# Telemanagement and Its Benefits to Energy, Environment, and Society: A Case Study in Street Lighting

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**Abstract.** Brazil plays a fundamental role in mitigating environmental impacts and climate change. The country is part of the Paris Agreement signed in 2015 and one of its goals established in the "Nationally Determined Contributions" (NDS) is to achieve 10% of efficiency gains in the electricity sector. This article aims to analyze the contributions to comply with SDG 7 (Affordable and Clean Energy) and SDG 11 (Sustainable Cities and Communities) through the modernization of public lighting and the use of remote management, i.e., the application of a set of hardware and software that work with the lighting poles and aims, among other things, to remotely control the lamps, perform measurements such as voltage, power, and efficiency, in addition to paving the way for various applications aimed at the Internet of Things (IoT). In other words, the equipment, such as public lighting fixtures, that are already installed in large and small cities in Brazil could be modernized and remodeled, to assign new characteristics, integrating the entire system of a smart city and the equipment currently used to benefit the population as a whole. Thus, by modernizing the system, the objective of this work is to bring and boost countless benefits to the society and the electric company, which, through the use of this system, can eliminate an old deficiency present in charge systems by estimation, adopting a real-time consumption measurement system with more precision.

**Keywords:** Street lighting · Remote management · Smart Cities · IoT (Internet of Things) · Smart Grid · Energy efficiency

## 1 Introduction

The United Nations Sustainable Development Goals (SDGs) provide guidelines for society. They try to respond to a series of challenges, and one of them is energy. Thus, the SDGs became essential for formulating energy policies, and their positive interactions are proven [1].


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The real challenges of climate change are the search for ways to mitigate the impacts on the economy and the environment, as progress has been slow since the Paris agreement, signed in 2015 [2]. All areas of the economic sector must innovate in search of energy efficiency, offsetting the greenhouse effect caused by emissions of other activities that cannot yet be eliminated [3].

There is an increasing need of using tools such as traffic lights, lamps, trash cans, sidewalks, and others throughout a conventional city so that they can be used not only for their usual role but also be updated and modernized for new and diversified assignments within a single device, which serve to benefit the municipalities and society in general. In this sense, Brazil needs to look for alternatives to fulfill its NDC (Nationally Determined Contributions) targets.

Based on theoretical research of data made available by companies and institutions such as ANEEL (Brazilian Electricity Regulatory Agency), ABD, and ABCIP (Brazilian Association of Public Lighting Concessionaires), the objective of this article is to carry out a theoretical review of the main contents that guide and are addressed in this scientific research and demonstrate the potential for energy efficiency obtained from the modernization of public lighting with the adoption of LED (Light Emitting Diode) and the application of the Telemanagement system, relating the benefits to energy, environmental, and social issues. Finally, it is proposed a complex neural network, which can serve for future work to capture more accurate information, meeting the real objective of this work in practice [4–6].

## 2 Theoretical Development

In this chapter, the main concepts that guide this research will be discussed with a focus on introducing the main issues addressed in this scientific article.

### 2.1 Remote Management

The Remote Management concept is a conglomerate of hardware and software attached to the streetlights that allow the measurement of the voltage, energy, and efficiency and also open doors for a new technological segment: the Internet of Things.

Basically, a remote management device consists of the following elements:

- One sensor, responsible for the measurement;
- One mobile interface to connect to the Internet;
- One BLE (Bluetooth Low Energy) interface.

It should be emphasized that the last two elements are responsible for the system connectivity through Internet or Bluetooth so that they are essential for the information exchange [7–10].

Besides de aforementioned devices, the system also needs lamps, which are connected in standard sockets model ANSI C136.41 (Dimmer socket TE Connectivity ANSI C136.41) that are widely used in Brazil [7–10].

This system is extremely relevant because it can store the information/data generated by the measurements in the remote devices, making possible the development of a database of great value to all stakeholders (e.g., citizen, public agencies, and concessionaire) [7–10].

Since 2010, with the effectiveness of ANEEL resolution, the companies specialized in the development of solutions for the management of public lighting have been strengthening their relationship with the PPPs (Public-Private Partnership), aiming to offer cost savings and control the assets [7–10].

### 2.2 Smart City

Although there is no single accepted definition, the contemporary understanding of a smart city presupposes a coherent urban development strategy administered by the municipal government that seeks to plan and align, in the long term, the management of the city's infrastructure and goods to improve citizens' quality of life. So, throughout the 20th century, the idea that a city could be smart was science fiction portrayed in popular media but, with the massive proliferation of new technologies and smart devices, the perspective that a city can become smart and even sentient is quickly becoming a reality [11–14].

The convergence of information and communication technologies is creating urban environments that are different from everything that has been tried so far. When cities become smart, it is possible to automate functions that serve people, buildings, and traffic systems and monitor, understand, analyze and plan the city to improve efficiency, equity, and citizen quality of life in real-time. The way people can plan on various timescales is changing, which means there is an evolution in the perspective that cities can become smarter in the long term by thinking and acting in the short term [11–14].

Smart cities are often represented as constellations of instruments connected through many networks that provide continuous data on the movement of people and materials as a function of the decision flow about the physical and social form of the city [11–14].

### 2.3 Internet of Things

The IoT (Internet of Things) is moving from infancy to maturity and establishing itself as part of the Internet of the future. The Internet is a global system of interconnected computer networks that use the same set of protocols (TCP/IP) to serve billions of users around the world. It is a network made up of millions of private, public, academic, business, and governmental networks connected through a wide range of electronic, wireless, and optical networking technologies, as illustrated in Fig. 1 [15–20].

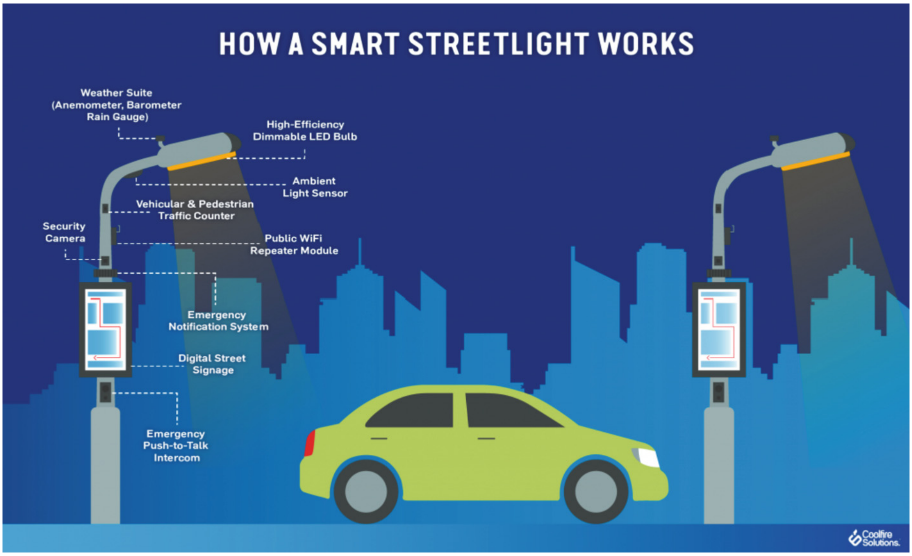


**Fig. 1.** IoT public light [21].

Currently, there are more than 100 countries involved in the exchange of data, news, and opinions via the Internet. According to Internet World Statistics, as of December 31, 2011, there were approximately 2,267,233,742 users on the Internet, which was equivalent to 32.7% of the world's population [15–20].

Essential components for the urban development of a smart city must include smart technologies, smart industries, smart services, smart management, and smart lives. The main characteristics of a smart city comprise a high level of information technology integration and a wide application of information resources [15–20].

The IoT consists of installing sensors (RFID, IR, GPS, scanners, and others) for everything and connecting them to the Internet through specific protocols to exchange information, aiming to develop intelligent recognition, location, tracking, monitoring, and management applications. New IoT applications are enabling smart city initiatives around the world. They offer the ability to remotely monitor, manage and control devices and create new insights and information from massive real-time data streams [15–20].

### 2.4 Smart Grid

The expression Smart Grid should be understood more as a concept than as a specific technology or equipment. It is based on the intensive use of automation, computing, and communication technology to monitor and control the electrical network, which will allow the implementation of control and network optimization strategies much more efficiently than those currently in use, as illustrated in Fig. 2 [22–25].


**Fig. 2.** Public smart lighting [26].

The introduction of the Smart Grid concept will produce a sharp convergence between the energy generation, transmission, and distribution infrastructure and the digital communications and data processing infrastructure. The latter will function as an Internet of Equipment, interconnecting the so-called IEDs (Intelligent Electronic Devices) and exchanging information and control actions between the different segments of the electrical network. This convergence of technologies will require the development of new methods for controlling, automating, and optimizing the operation of the electrical system, with a strong tendency to use distributed problem-solving techniques based on the use of multi-agents [22–25].

Some of the features usually attributed to Smart Grid are:

- Auto-recovery: the ability to automatically detect, analyze, respond, and restore network failures;
- Consumer empowerment: the ability to include the consumer's equipment and behavior in the network planning and operational processes;
- Tolerance to external attacks: the ability to mitigate and resist physical and cyber-attacks;
- Energy quality: provide energy with the quality required by the digital society.

One of the most promising technological innovations proposed for Smart Grid implementation are Smart Microgrids, or simply Microgrids, which are an efficient way to connect energy sources of different types and capacities, energy storage devices, and special loads. They are a mini-SEE that can operate in a semi-autonomous way, connected to the utility system, or isolated. They use power electronics-based converter devices to connect and control the various sources of energy generation and storage, as well as special loads. They also use advanced electronic metering technology, distributed sensors, digital communications, and computing, for supervision, control of the quality and reliability of power supply, and cost and emissions optimization [22–25].

The evolution of the Smart Grid deployment process must follow the steps below:

1. Installation of smart device infrastructure;
2. Installation of communications infrastructure;
3. Integration and interoperability;
4. Availability of analytical tools;
5. Operational optimization.

## 3 Contributions to SDGs and the Current Scenario of Public Lighting

Considering the Sustainable Development Goals (SDGs) defined by the United Nations (UN) in 2015, SDG 7 (Affordable and Clean Energy) aims to double the global rate of energy efficiency by 2030. Brazil is part of the Paris Agreement signed in 2015 and one of its goals established in the Nationally Determined Contributions (NDS) is to obtain 10% of efficiency gains in the electricity sector [27].

For the UN, cities may represent two-thirds of electricity consumption in the world by 2030. It is estimated that, in Brazil, about 4% of the electricity consumed is destined for public lighting. The cost of energy for public lighting in most Brazilian municipalities already represents the second-largest budget item, second only to payroll (IBD, 2017). The modernization of public lighting is, therefore, beneficial to the energy matrix and reduction actions [28,29].

According to studies carried out in the country, if the cities just converted the current public lighting system to a more efficient technology such as LED, one-fifth of the goal would be achieved. Caraguatatuba, São João do Meriti, Belo Horizonte, and Mauá are examples of cities that carried out the modernization of their lighting parks with LEDs and reached 55% to 75% energy efficiency [27]. These municipalities have also implemented Telemanagement, but it is only used for comparison purposes and reducing operating costs since energy metering is not accepted by the Energy Concessionaires since there is no regulation in force that makes it mandatory.

It is estimated that Brazil has approximately 18 million light points for public lighting. Among the existing light sources, the LED technology reaches about 5%, requiring an investment of approximately 30 billion BRL for the complete modernization [29].

There are two federal government energy efficiency programs, PROCEL-Reluz by Eletrobrás and PEE - Energy Efficiency Program managed by energy distributors and managed by ANEEL. Reluz, in its last edition of 2019, announced an investment of 30 million BRL, not being significant for the Brazilian scenario. The PEE is an obligation of energy distributors, which since 2000 must direct 0.5% of their Net Operating Revenue in selected energy efficiency projects as required by ANEEL through a competition mechanism forcing a cost-benefit ratio [29].

With pressure from the private sector, the Federal Government and the World Bank are currently working in the Support Fund for the Structure and Development of Concession Projects and Public-Private Partnerships of the Union, States, Federal District, and Municipalities. In partnership with Caixa Econômica Federal, they carry out the structuring of projects until the publication of notices. This is part of the FP065 project where 1.3 billion USD is already being invested by the Green Climate Fund to support Brazil in meeting its NDC targets. This resource will be dedicated exclusively to energy efficiency projects for public lighting and industry, helping to provide financing in standardized and replicable street lighting modeling [5].

A new economic model, which integrates ecological modernization and sustainable development, offers win-win scenarios. Movements in the energy efficiency and public lighting sector have a positive impact on the economy, environment, and society [30].

## 4 Analysis and Discussions

Based on the data obtained, it is possible to confirm the contributions to compliance with SDG 7 (Affordable and Clean Energy) and SDG 11 (Sustainable Cities and Communities) through the modernization of public lighting and the use of remote management.

The Energy benefit is achieved with the use of LED luminaires, which can reduce up to 75% of energy consumption compared to conventional light sources, and the use of the lighting system remote management, consisting of wireless controllers coupled to public lighting fixtures capable of reducing up to 30% of additional consumption with dimming.

The benefit to the environment and society by the public lighting sector also occurs through the contribution to SDG11 - Sustainable Cities and Communities, aimed at planning the energy matrix and conditions of cities to prepare themselves to be more suitable for use by citizens. The correct lighting, respecting the levels established in the norms, generates an increase in public safety, a reduction in traffic accidents, greater occupation of public spaces, enhancement of facades, monuments, and historical heritage. LED technology does not contain toxic substances and has a low impact on the ecosystem, reducing light pollution and not attracting insects as it does not emit infrared and ultraviolet rays. The implementation of LED allows automation systems to be integrated through electronics, generating benefits such as the inclusion of remote management, considered by Aneel as the first level of the structure of Smart Cities. Internet-connected controllers manage assets remotely, reduce operating costs and allow integration with other smart devices [1].

The correct measurement of consumption is essential for achieving the established goals. The collection of energy consumption carried out by concessionaires follows Decree 41.019/1957 art. 128, which indicates that measurement in public lighting is not mandatory. Municipalities are billed by Energy Distributors based on an estimate based on the power register of installed lighting fixtures, and there are no obligations regarding the periodic updating of assets.

There is no control without measurements and no reduction parameters without historical consumption data. Widely applied in Europe and the United States, remote management allows qualifying and quantifying the service provided and the performance of the luminaires, in addition to measuring consumption. The system makes up for the absence of conventional meters in the energy networks dedicated to public lighting, being a quick way to determine consumption, with automatic registration updates, representing a fair and accurate way of charging. However, there is a lack of mechanisms for certification in Brazil and its official recognition for collection purposes.

The adoption of new technologies in public lighting for energy conservation purposes is necessary. In addition, the use of more reliable and transparent methodologies for calculating energy consumption benefits the environment and society with resource control and fair charges. In the short term, 100% of Brazilian cities will practice the Contribution of Public Lighting for maintenance and modernization, but it is recommended to improve its calculation not only based on the quality and scope of the services provided, but also on the economies of scale that will be generated by the efficiency and implementation of new technologies.

The high investment is a worrying factor for the modernization of public lighting, even when economic feasibility analyses are carried out. However, the scenario is more favorable with the participation of the private sector and the Green Climate Fund.

## 5 Conclusion

Public lighting has a great impact, and it is a key factor to achieve energy efficiency in Brazil. Projects related to public lighting directly impact the financial health of municipalities and the quality of services provided to society through possible budget redistribution. In most cases, the citizens pay for the public lighting service in the municipalities and it is a right of them to verify that the lighting fixtures used are efficient. Since their use impacts public accounts, measurements must exist and be transparent so that the contribution value can be reviewed periodically, following pre-established parameters.

The transfer of asset management to the municipalities reinforces the responsibility of the government as an agent of transformation, aiming not only to supply essential services but also to commit to achieving the goals of the SDGs.

It should be mentioned that, once the luminaires proposed in this work already have a connectivity characteristic, it would be suggested that the communication of these devices may be exploited for the construction of an IoT architecture with the use of artificial intelligence and cross-linking data. Taking into account that the proposed model aims to serve and benefit a small-sized town, with the cross-linking of the resident and visitor's information.

The proposal is to apply artificial intelligence with a focus on the creation of a database fed by the sensors installed in the luminaires. These systems would be based on the application of mathematical models for waste reduction, synchronization of safety cameras with the city monitoring central to prevent accidents, and other integrations that would be useful for the municipal administration and the citizens as a whole, with the objective of bringing more connectivity, information, and safety for everyone.

Therefore, we conclude that nowadays it is necessary to modernize and include technology in urban equipment, as a way of attributing more characteristics to the same system and generating an intelligent city. With the application of basic concepts discussed in this work, and a technical proposal as a way to descriptively formulate this research, we were able to propose a smart lighting model, thus generating countless benefits to society in general, and the sectors involved, such as energy companies and public agencies.

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