions, environmental sensing or traffic control. The main goal has remained the same: to ease and protect investment decisions of cities and utilities.

The TALQ Smart City Protocol (TALQ Protocol/TALQ Specification) is a communication protocol enabling interoperability of various outdoor lighting networks (OLN) with a central management software (CMS). The protocol is defined with the OpenAPI Specification, it follows the RESTful approach with JSON data and is publicly available on GitHub.

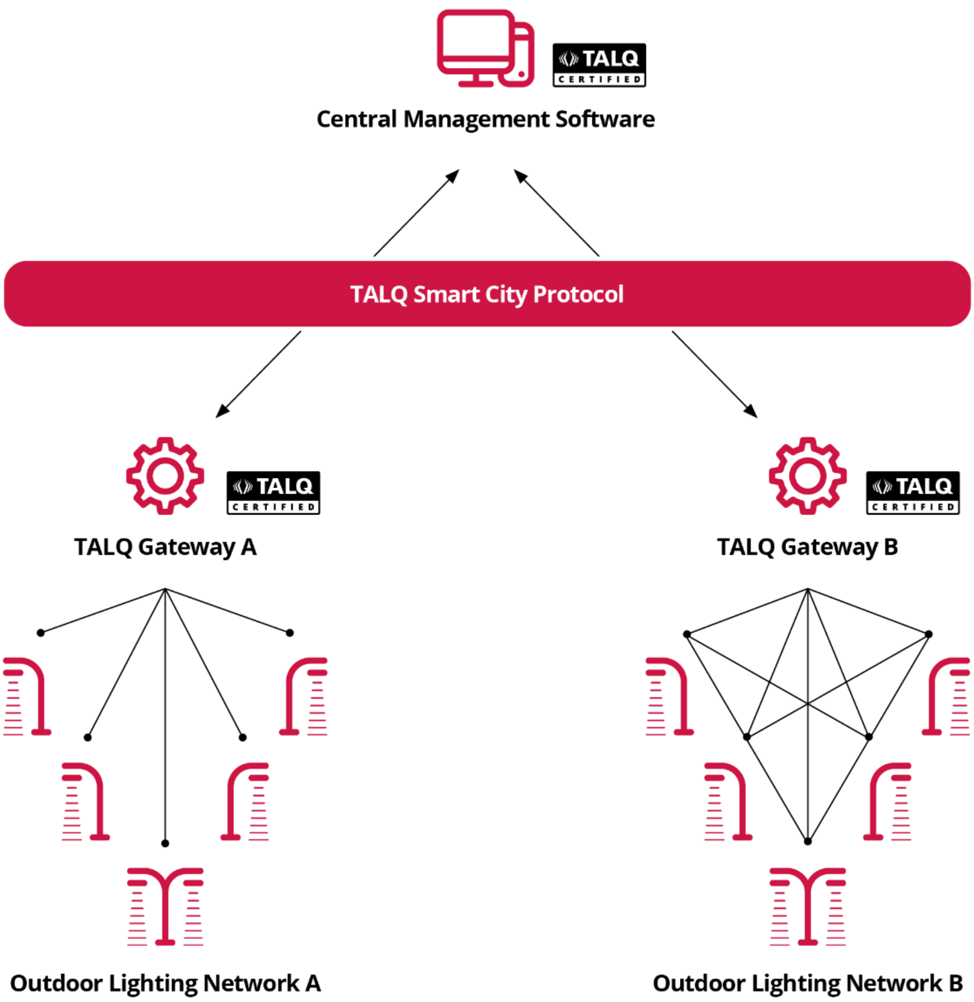

Fig. 1: TALQ allows controlling various outdoor lighting networks, even based on different communication technologies, centrally

In the context of ALAN, focusing on a city's or lighting network operators' ability to implement coordinated and effective strategies, TALQ-certified solutions act as a 'toolbox' to enable managing and optimising the entire street lighting operation. Outdoor lighting solutions based on the global TALQ Standard allow cities to maintain greater control over different systems and to manage flexibly a variety of devices on a smart platform able to communicate, exchange data, and operate in a seamless and standardised manner.

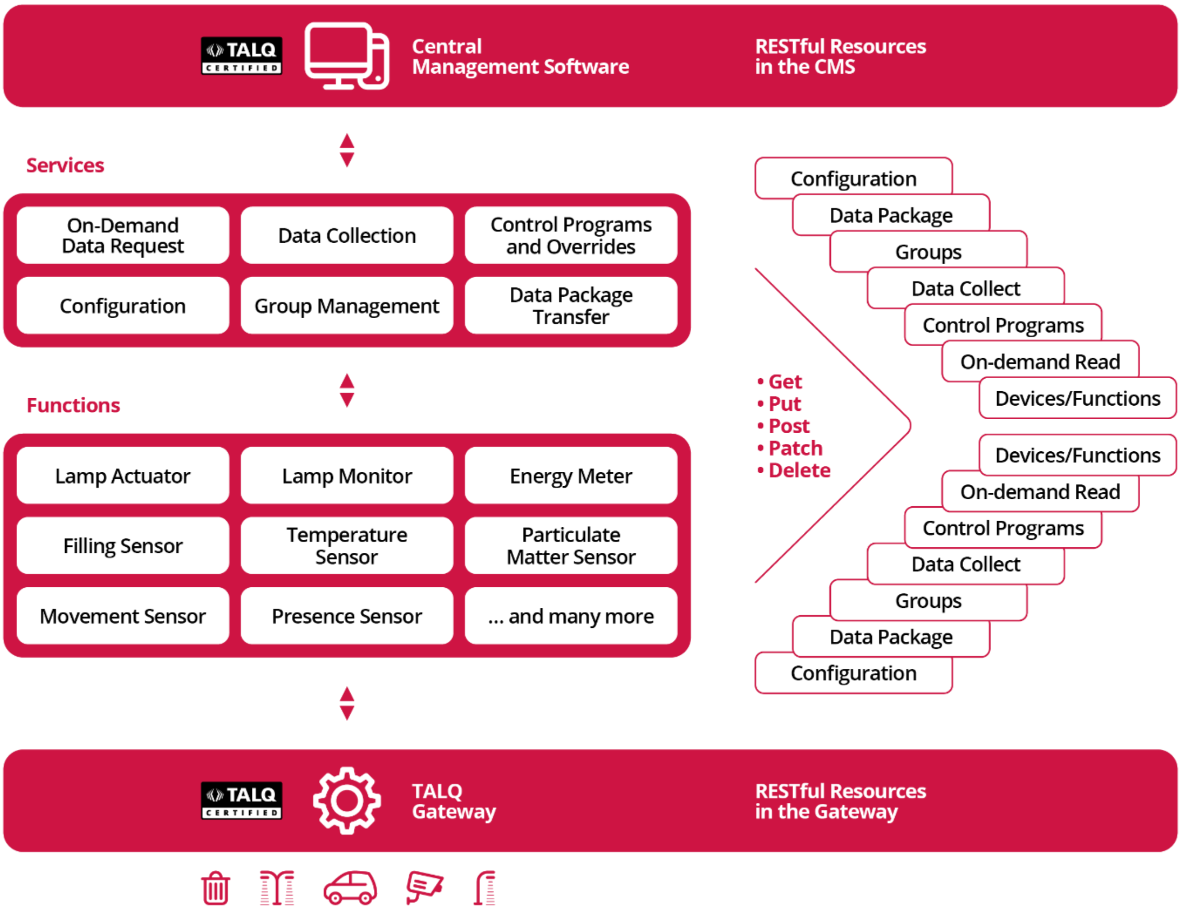

Fig 2: TALQ toolbox to reduce adverse ALAN-effects

Smart lighting technologies provide important capabilities – but their full potential is realised only when they can operate seamlessly across systems and vendors. The TALQ Smart City Protocol contributes as an interoperability layer that enables cities to implement adaptive, data-driven lighting strategies in complex, multi-vendor environments.

Combining TALQ-certified products allow multi-vendor infrastructures and managing all lighting assets as part of a unified, flexible system. Through interoperable communication and centralised control, the TALQ Protocol facilitates all use cases by enabling both dimming and colour control combined with flexible adjustable timing mechanisms. It helps ensure that adaptive strategies can be deployed consistently and at scale as it facilitates dimming and light colour control combined with flexible adjustable timing mechanisms.

When asking for TALQ-certified products cities can integrate new technologies and sensors as they become available, expand their systems without being constrained by existing vendor choices, and adapt strategies in response to new regulations or environmental goals. The TALQ Protocol is equipped with the tools to reduce the adverse effects of ALAN.

4 GUIDANCE FOR CITIES AND OTHER STAKEHOLDERS

The following considerations can support decision-makers in developing and implementing sustainable, future-ready outdoor lighting strategies.

4.1 Integrating ALAN into Urban Planning and Policy

A growing number of cities worldwide are recognising that lighting is not only an infrastructure issue, but also an environmental and quality-of-life consideration. Addressing future-oriented tasks is most effective when it is embedded early in planning and policy frameworks. Cities and roadway operators may consider incorporating ALAN-related objectives into sustainability and climate strategies to align lighting policies with biodiversity and environmental protection goals.

This will allow coordinating across departments (e.g., lighting, environment, mobility, urban planning) efficiently.

4.2 Making Interoperability a Procurement Requirement

Procurement and public tenders play a key role in shaping long-term outcomes. To avoid proprietary systems and ensure future flexibility, cities are increasingly including interoperability requirements in tenders. In this context, tools such as the **TALQ Tender Template** can provide practical guidance.
By offering a structured way to specify interoperability requirements and a complete overview over important criteria to analyse and describe in order to translate strategic objectives into concrete procurement criteria, the tender model assures to avoid shortfalls.

Planning for long-term scalability and flexibility is indispensable as public lighting infrastructure typically operates over long lifecycles. Decisions made today must therefore accommodate future developments, as the ability to integrate new technologies (e.g. sensors, communication systems), the flexibility to adapt lighting strategies over time and to assure compatibility with evolving standards and regulations.

Open standards help cities maintain control over their infrastructure and adapt to changing requirements without requiring complete system replacement. Engaging other stakeholders – including utilities and operators, environmental experts, urban planners, and lighting system manufacturers – can further support balanced and accepted solutions. A collaborative, ecosystem-based approach can help ensure that lighting systems deliver both functional and sustainable outcomes.

Cities that take a structured approach – integrating ALAN considerations into planning, procurement, and operations – are better positioned to achieve long-term benefits in terms of sustainability, efficiency, and quality of life.

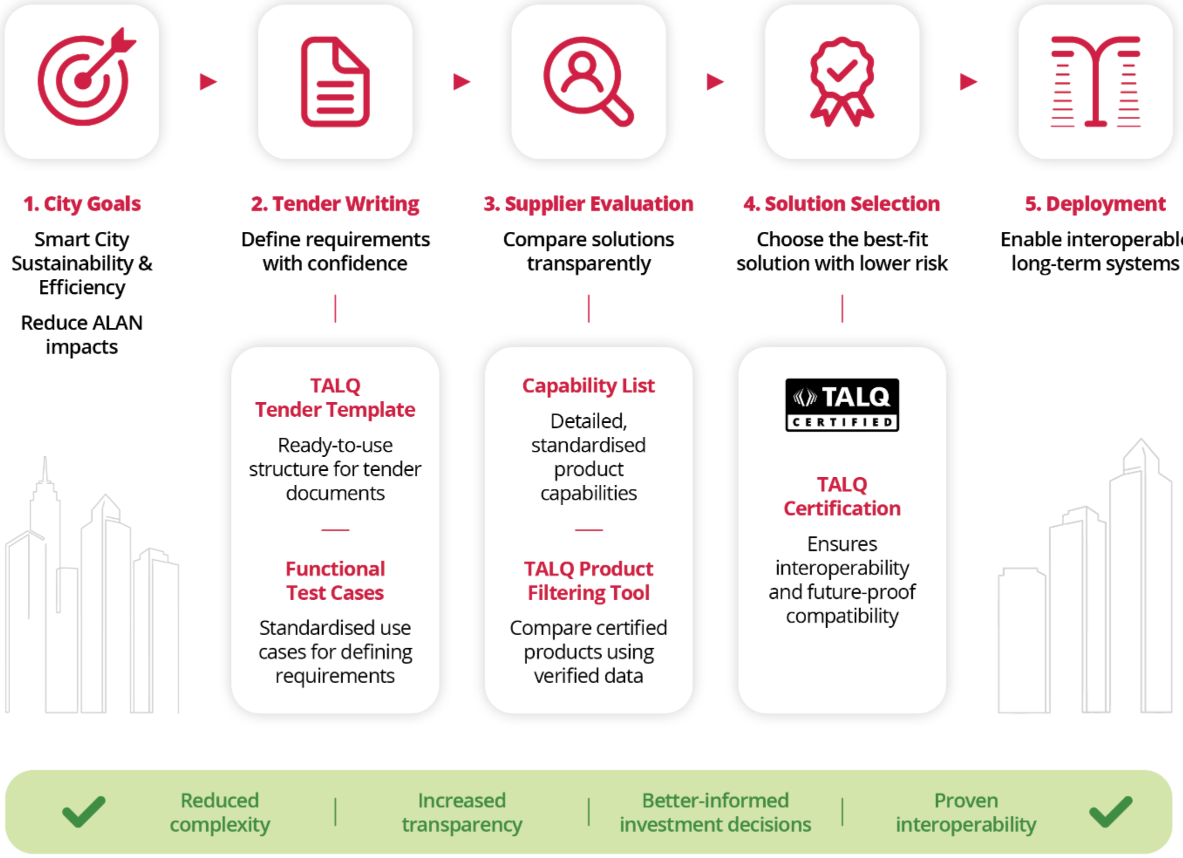

Fig. 3: The TALQ Standards acts as enabler for responsible and sustainable street lighting

4.3 Outlook

ALAN is expected to gain further importance in the coming years, driven by increasing environmental awareness, evolving regulatory frameworks, and ongoing advances in smart city technologies. Across regions, policymakers and standardisation bodies are placing greater emphasis on light pollution, biodiversity protection, and energy efficiency. This is likely to result in more defined guidelines, stricter requirements, and stronger integration of lighting into broader sustainability strategies.

At the same time, the continued evolution of smart city technologies will provide new opportunities and challenges. Technological innovation continues to expand the possibilities for how lighting systems can be designed and operated. Developments in sensor technology, data analytics, and connectivity are enabling more precise and context-aware lighting control. These capabilities allow cities to move beyond static or pre-defined approaches towards increasingly dynamic and responsive systems. In this context, interoperability will play an increasingly central role.

As cities seek to combine systems from multiple vendors and integrate new functionalities over time, open and standardised interfaces provide the foundation for flexibility and scalability. Standards such as TALQ, alongside complementary initiatives, like by the DALI Alliance and the Zhaga Consortium, contribute to creating a more cohesive and future-proof ecosystem for smart outdoor lighting and enable all stakeholders to reduce the adverse effects of ALAN.

5 REFERENCES

International Commission on Illumination, CIE Position Statement on Obtrusive Light and Light Pollution, 1st Edition, 2025
https://cie.co.at/publications/cie-ps-0032025-cie-position-statement-obtrusive-light-and-light-pollution-1st-edition

DLC Luna, October 2024: Seven Strategies to Minimize Negative Impacts of Outdoor Light at Night
https://designlights.org/resources/reports/seven-strategies-to-minimize-negative-impacts-of-outdoor-light-at-night/

LightingEurope, July 2025: Draft Position Paper on Artificial Light at Night (ALAN)
https://www.lightingeurope.org/images/WG_VoL_-_ALAN_Position_Paper_-_20250709.pdf

DarkSky International, March 2026: Evaluating Near-Horizontal Light Emission from Outdoor Lighting
https://darksky.org/what-we-do/advancing-responsible-outdoor-lighting/research/

DALI Alliance, December 2025: Artificial Light At Night: How DALI Controls Can Help
https://www.dali-alliance.org/data/downloadables/4/7/1/cdiiaak001a-alan-251217.pdf

Zhaga Consortium, March 2026: Artificial Light at Night: Zhaga's contributions to balancing benefits and challenges
https://zhagastandard.org/media/acfupload/2026_ALAN.pdf

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