Green Electric Energy Technology in the Automatic Monitoring System of Electrical Street Lamp Lighting  

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Abstract. Low-carbon economy has become the focus of global development, and the concept of environmental protection has become increasingly popular. As a high-tech industry, LED green lighting not only represents the future development direction of green lighting, but also sets an example in environmental protection and energy saving. The article introduces a wireless monitoring system that Kingsun Optoelectronics uses the latest ZigBee and GPRS technologies for LED street lights. The real-time data in the street lamp controller of the system is transmitted to the cloud server through the data concentrator through the ZigBee node, and the cloud server processes the data and distributes it to the corresponding monitoring terminal. At the same time, the remote control of each wind and solar complementary street lamp can also be realized through each terminal. Experiments have proved that the system realizes the intelligent management and monitoring of street lights based on saving electric energy and ensuring the reliability of lighting. The use of this system can realize the monitoring of all street lights without leaving the house, and finally realize the low-carbon economy and sustainable development of urban lighting.

Keywords: Green environmental protection, management, green street lamp lighting, automatic monitoring.

1. Introduction
The so-called low-carbon economy means that under the guidance of the concept of sustainable development, through various means such as technological innovation, institutional innovation, industrial transformation, and new energy development, to reduce the consumption of high-carbon energy such as coal and petroleum as much as possible, and to reduce greenhouse gas emissions. A form of economic development that achieves a win-win situation for economic and social development and ecological environmental protection [1]. To develop a low-carbon economy, on the one hand, it is to actively assume the responsibility of environmental protection and fulfill the requirements of the national energy saving and consumption reduction targets; on the other hand, it is to adjust the economic structure, improve energy efficiency, develop new industries, and build ecological civilization. Lighting plays an important role in power plants and is mainly used in roads, factories, and other locations. LED lighting is superior to conventional lighting in terms of light source
technology and use effect. Today, when the traditional high energy consumption development model is widely criticized, governments of various countries are gradually introducing supportive industrial policies for the green lighting industry in accordance with the development requirements of the "low-carbon economy". LED lighting is light-emitting diode lighting. It is called the fourth-generation lighting source or green light source. It is one of the most promising high-tech industries in the 21st century. It has the characteristics of energy saving, environmental protection, long life, and small size. A remote wireless monitoring system for LED street lights based on ZigBee and GPRS communication technology came into being. It has a high degree of automation, high efficiency, energy saving, and convenient management, which is of great significance to the construction of an ecologically civilized city.

2. Structural design of the new street lamp system
In the design, conventional LED street lights and wind-solar complementary LED street lamps are arranged on both sides of the highway. It is required to install wind-solar complementary LED street lamps on the opposite side of a conventional LED street lamp to form a father-son relationship to facilitate communication. The cross-structure diagram of this new street lamp system is shown in Figure 1.

![Figure 1. Schematic diagram of the cross structure of the new street light system.](image_url)

The working mode of the street lamp system is as follows: when the power supply of the power grid is normal, from evening to midnight, the two kinds of street lamps are based on the time-sharing dimming control algorithm of the sunset time to realize the light control; after midnight, the regular LED street lights are turned off regularly, only Wind-solar complementary LED street lamp lighting, based on the time-sharing dimming control algorithm at sunrise, realizes the light-off control and reduces the power consumption of the power grid [2]. When a large-scale blackout occurs, at least ensure that the wind-solar complementary LED street lights are turned on cross-structure time every night, and the illuminance of the street lights is appropriately adjusted to reduce the incidence of traffic accidents at night.
3. Overall design of street lamp monitoring system

3.1. System structure
The structure of the wind-solar hybrid LED street lamp monitoring system is shown in Figure 2. The system is composed of wind-solar complementary LED street lights on the road site, ZigBee wireless communication node, concentrator gateway, remote monitoring platform, cloud communication server and database server. Each wind-solar complementary street lamp is equipped with a wind-solar complementary street lamp controller and a corresponding wireless communication node. All street lamp nodes and the wireless communication modules in the concentrator gateway form a wireless ad hoc network data communication network [3]. The data of each wind-solar complementary street light can be sent to the concentrator gateway of the corresponding road section through the wireless communication node in the corresponding street light, and uploaded to the cloud server through GPRS communication, and finally transmitted to the remote PC and mobile phone monitoring platform.

![Figure 2. Structure diagram of wind-solar hybrid street lamp monitoring system.](image)

3.2. System function
The wireless intelligent control system for urban LED street lights is a new type of hybrid network structure that combines the upper layer GPRS communication and the lower layer ZigBee communication. Different from the current mainstream domestic lighting control field, only the GPRS control loop method is the first to apply ZigBee technology to lighting control. The system can be divided into three layers: server layer, electric control cabinet main node layer and terminal layer. The terminal layer of the system is composed of wireless sensors, and each street lamp is controlled by a single light pole intelligent terminal, which can detect parameters such as voltage, current, and power factors in real time [4]. At the main node level of the electric control cabinet, the main control box collects the sensor information at the bottom layer and sends it upwards through the GPRS network to the monitoring centre of the application layer. At the server level, the monitoring software can display the geographic information of urban lighting in real time, detailed statistical reports, as well as the total power consumption, lighting rate, power factor compliance rate, energy-saving coefficient compliance rate, etc., displayed by the server, large screen, and Centre View central control system software platform, etc., through zooming and transforming the Centre View central control system, observe and control the lighting conditions of the entire city, a street, a road, and even a street lamp from a bird's-eye view. Mobile monitoring and management equipment (laptop computers, PDAs, mobile phones) and street lamp maintenance vehicles can also be remotely telemetered and controlled through the control centre.
3.2.1. **Lighting control terminal.** The lighting control terminal circuit composition is shown in Figure 3. Among them: 2.4G module is used for network communication nodes; pyroelectric and light are used to detect human body and vehicle signals and light brightness; relays are used to control LED street lights On and off; STM32 is the core of the entire control unit node system, and all control command signals must be controlled by STM32. The whole system is flexible and stable.

![Lighting control terminal diagram](image)

**Figure 3.** Lighting control terminal circuit composition.

3.2.2. **Wireless transmission terminal.** It is composed of ZigBee module (with self-organizing network function, which can be used as a terminal node, but also as a router or coordinator), antenna and control circuit (used for power supply, drive, and control of street lights). It is the executive part of the control function in the street lamp monitoring system, and it also completes the signal acquisition in the detection function. Through the network built by the ZigBee module itself, the wireless terminal can accept commands from the on-site controller and exchange data with the on-site controller, such as turning on the lights, turning off the lights, adjusting the brightness, and judging the current running status of the street lights based on the feedback information, such as Whether there is a fault [5]. The hardware design of wireless transmission terminal mainly includes: ARM9 main controller, network coordinator, router system and so on. Its structural hardware design principal block diagram is shown as in Fig. 4.

![Wireless transmission terminal diagram](image)

**Figure 4.** Composition of wireless transmission terminal.

3.3. **Multi-platform monitoring software design**

Delphi has always been the mainstream choice for software development on the Windows platform, but with the growing demand for Web and mobile terminal development, Delphi has gradually been surpassed by other development software [6]. In 2013, EMB released XE4, which opened a chapter for
Delphi to directly develop Apple App. At the same time, OrangeUI began intensive research and development, which took four years. During the EMB also released XE5, XE6, XE7, XE8, D10Seattle, until D10.1Berlin version, Delphi has already available a set of code, while developing stable iOS and Android two platform App.

In addition, because the Data Set Provider needs to return the data set in Ole Variant format, and the PC or mobile phone client is also developed with Delphi, the resulting performance is the highest. Therefore, this system chooses D10Seattle to develop remote monitoring terminal software based on Windows and Android systems.

3.3.1. Data transmission function. The monitoring platform can receive the data on the communication node of the on-site street light controller through the data concentrator, or it can send the data to the designated street light controller communication node through the reverse process of the communication server on the monitoring platform.

3.3.2. Project information management. The basic information of wind-solar complementary street lamps can be entered on the platform individually or in batches, including project, area, road section, gateway address, street lamp address, latitude and longitude, street lamp configuration information, etc.

3.3.3. Monitoring function. The status of street lights, wind turbines, solar panels, and batteries can be displayed in real time through the monitoring platform.

3.3.4. Data management function. For the collected bottom street lamp data, the remote monitoring centre can edit and analyse the data, store, and archive the data, and give alarms to the wrong data. Considering the data security requirements, the monitoring centre must have the function of regularly backing up and restoring data.

3.3.5. Control function. It can control the remote functions such as switch control, fan brake and de-brake and time synchronization of the entire wind-solar complementary LED street lamp or selected certain wind-solar complementary LED street lamps.

3.3.6. Setting function. You can set the lighting strategy of wind-solar complementary LED street lights (such as the ambient light brightness of the switch lights, load working mode, lighting time, lighting duration and lighting power, etc.). The charging and discharging parameters of the wind-solar hybrid LED street lamp battery and the parameters of the fan operation can be set.

3.3.7. Alarm function. The wind and solar hybrid LED street lamp monitoring system can generate corresponding alarm codes according to different fault codes. The fault codes should be uploaded to the remote monitoring centre through the wireless communication node and data concentrator in time. The monitoring centre responds to the fault alarm in time, and the monitoring centre can pass it if necessary. Notify the corresponding responsible person in the form of SMS or phone dialling.

3.3.8. Data storage and statistical functions. The remote monitoring centre can save the operating data for a period in the past, perform statistics on the operating data, and generate reports to facilitate the analysis of whether the system is operating normally, provide design references for future projects of the same type, and improve the operating conditions of the system.

4. Economic analysis of system operation

Judging from the situation after the system is running, the huge gap can be seen through statistical analysis of the electricity consumption of the street lamps installed with the system and those without the system. Taking 500 LED street lights on a main road in a certain area as an example, we separately counted the electricity consumption in the two cases. Before the street lights were installed with the
control system, the daily electricity consumption was 1380 degrees [7]. After the control system was installed, every day the electricity consumption is 966 kWh; the electricity fee is calculated at 1.2 yuan per kWh; the labour cost is 2,000 yuan/month for a total of 2 people; the depreciation fee is 8,000 yuan/month, the specific data is as follows:

### Table 1. Operating economy table.

| Project                          | No system installed | Installed system  |
|----------------------------------|---------------------|-------------------|
| Daily electricity consumption (degrees) | 1380                | 966               |
| Daily electricity fee (yuan)      | 1656                | 1159.2            |
| Labor cost (2 people)             | 4000 (monthly)      |                   |
| Depreciation expense (yuan)       | 8000 (monthly)      |                   |
| Total annual cost (yuan)          | 748440              | 567108            |

It can be seen from the above table that the street lights with the control system installed can save 362.6 yuan per year, and the construction cost of the control system is about 150 yuan per street light. In this way, the construction cost can be recovered in about half a year. Through long-term use, it can achieve the effect of saving a lot of investment.

5. Conclusion

"Urban LED Street lamp wireless intelligent control system" has the advantages of strong practicability, reliable operation, easy control and easy installation and maintenance, which can solve the problem of urban LED street lamp maintenance and management. Comprehensive technical and economic analysis, the use of LED lighting equipment can save the total cost of investment in the case of high lighting, with greater economic and social benefits, and to a certain extent help power plants save capital investment. The author analyses the technical characteristics of LED lighting sources, the analysis of the application of LED lighting technology in power plants, and the economic comparison between LED lighting and conventional lighting. It is recommended that LED lighting equipment be suitable for use in power plants.

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