Application of Energy-saving and Emission-reducing Technology in Street Lights in Citizens' Exercise Areas

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Abstract. At this stage, research and development and use of energy-saving and environmental protection technologies are increasingly widespread. Especially in recent years, China has put forward a sustainable development strategy. The author has carried out a retrofit study on the urban street lighting system and transformed the urban lighting system. This paper proposes to build a professional and energy-efficient urban street lighting that meets the standards of energy conservation and environmental protection System, and specifically proposed a new type of lighting system, which can effectively reduce the energy consumption of power supply, effectively provide power supply when suppressing reactive power, and rebuild the circuit, in the street light After the system was applied to the residents' sports area, we found that it has the advantages of low running cost, easy expansion and convenient maintenance.

Key words. Energy saving and emission reduction, environmental protection, citizen training area, energy-saving street lights, key technologies.

1. Introduction

As an important part of urban infrastructure, urban road lighting systems play an important role in the urbanization process. However, traditional urban road lighting systems have extensive management methods, large energy consumption, low operation and maintenance efficiency, and inflexible lighting control. Such shortcomings have greatly increased the difficulty and cost of management. According to statistics, the annual electricity consumption of China's urban lighting currently accounts for about 7% to 8% of the country's total power generation. With the introduction of national policies such as the "Twelfth Five-Year Plan" and the comprehensive work plan for energy saving and emission reduction, lighting saves electricity in addition to power saving, it has become another major power saving project [1]. Therefore, the research on the energy-saving system of street lighting is of great significance to achieve the national energy saving and emission reduction goals and promote the modernization of the city.

Based on this, this paper proposes a smart street lamp system design based on the Internet of Things technology. Through the LTE network and the MQTT communication protocol, the smart street lamp management cloud platform can achieve precise control and information tracking of each street lamp, and apply it to citizens' exercise In the street lamp system of the region, the vision of green lighting and cost reduction and efficiency increase is realized [2].
2. System design

The street lamp control system proposed in this paper is based on the multi-agent system organizational structure. The organizational structure of the system can be a fully autonomous equal structure or a hierarchical structure with a master-slave relationship [3]. Different organizational structures behave differently, and the corresponding system performance is also different. In the hierarchical structure, the system members only need to save the relevant information of the members at the next level, which is suitable for a tightly coordinated working mode, and under this structure, unnecessary communication between agents can be reduced, thereby reducing the complexity of the system. According to the demand characteristics of road lighting, this system adopts a hierarchical structure, which is composed of a three-layer structure of street lamp node controller, area control terminal and urban street lamp monitoring centre, as shown in Figure 1 [4].

![Figure 1. Control system architecture](Image)

The intelligent street lamp energy-saving control system based on multi-agent technology is based on a single street lamp node controller, and different control zones are divided according to the characteristics of road distribution, and each zone sets up a street lamp control terminal. In the same area, that is, in the same area of street lamp control terminals, all node controllers are in an equal relationship, and the activities of each street lamp node controller are autonomous and independent, with real-time control capabilities for street lamps, which can be flexible according to the scene environment illumination 3. Effective single lamp control to ensure the voltage stability of each lamp. At the same time, it can communicate and cooperate with street lamp nodes in the same area to send its own data information to the area control terminal. As a district street lamp control and management unit, the district street lamp control terminal communicates with each node controller in the district through wireless, wired or power line carrier, etc., is responsible for the overall control of the entire area, and at the same time with other regional street lamp control terminals Communicate with each other via GPRS network to coordinate road lighting between areas. As the control and management centre of the entire street lamp energy-saving control system, the monitoring centre communicates with regional street lamp control terminals in various places through GPRS network or wired communication, supervises and manages communication scheduling among multiple agents, and reflects the operation of street lamps in various regions in real time Need to perform manual remote control, and provide abnormal detection and automatic alarm functions [5].

3. Smart street lamp intelligent terminal design

As an important part of the smart street lamp system, the smart street lamp intelligent terminal assumes the role of the perception layer in the basic architecture of the Internet of Things and is responsible for collecting front-end information to the back-end platform and executing queries or control commands.
from the back-end platform. It includes the main control core board module, communication module, wireless AP module, power supply module, LED control module, voltage and current detection and alarm module, front-end sensor and other parts. The topological structure of smart street lamp intelligent terminal is shown in Figure 2.

During exercise, the eyes of the public are located on the road surface 60m to 160m in front of the road. The reflected light generated by the street lamp lighting forms a bright background, and the obstacles on the road are displayed as dark shadows. The ratio of the difference between the brightness of the obstacle and the background and the threshold of human eye resolution is defined as the visibility:

$$VL = \frac{|L_b - L_o|}{\Delta L_{\text{min}}}$$  \hspace{1cm} (1)

In the formula: $VL$ stands for visibility; $L_b$ stands for background brightness; $L_o$ stands for obstacle brightness; $\Delta L_{\text{min}}$ stands for brightness difference discrimination threshold. For road lighting, the road surface brightness is $0.05 \text{cd} / \text{m}^2 \sim 5 \text{cd} / \text{m}^2$, the threshold increment can be calculated by the following formula:

$$TI = 65 \frac{L_v}{L_{\text{av}}} = 65 \frac{K E_{\text{eye}}}{\Theta^2}$$  \hspace{1cm} (2)

In the formula: $L_v$ represents the equivalent brightness of the light curtain (the observer looks at the brightness on the road surface 90m in front of the road at an angle of $1^\circ$ to the horizontal line); $L_{\text{av}}$ represents the average brightness of the road surface; $E_{\text{eye}}$ represents the glare light source perpendicular to the line of sight of the observer’s eyes. The illuminance generated on $\Theta$; represents the angle between the line of sight and the incident direction of the light from the glare source; $K$ represents the proportionality constant, $K = 10$ when the unit is degree.
In the road lighting design, in order to prevent the lane from being bright, but the sidewalk is very dark, it is not conducive to the driver to observe the roadside environment, and there is a potential danger (for example, someone suddenly rushes from the side). A certain environmental ratio (SR) is required. That is, the ratio of the average horizontal illuminance in the 5-meter-wide strip area outside the roadway to the average horizontal illuminance on the adjacent 5-meter-wide roadway [6].

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SR = \frac{(E_{av} - B)}{(E_{av} - A)}
\]  

3.1. Main functions of the system

3.1.1. Remote control. The control centre computer wirelessly controls the on / off the street lights at each station according to the local standard switch light time and illuminance meter. It can also be manually controlled remotely or set the switch status directly on site. If the weather is ideal for sunny days, it is enough to control street lights in a flat open-air environment according to the standard switching time. However, the weather will change, which makes the system need to rely on the illuminance meter to adjust the time of switching lights, when the light intensity is insufficient, turn on the street light early or delay the street light. The proofreading command can be sent from the microcomputer or the main control station to calibrate the internal real clock of the microcontroller system of each slave station. You can also reset the time for switching lights on and off every day. Yesterday's actual light switch time is stored in the MCU system of each slave station. If it is not reset, if the main control station is out of control, each slave station still performs the switch control of the street lamp according to the actual switch time of yesterday.

3.1.2. Telemetry. Inspection or random detection of street lamp parameters such as voltage and current of street lamp lines at each station. Randomly detect the parameters of the street lamp line of the slave station, only need the monitoring centre to send the corresponding command (in the form of a command frame) to the slave station, and the communication module that the slave station is listening to will pass the recently collected parameters to it after receiving this command. The main station, the main station analyses and processes the received parameters, and stores these data as the historical information of the station in the database. The patrol inspection means that during the time period when no one is authenticated, the monitoring centre continuously inquires the status of all the slave stations that meet certain conditions in a certain order at present time intervals. In this process, the voltage and current data and running status of the current lines of each slave station are collected into a microcomputer for discrimination and storage. When a running fault is found, an alarm is generated through the analogy screen and the cabinet speaker. The computer screen of the monitoring centre can dynamically display the working conditions and parameters of the street lamps of the most recently queried site.

3.2. Software implementation

3.2.1. Monitoring centre. The man-machine interface of the monitoring centre is an important part of the software design. The interface design is an important part of the screen product, which can directly affect the ease of use of the program, as well as the customer's acceptance of the program, and the friendly interface. It is related to the usability of the software, so the design of the man-machine interface of the monitoring software is a very important link.

The main menu includes user management, system management, module management, centralized control management, electronic map, information query, help, etc :: while user management includes user login, user logout, account management; system management includes start service, stop service, Sound settings; module management includes automatic collection, manual collection, stop collection, single module data viewing, multiple module data viewing; centralized control management includes road segment collection, road segment data viewing, information query; electronic maps have zoom in, zoom out, Positioning, short message, street light attribute, road section attribute, control box attribute,
fault location, etc.; information query includes system log, connection information, data query, fault query, alarm query, report making; tool bar has start service, stop service, Automatic collection, manual collection, set power control file, light on/off, etc. As shown in Figure 3.

![Figure 3. Functional block diagram of street lamp monitoring centre](image)

3.2.2. Business platform. The business platform includes equipment monitoring, personnel management, work order business management, basic management, report management, system management, and large-screen display functions.

(1) Device monitoring analyses the device status and uploaded data of the device management platform, and displays it in front of the user. You can check whether the device is operating normally, whether the data is within the threshold interval, and whether the command is executed. (2) Personnel management can carry out various management and query work of terminal equipment operation and maintenance personnel information. (3) Work order business management can carry out equipment maintenance management, inspection and maintenance management, and maintenance plan management. It can perform work order automation management, and automatically dispatch work orders to designated operation and maintenance personnel for on-site inspection in case of failure. (4) Basic management includes equipment file management (equipment file entry management, management of customer service information, manufacturer information, equipment information, etc.), spare parts management of the warehouse.

4. Research on key technologies

4.1. Energy-saving light source
There are already many self-developed energy-saving lamps and lighting products in China, which have laid a good technical foundation for the future development of the energy-saving and environmental protection industry. However, due to its very high market price, its popularity is small and slow. China should issue corresponding supporting preferential policies for the research and development of energy-saving lighting technologies. While drawing on advanced foreign technologies and research results, we
must actively develop new types of energy and equipment to promote the use of energy-saving green light sources in the process of urban street lighting. From the current situation, China can gradually promote the use of high-efficiency energy-saving lamps, LED street lamps and light energy street lamps.

4.2. **Adopt street lamp buck control technology**

With the continuous completion of China's power generation equipment and grid-connected power generation, the transmission and distribution network has undergone step-up transformation, resulting in a generally higher voltage in the power grid, especially at night. At this time, the street lamp system is operated above the rated voltage of the device, which will cause the device to overheat, shorten the life, and waste a lot of energy. By adjusting the power supply voltage and reducing unnecessary power consumption, it cannot only achieve the purpose of saving electricity, but also protect the terminal equipment and extend the average life of the equipment. At present, the practice of China's street lighting industry to achieve power saving through the way of voltage reduction is roughly divided into three categories from the working principle: 1. Thyristor chopper type lighting energy-saving device. By controlling the conduction angle of the thyristor, the sine wave voltage input by the power grid is cut off, and the average value of the output voltage is reduced to achieve the purpose of voltage control and power saving; 2. Self-coupling step-down control device. The primary and secondary coils of the autotransformer have magnetic and electrical connections. When the output voltage adjustment range is not large, its capacity is relatively small, so it consumes less materials, low cost, and high efficiency; 3. No contact compensation type Regulator. Replacing the relay contacts with thyristors, the thyristors work in a fully-on state, so no harmonics are generated. It is a new generation of AC voltage regulators developed and produced in response to most of the current grid voltage instability and frequent mutations.

4.3. **Use innovative energy-saving lighting technology**

The large-scale use of smart grids is also an innovation in energy-saving technology. In many cities of our country, street lighting systems cause a lot of energy waste due to long power supply lines, and to a large extent affect the brightness of energy-saving street lighting. In the design process of the power grid, energy-saving technology uses photovoltaic cables of better quality and reasonable radius. In addition, through actual operation, it can be found that the voltage of the energy-saving street lamp system will increase significantly at night, so that irregular voltage fluctuations can easily shorten the life of the street lamp and cause a lot of waste of power resources. In response to this phenomenon, the energy-saving technology uses an automatic intelligent light brightness regulator. Through the use of microelectronic technology, the use voltage and lighting brightness of the street light are intelligently controlled under the premise of ensuring the normal function of the street light, thereby greatly extending the use of the energy-saving lighting system Cycle, and can effectively achieve the dual effect of saving power resources.

5. **Conclusion**

In today's deteriorating energy and environment, the large-scale use of energy-saving technologies in urban lighting systems can significantly reduce the waste of social resources, and will achieve significant energy-saving and environmental protection benefits, which have played a positive role in promoting social development. In the process of use, energy-saving technologies must be reasonably and effectively implemented to provide a solid foundation for sustainable development strategies.

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