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IoT and LED-Based Approach in Smart Street Lighting: A Review

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Abstract: Traditional street lighting systems are inadequate in performing basic functions such as monitoring, control, and centralized management. The traditional lighting technologies used in these systems do not allow for the optimization of energy consumption and maintenance activities. A significant portion of the existing infrastructure is designed with older generation lamps and analog control units, which imposes major limitations in terms of energy efficiency and sustainability. However, rapid technological advances in recent years and increased industrial activity focused on smart lighting solutions have enabled the integration of sensor-based, communication-enabled, and remotely accessible Internet of Things (IoT) and LED-based systems into street lighting systems.

This study examines IoT and LED-based systems developed to increase energy efficiency and reduce operating costs in street lighting applications. The study describes current technological developments in IoT applications by bringing together smart poles equipped with LED lamp technology, smart sensors, communication networks, and monitoring unit components. Furthermore, LED-based systems used in lighting systems are evaluated in comparison with traditional high-pressure sodium (HPS) and mercury vapor (HPM) lamps. Technical parameters such as power consumption, light efficiency, color rendering index (CRI), and lifespan are analyzed. Furthermore, this study demonstrates the applicability of these systems in smart city infrastructures in line with Turkey's National Energy Efficiency Action Plan and contributes to future applications.

Keywords Smart Street Lighting, LED-Based Systems, Internet of Things (IoT)

1. Introduction

Energy saving, low power consumption, energy efficiency, and environmentally friendly energy sources have become crucial in today's world. The increasing demand for electricity both globally and in our country, combined with the fact that resources like natural gas and petroleum are imported, has made the efficient use of energy inevitable. Approximately 20% of the electricity produced worldwide is used for lighting. Within this rapid development process, smart control technologies are gaining prominence in the lighting field due to their low power requirements, long service life, and compatibility with automation systems. Each emerging technology offers many advantages when compared with its predecessor. A prominent feature that accelerates the adoption of new lighting technologies is luminous efficacy—that is, the amount of energy consumed by a light source to produce a unit of light is decreasing over time (D. Tran & Y. Kheng, 2014).

Figure 1 shows some of the impact areas within the smart city lighting concept (Ioannis et. al, 2022). The impact areas shown in the figure are classified as banking systems, hospitals, public buildings, public space lighting, transportation infrastructure, residential buildings, the energy sector, public administration, industrial facilities, and corporate structures. The areas of influence shown in the figure highlight the multifaceted and integrated role of smart lighting systems within the smart city ecosystem. In critical infrastructure such as banking systems, hospitals, and public buildings, smart lighting stands out as a strategic component that supports security, service continuity, and energy efficiency. In public spaces and transportation infrastructure, dynamic and context-sensitive lighting management contributes to increased user safety, improved traffic flow, and more ergonomic learning environments. In the context of residential and corporate buildings, smart lighting supports user comfort, energy savings, and operational efficiency goals, while increasing the efficiency of production processes and workplace safety in industrial facilities. Integration with the energy sector and public administration makes smart lighting systems a key component of sustainable energy management and data-driven city governance, thanks to their real-time data generation and centralized control capabilities.

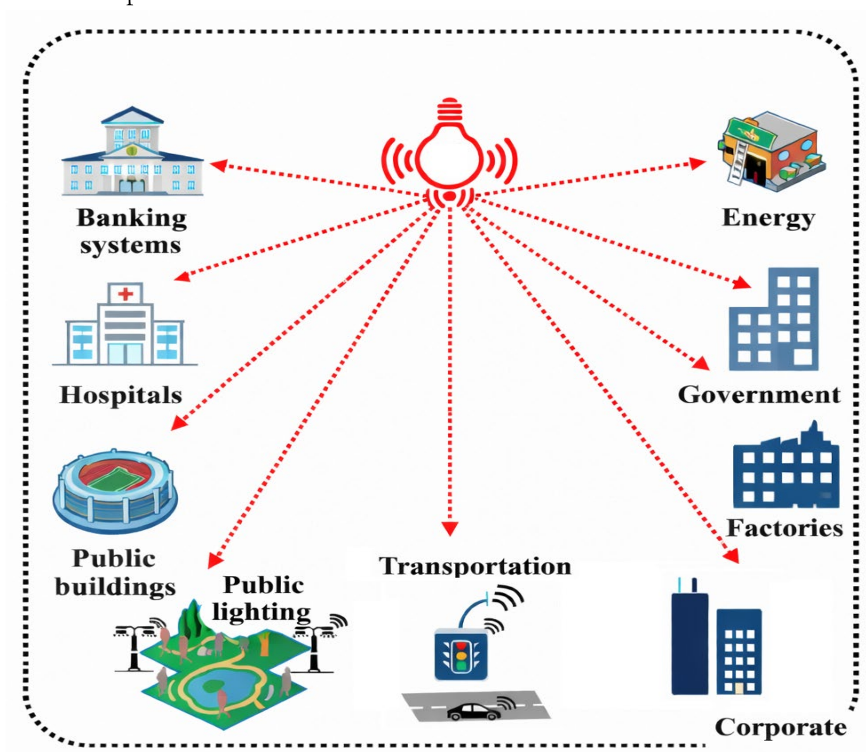

Figure 1 Examples of some areas of impact within the smart city lighting concept

The Internet of Things (IoT) is gaining increasing importance as a transformative concept that connects physical objects, mechanisms, or devices to each other by leveraging the capabilities of the internet. Smart cities aim to improve the daily activities of their residents and institutions and support sustainable economic development practices by utilizing advanced technologies. At this point, the concept of IoT plays a central role. The IoT supports the development of smart cities by creating robust connections between the devices, sensors, and networks necessary for their establishment. By integrating IoT devices into information systems, cities can increase transparency in governance, involve users in policy decisions and urban issues, improve healthcare services, increase individual well-being, and make positive contributions to many aspects of human life (Garcia et al., 2017). In this regard, the integration of IoT concepts strengthens smart cities and has positive effects on many areas of human life. IoT enables the provision of low-cost services, improves public transportation systems, reduces traffic congestion, and supports the safety and health of citizens. Furthermore, IoT is also of great importance at the national level, offering significant contributions in areas such as pollution reduction, energy conservation, monitoring systems, lighting, and the development of basic infrastructure. Therefore, smart cities supported by IoT technology can provide lower costs, higher efficiency, and stronger operational security thanks to energy-saving measures, economic assessments, and increased reliability levels (Janani et al., 2021).

Luminous efficacy indicates how efficiently a lighting element converts electrical power into light. Just as in other rapidly evolving technologies, the lighting sector is also transitioning toward more efficient, longer-lasting, maintenance-free, non-toxic, and smart lighting that are adaptable to LED-based systems and manageable via digital platforms (Özçelik & Yılmaz, 2019; Bukarica & Tomsic, 2017). Today, a significant transformation is underway toward LED technology in both indoor and outdoor lighting applications. This shift is driven mainly by two technological advancements: increasing luminous efficacy and decreasing product costs. One of the major application areas of this LED transformation is street lighting. Around the world, governments, municipalities, and electric utility companies are switching to LED-based street lighting to reduce energy consumption and related expenses. In Türkiye, this transition was incorporated into the National Energy Efficiency Action Plan announced in 2018 (Yılmaz et al., 2019). Proper and sufficient illumination of streets is essential for safe nighttime driving. According to statistics, the accident rate on poorly lit streets is approximately three times higher than during the day. Moreover, to ensure a comfortable driving experience, it is desired that street lighting maintains a certain level of illuminance and that luminance distribution is as uniform as possible. Effective street lighting in previously poorly lit areas can significantly reduce traffic accidents. Therefore, the positioning of highway lighting lamps and the proper adjustment of their power levels are of great importance (Yılmaz et al., 2019).

2. Related Works

A review of the literature reveals several significant contributions. Bhosale et al. (2017) examined various strategies utilizing IoT technology, sensors, devices, and wireless communication capabilities, focusing on the monitoring and control of street lighting systems. However, they also highlighted significant challenges in implementing such systems, including the need for reliable and secure communication protocols and the high costs of installation and maintenance. Zhong et al. (2023) addressed IoT devices used in smart cities and drew attention to the high energy demands that arise during data exchange. In this context, they proposed the Green IoT approach, which aims to reduce device energy consumption using hybrid deep learning techniques. Sarrab et al. (2020) addressed increasing urbanization and traffic management issues and proposed an IoT-based system for real-time traffic monitoring. However, they emphasized that implementing this architecture is costly due to infrastructure investments, sensors, and data management, and that collecting real-time data on traffic, vehicles, and pedestrians raises privacy concerns. Zalewski (2016) has studied street safety and explored improved lighting solutions for enhanced security and comfort. Li et al. (2009) conducted a comparative study evaluating energy savings when using LEDs instead of high-pressure sodium vapor lamps in street lighting. Their findings indicate that with improvements in initial cost, lifespan, temperature stability, and lighting efficiency, LEDs are expected to become the most energy-efficient light source in the near future.

Iacomussiet al. (2015) investigated the glare effects of LED lighting and demonstrated that this issue could be mitigated by concealing the light source using a diffuser, which also helps achieve more uniform light distribution. Huang et al.(2018) studied the thermal performance of LEDs and found that only 20–30% of the energy consumed by high-power LEDs is converted into light, while the remainder becomes heat. This heat increases the junction temperature of the LED, adversely affecting its light intensity, color stability, and lifespan. The proposed passive cooling system was shown to effectively dissipate heat and extend the life of the light source. Carli et al. (2018) showed that implementing the latest lighting technologies in updated projects can significantly reduce energy costs. Akalp et al. (2021)emphasized that implementing smart lighting systems in street lighting can lead to up to 50% energy savings. Pradeep et al. (2025) proposed a smart street lighting architecture aimed at solving the excessive energy consumption, maintenance difficulties, and ecological problems observed in traditional street lighting systems that operate from dusk to dawn.

Álvarez et al. (2025) presented a highly efficient, independent LED street lighting system based on a Phase Shift Modulation (PSM)-controlled Dual Active Half-Bridge Transformerless converter. Dimitrakis et al. (2025) comprehensively examined the transition from traditional HPS and MHL lamps to modern LED-based fixtures. Gupta et al. (2024) developed a self-sufficient, autonomous smart street lighting system capable of making decisions by combining machine learning and embedded systems. Wei et al. (2025) examine pedestrian obstacle detection under authentic outdoor street-lighting conditions. Rabaza et al. (2025) propose an integrated photovoltaic street-lighting model that simultaneously optimizes luminaire power, pole spacing, mounting height, PV module sizing, battery capacity, and autonomy days. Khemakhem & Krichen (2024) present a comprehensive survey of IoT-based smart public street lighting for smart-city applications. Petrov et al. (2025) conduct a comparative analysis of LED lighting systems installed in railway-infrastructure spaces.

3. Street Lighting Calculations

The basic purpose of lighting designs is to provide sufficient average luminance with an appropriate level of uniformity on the road surface to enhance the driver's object perception performance and to control glare. Therefore, the calculation process requires a comprehensive analysis based not only on the evaluation of light flux, but also on the reflective properties of the road surface, the optical performance of the luminaire, and the lighting geometry The primary parameters that determine the quality level of street lighting can be summarized as (Jin et al., 2015; Cihan, 2020);

- Ensuring adequate levels of illumination and surface luminance,
- Maintaining uniformity in light distribution,
- Minimizing and controlling glare effects,
- Providing effective visual guidance for both drivers and pedestrians.

Table 1 Street classes used in street lighting, average luminance coefficients, and specular reflection coefficients S1 and S2.

Street Class	Surface Material Description
R1; N1	Concrete street surfaces, asphalt pavements with 15% artificial brightness; surfaces composed of 80% highly reflective stone aggregates.
R2; N2	Coarse-textured and fine gravel surfaces, asphalt surfaces with 10–15% artificial brightness; asphalt pavements rich in gravel content (60%) with aggregate sizes over 10 mm.
R3; N3	Dark-colored, coarse-textured asphalt surfaces containing gravel less than or equal to 10 mm in size; coarse but reflective street surfaces.
R4; N4	Mastic asphalt; smooth and highly reflective street surfaces.

In this context, understanding the requirements of current standards and regulations accurately during the design and implementation phases of street lighting systems is of critical importance (Sun, 2017). It is essential to meet the lighting conditions specified by these standards. Street lighting systems must comply with the following EN 13201 standards: EN 13201-1: defines lighting classes, EN 13201-2: specifies performance requirements, EN 13201-3: includes performance calculation methods, EN 13201-4: describes methods for measuring lighting performance. Street lighting calculations are generally carried out using the point-by-point calculation method. The reflective properties of street surfaces are represented either by the luminance coefficient q (β, γ) or the reduced luminance coefficient r (β, tgγ). In practice, these coefficients depend on the angles between the point being considered, the observer's line of sight, and the direction of the light source. The street classes used in street lighting, their average luminance coefficients, and specular reflection coefficients S1 and S2 are provided in Table 1 and Table 2 (Bektaş et al., 2019).

Table 2 Classification of street surfaces ased on material type

Street Class	q0	S1	S2
R1	0.10	0.25	1.53
R2	0.07	0.58	1.80
R3	0.07	1.11	2.38
R4	0.08	1.55	3.03
N1	0.10	0.18	1.30
N2	0.07	0.41	1.48
N3	0.07	0.88	1.98
N4	0.08	1.61	2.84
CI	0.10	0.24	-
CII	0.07	0.97	-

4. Smart Street Lighting

Today, energy consumption has increased significantly compared to previous decades, prompting many sectors to call for energy conservation. Furthermore, there is a growing awareness that energy conservation is vital not only for economic reasons but also for environmental sustainability. Therefore, energy efficiency has become a fundamental criterion for smart cities. In this context, many cities are showing great interest in exploring the opportunities offered by smart lighting systems as an alternative to the costly and inefficient methods used in traditional lighting networks. Smart street lighting can be defined as an intelligent system that uses innovative light source technology, serves multiple user-defined purposes, and is integrated with IoT technologies. By adding smart features to street lighting services, smart cities aim to meet the changing needs of their residents (Narboni, 2020). The fundamental goal of this process is to increase the reliability and resilience of smart city infrastructure, promote energy efficiency, improve safety, support cleanliness and environmental monitoring, reduce electricity consumption, lower greenhouse gas emissions, and ultimately increase overall urban livability by creating more comfortable urban environments. Research on smart lighting systems generally revolves around two main approaches. The first approach focuses on increasing the efficiency of traditional lighting devices. The second approach focuses on developing smart management strategies to optimize the operation of lighting systems (Poza et al., 2021).

Smart street lighting systems are built on a multi-layered architecture and consist of four main components: the sensor layer, the communication layer, the management layer, and the application layer. The sensor layer continuously monitors environmental variables such as ambient light, motion, traffic density, temperature, and humidity. This data is transmitted to gateways via a wireless communication infrastructure. The communication layer's low power consumption and wide coverage area transform street lighting poles into urban data collection points. The management layer processes this collected data to determine the most suitable operating profile for each luminaire. At the application layer, user-friendly interfaces enable operations such as brightness adjustment, fault reporting, maintenance planning, and energy reporting. This structure allows lighting systems to evolve beyond being mere light sources, becoming a central component in smart city integration (Zanella, 2014). The core components of a smart street lighting are as follows (Tung, 2019; Sarr et al. 2019):

- Each street lamp is equipped with sensors to dynamically control the illumination level.
- Terminals collect data from the sensors and transmit this information to network gateways.
- Gateways consolidate data received from surrounding street lamps.
- These gateways can also be integrated with other sensors used in smart city applications.
- The data collected by the gateways is transmitted to a central server where analysis is performed.
- The server not only manages the control of lighting units but also monitors overall maintenance requirements and issues related alerts accordingly.
- The sensor layer interacts directly with the physical environment by working in conjunction with lighting nodes. This layer gathers environmental data triggered by external stimuli such as sunlight, motion, and sound through various sensors.
- The collected data is transmitted to the communication layer, which facilitates data transfer between the sensors and the gateways using different communication protocols (e.g., Zigbee, LoRaWAN)
- The gateways forward the data to a centralized management system for processing.
- The management layer analyzes the incoming data, generates decisions to optimize system behavior, and transmits these decisions to the control mechanisms. This ensures that the system is managed in a balanced manner in terms of energy consumption and lighting demand.
- The application layer presents the analyzed data to the end-user via user interfaces that allow for monitoring, controlling, and intervening in the lighting conditions when necessary.

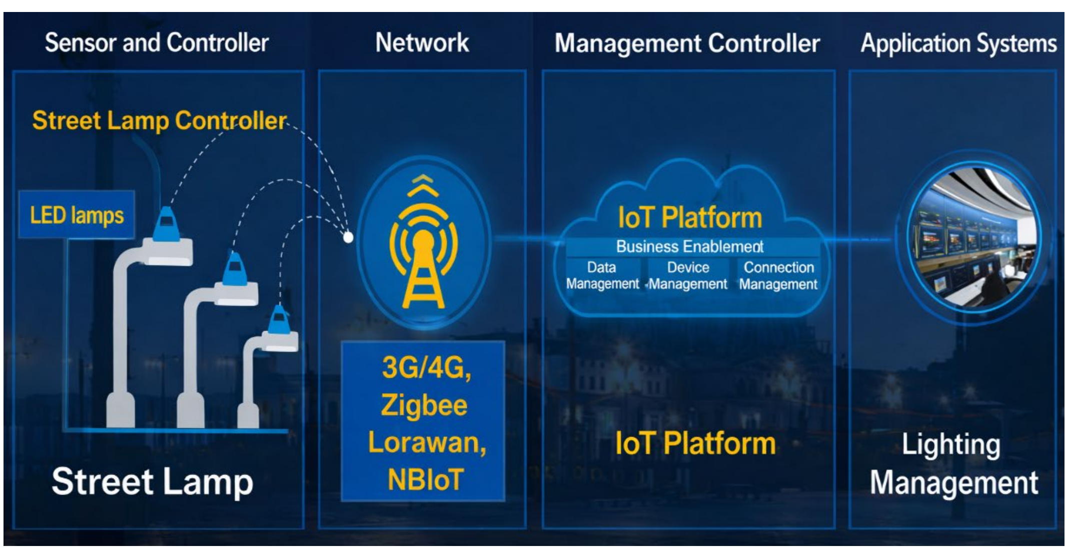

Figure 2 Smart street lighting system

The overall structure of a typical smart street lighting system is illustrated in Figure 2 (Tung, 2019). On the left side of the figure, it is shown that street lighting lamps gather environmental and operational data through integrated sensors and transmit this data to a central server using wired or wireless communication protocols. Users can access the server via the management interface through personal computers or mobile devices. The system utilizes advanced data communication technologies that support functionalities such as connection management, real-time data analysis, reporting, and geolocation tracking. Today, many smart lighting systems employ communication technologies such as PLC, ZigBee, SigFox, LoRa, and NB-IoT. While PLC, ZigBee, SigFox, and LoRa require the deployment and management of private network infrastructures on the client side, NB-IoT can operate over existing 5G infrastructures, offering low-cost and wide-area coverage by utilizing publicly available operator networks. Figure 3 represents an application scenario of a smart lighting system (Putrada, 2022). The lighting unit in the system communicates with various sensors through an access point. Following this infrastructure, the user interface comes into play; for example, a desktop computer is used to monitor the lighting performance. Data exchange between the system components is carried out via a Wi-Fi connection over a local network or the Internet (Prasad, 2020; Putrada, 2022).

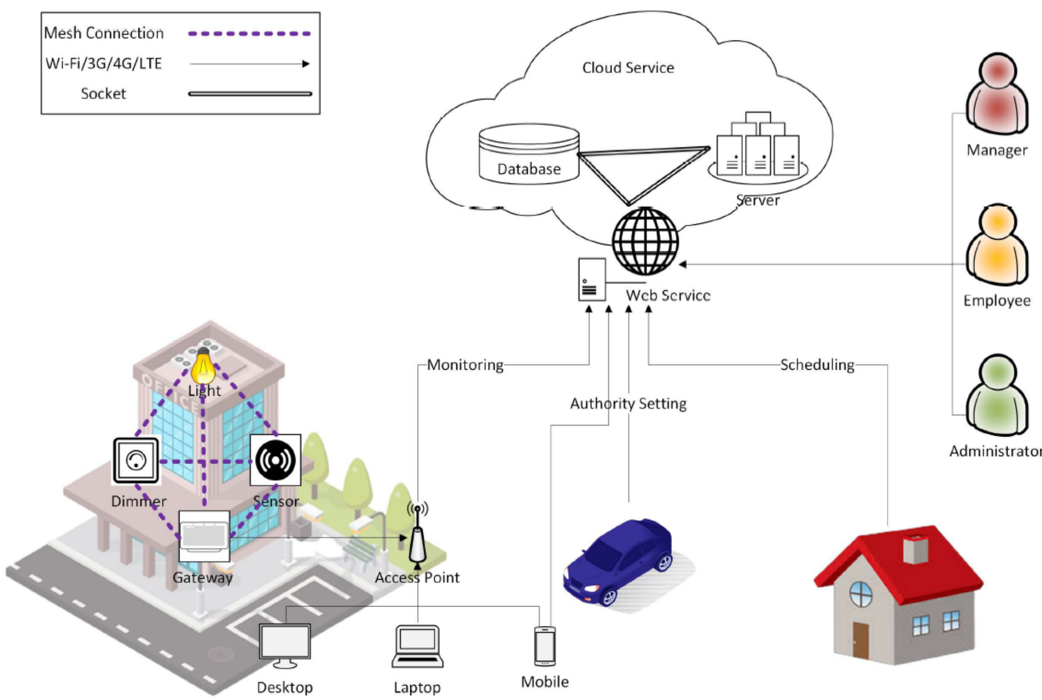

Figure 3 A schematic illustration representing the layout of a complete smart lighting system

5. IoT-Based Systems

The Internet of Things (IoT) is an innovative approach that connects physical objects, mechanisms, and devices to each other by leveraging the capabilities offered by the internet, and it is gaining increasing importance. Thanks to this connection, these entities can communicate with each other, exchange data, and provide users with meaningful services and valuable insights. This structure is essentially made possible by the collaboration of sensors and communication networks and supports device-to-device communication. This contributes to the development of smarter and more efficient energy monitoring systems. Different IoT architectures have been proposed for use in smart city lighting applications, with the basic architecture consisting of three main layers. These layers are defined as follows (Lombardi et al., 2021; Whaiduzzaman et al., 2022).

• The first layer is called the perception layer and is responsible for collecting, distinguishing, and identifying data from the physical environment. This layer includes tags, sensors, laser scanners, and similar technologies.

• The second layer is defined as the network layer and ensures that data is transmitted via reliable communication infrastructures.

• The third layer is called the application layer and is responsible for processing data, integrating information obtained from different sources, and presenting it to the user.

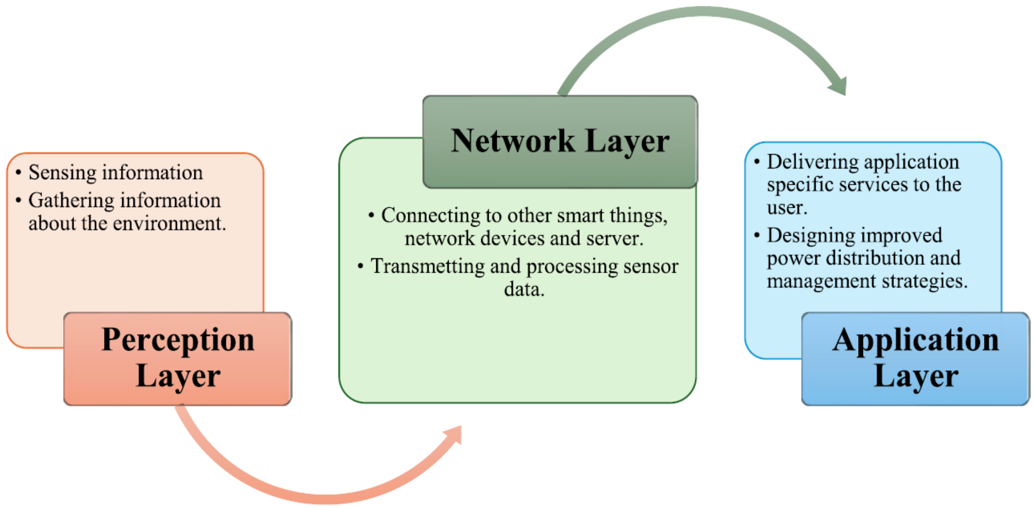

Figure 4. Main functions of the layers in IoT architecture

The three basic layers, whose main functions are shown in Figure 4, are examined in detail (Nur, 2016; Ganvir et al., 2024; Siwar, 2024):

5.1. Perception Layer

This layer includes various lighting sensors, actuators, tags, and readers, primarily power sensors. This includes different sensing equipment such as Global Positioning System (GPS) devices, cameras, and Radio Frequency Identification (RFID) devices. These internet-connected devices can sense environmental conditions, identify objects, collect data, and share data with other devices via internet-based communication networks.

5.2. Network Layer

Also known as the connection layer, this layer plays a key role in transferring information obtained from the sensing layer to the application layer. Device capabilities, network constraints, and application requirements are taken into account during this transfer process. The network layer ensures that data collected from lighting sensors is processed, managed, and made accessible within the main network, while also supporting reverse data flow. In this layer, data transmission from sensing devices to nearby network gateways is achieved using short-range communication technologies such as ZigBee and Bluetooth. Furthermore, communication is supported over Local Area Networks (LAN) and Wide Area Networks (WAN) through both wired and wireless technologies. Technologies used in this context include cellular networks, WiFi, Bluetooth, Ethernet, Near Field Communication (NFC), Low Power Wide Area Network (LPWAN), ZigBee, 2G, 3G, 4G, public switched telephone networks, wired broadband, and Power Line Communication (PLC).

5.3. Application Layer

The application layer plays an important role in managing the data obtained from the network layer in real time. This enables effective control of IoT devices and the development of more efficient energy distribution and monitoring strategies. The layer utilizes various IoT lighting technologies that support a wide range of IoT services and includes application configurations. These configurations are responsible for data processing, computation, and resource interaction processes. Thanks to the application layer, IoT ensures the seamless integration of information technologies and applications such as smart buildings, smart cities, smart healthcare systems, and smart transportation systems. These solutions offer various user-friendly interfaces that improve the monitoring of smart lighting systems, enable demand-side energy management, coordinate distributed energy storage systems, and integrate renewable energy sources.

6. LED-Based Systems

LED-based lighting systems are rapidly becoming widespread and are being adopted as a standard application model in developed urban areas. The primary objective of implementing these technologies within advanced urban infrastructures is to minimize energy consumption and maximize energy efficiency. Next-generation LED-based lighting systems have evolved beyond traditional street lamps to become multi-purpose urban infrastructure components. Integrated sensors, 5G small cell stations, environmental sensing modules, security cameras, electric vehicle charging units, and wireless access points embedded in poles play a critical role in the digital transformation of cities. This infrastructure enables cities to generate big data in processes such as energy management, traffic flow optimization, security, and environmental monitoring, thereby strengthening decision support mechanisms. Thus, street lighting systems become not just an energy-consuming element, but the fundamental backbone of the urban digital infrastructure. Figure 3 presents a representative example of a LED-based street lighting system (Huang et al., 2014).

Compared to traditional street lighting systems, LED-based systems are equipped with advanced communication protocols, intelligent control mechanisms, and flexible management capabilities. In conventional systems, control is limited to fixed on/off schedules or group-based regional modes, and independent control of individual lamps is not possible. Moreover, due to the absence of cloud-based infrastructure, real-time status information of lighting poles cannot be collected, nor can fault detection be performed, making precise system management challenging. LED-based systems, on the other hand, operate in a networked structure thanks to node controllers integrated into each pole. All status data is transmitted in real time to a cloud-based management system. This system provides independent control over each lamp, minimizing energy losses caused by manual operations and enabling efficient remote management. In contrast to traditional time- or region-based control strategies, LED-based systems can dynamically adjust their brightness levels based on variables such as traffic density, seasonal conditions, and ambient lighting. Furthermore, unlike conventional systems that only provide lighting, LED-based street lamps are integrated with wireless communication infrastructure, video surveillance systems, information display panels, environmental data sensors, electric vehicle charging units, and various other urban services (Pinto et al., 2015).

The representative structure of an LED-based smart street lighting pole system is shown in Figure 5 (Chen, 2018). A smart lighting pole is essentially a street lighting fixture consisting of a street lamp equipped with high-efficiency LED lamp technology, a local light control unit, smart sensors, and communication components. These poles work in a network structure, connected to each other; they can mutually transmit control commands and information requests. In addition, they communicate with the monitoring unit via a gateway. The monitoring unit functions as a central infrastructure management point and is responsible for configuring and controlling each street lamp and monitoring its operating status. Data exchange between the monitoring unit and individual street lights is carried out via a communication network designed to cover the entire area where the lighting fixtures are installed. The development of smart public street lighting systems over the past twenty years has gained significant momentum, particularly with the transition from traditional lighting solutions to LED technology. This transformation has contributed to increased energy efficiency and reduced operating costs. Initially costly, LED and IoT sensor integration has become more affordable over time due to technological advances and economies of scale. Furthermore, government policies and incentives supporting sustainability and smart city applications have accelerated this transformation process (Chiradeja, 2023).

Figure 5 LED-based smart street lighting pole system and its components

In traditional street lighting systems, visible light is typically produced either by heating metal filaments or by converting ultraviolet radiation, generated through gas discharge, into the visible spectrum using phosphor coatings. In contrast, light-emitting diodes (LEDs) operate based on solid-state physics, where light generation occurs as electric current passes through a semiconductor crystal structure. This semiconductor structure consists of an n-type and a p-type region. When a voltage is applied in the correct polarity, electron-hole recombination occurs in the junction between these two regions, resulting in photon emission. The electrical and photometric performance parameters of LED arrays have been analyzed and compared with those of traditional lamps. The comparative results are presented in Table 3. As illustrated in Figure 6, due to the relatively recent development of LED-based technology, significant improvements in efficiency are expected in the coming years (Rodrigues et al. 2011; Jia, 2020).

Table 3 Comparison of different lamp parameters

Lamp type	Luminous efficiency / (lm/W)	Color rendering index	Color temperature /K
Fluorescent lamp	70~90	80	4000
High-pressure mercury lamp	35~65	40~60	4500
HPS	120~140	25	<2500
Metal halide lamp	80~120	60~80	4000
Electromagnetic induction lamp	85	>80	2700~6500
LED lamp	110~130	>70	2700~6500

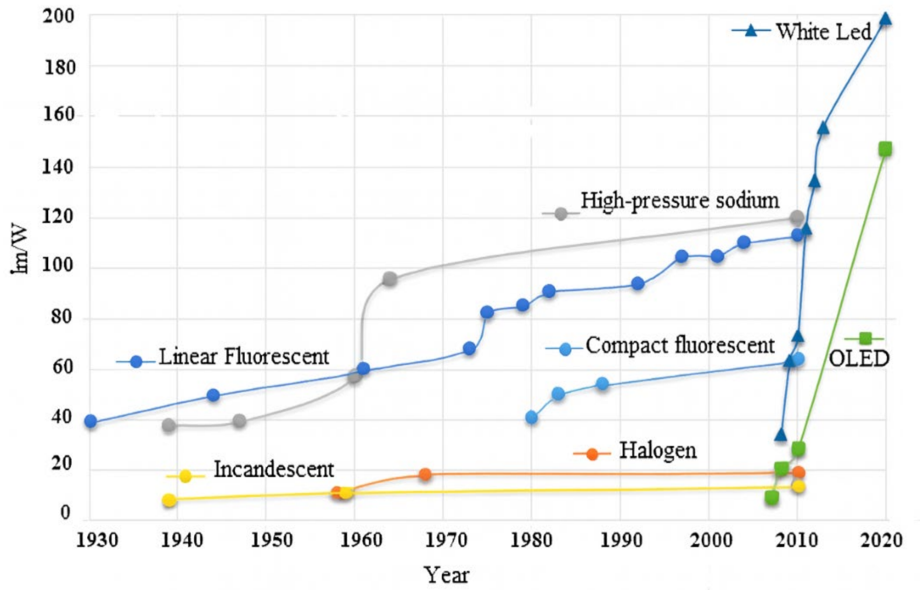

Figure 6 Comparison of LED-based lighting technology with traditional lighting technologies

7. Conclusions

Compared to traditional street lighting systems, smart city lighting systems are equipped with advanced communication protocols, centralized control architectures, and flexible management infrastructures. In conventional systems, individual luminaire control is not possible; typically, the entire lighting line is controlled via time relays or manual switches. Moreover, due to the absence of a centralized monitoring mechanism, the fault status or operational data of each luminaire cannot be detected in real time, making effective maintenance and energy management difficult. Unlike the fixed time- and region-based control strategies of traditional systems, smart lighting systems can respond adaptively to environmental conditions (such as daylight levels, traffic density, weather, and seasonal changes), and dynamically adjust the light intensity of the lighting lamps. As a result, user safety is ensured while achieving significant energy savings.

In LED-based systems, each lighting lamp is equipped with an independent node control unit, and the entire lighting network is integrated into a central cloud-based management platform via wired or wireless communication. Through this structure, data from each lamp (such as voltage, current, temperature, operating time, fault status, etc.) is transmitted in real time to the cloud server, enabling remote monitoring of the system's overall status. The cloud-based centralized management system allows for individual control of each lamp, enabling automated functions such as fault detection, scheduled maintenance, dynamic dimming, and timing operations. This architecture not only reduces energy waste caused by human error, but also increases system efficiency and provides a high level of flexibility in energy management.

This study examines the Internet of Things (IoT) approach used in smart lighting technologies within a technical framework. IoT-based applications in the context of smart cities, the architectural layers of the system, and the basic functions performed by each layer are explained in detail. Furthermore, the main services provided by the monitoring unit are evaluated from a technical perspective; the critical role of this unit in improving the user experience and making interaction with infrastructure components more effective is highlighted. The study presents important findings regarding the impact of transforming smart street lighting systems into smart, sustainable, and energy-efficient structures on urban safety, modernity level, operational efficiency, and urban attractiveness.

In the study, LED-based systems—which are of great importance in terms of energy efficiency and environmental sustainability for smart city applications—have been examined. Traditional street lighting lamps were compared with LED-based systems, and the advantages of LED-based systems technologies were highlighted. Scientific comparisons were made regarding energy consumption, lifespan, and efficiency, with the aim of informing both consumers and energy system developers. As a result, LED-based street lighting has become an indispensable component for smart cities in terms of energy management, infrastructure efficiency, and sustainability goals. This situation has made LED-based systems essential for smart cities. This necessity is not merely a lighting upgrade; it is also one of the cornerstones of power system optimization, data-driven urban management, and technological smart city strategies. This study emphasizes the necessity of implementing LED-based systems in smart street lighting across all residential areas in Türkiye, in alignment with the National Energy Efficiency Action Plan, and in parallel with global developments.

Declaration of Ethical Standards

As the author of this study, he declares that he complies with all ethical standards.

Credit Authorship Contribution Statement

A.Nur: Investigation, Resources, Writing, Review

Declaration of Competing Interest

The author declared that he has no conflict of interest.

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Data Availability

No datasets were generated or analyzed during the current study.

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