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Application Analysis of Solar LED Street Lamps in High Altitude Areas

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Abstract

Under the concept of green and sustainable development, the application of renewable new energy has become the main direction of development in various industries. Solar LED street lamps belong to independent systems, so there are strong unknowns and unpredictability due to different environmental factors during the construction process. Failure to grasp them may have a negative impact on the reliability and operational stability of the system. This article takes the high-altitude and cold climate conditions of Longzi County, Shannan City, Tibet Autonomous Region as an example to analyze the advantages and innovative points of solar LED street lights application in high-altitude areas. Taking examples as reference, it explores the constituent elements and specific methods of solar LED street lights application, in order to improve the effectiveness of solar LED street lights application and provide assistance for the economic development of Tibet while adhering to energy conservation.

Keywords

High Altitude Areas; Solar Energy; LED Streetlights; Application Analysis.

1. Introduction

Road lighting plays an important role in social development, as a key public resource that has a direct impact on people's daily lives [1]. Traditional road lighting is supported by electricity and completed through the national power grid. Although it has a wide range of applications, it not only consumes high electricity but is also easily affected by the circuit, making it prone to lighting failures and causing inconvenience to people's normal lives [2]. Against the backdrop of sustained scientific and technological development, LED lighting technology has become increasingly mature and has become one of the most widely used lighting tools for road lighting. Moreover, under the concept of green and sustainable development, new energy lighting has also ushered in new opportunities for development. Solar LED street lights can not only save on the process of electricity conversion, improve the effectiveness and flexibility of lighting systems, but also expand new development paths for road lighting systems and flexibly apply them in complex and ever-changing environments [3]. In order to meet the needs of road lighting in complex environments such as low light, rainy, plateau, and high cold, improve the quality of life of local people through lighting, and promote the effective development of regional economy, it is necessary to strengthen the analysis and analysis of solar LED street lights, and apply their high quality to various complex environmental conditions at high altitudes.

2. Background Introduction

The main case analyzed in this article is the road lighting in Longzi County, Shannan City, Tibet Autonomous Region. The climate conditions in Longzi County are complex, with an annual average

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temperature of only 5.5℃, an annual precipitation of 297.41mm, an annual frost-free period of 238.3 days, and an annual minimum temperature of nearly -25℃. Considering the installation of the same number of street lights, if 170 power grid street lights are installed in Longzi County, with alternating 220V as the main power supply method, the total annual electricity consumption is about 90000 kW·h, therefore the electricity consumption is relatively high. Under the influence of many environmental factors such as temperature, sunlight, wind, etc., serious paint peeling and corrosion will occur on lamp poles, resulting in inconsistent appearance, low aesthetics, practicality, and large power consumption.

Street lighting is one of the necessary public facilities, but the use of traditional power supply methods not only does not meet the requirements of current energy-saving and environmental protection concepts, but also is more prone to failures [4]. This is because power supply requires complex wiring, heavy burying workload, and long cable lines. If a fault occurs during the application process, it is extremely difficult to troubleshoot, and directly affects the normal lighting of the public areas in the area. With the growth of the application years of traditional street lighting systems, the cost of operating and maintaining systems in enterprises is also significantly increasing, posing challenges to enterprise cost management. Driven by the concept of green and sustainable development and the development of science and technology, street lighting systems supported by renewable energy are increasingly widely used, mainly including wind energy, light energy, solar energy, and wind-solar complementation, with broad application prospects and prominent energy-saving effects [5]. In addition, neither wind-solar complementary solar street lamps nor single solar street lamps require the assistance of the national grid, which not only has low construction costs, but also relatively low maintenance costs, effectively reducing the consumption of traditional energy, achieving high efficiency, energy conservation, environmental protection, and low cost.

As far as the region is concerned, Longzi County, Shannan City, has good solar and wind energy resources. In terms of solar energy, the county has a long duration of sunlight and sufficient sunlight. The annual solar radiation is about 5900MJ/m2, and the annual average sunshine duration is 3005.9h. Therefore, the effective use of solar energy resources is extremely reasonable. The application of green and renewable resources effectively reduces the use of non renewable or polluting resources, and the emission of polluting gases is directly reduced to zero, which is an effective implementation of the construction of an environmentally friendly society. Moreover, the application of solar energy resources has reduced the dependence of regional public lighting on traditional electric energy, resulting in greater stability, flexibility, and obvious application advantages. Figure 1 shows the construction photo of solar LED street lamps in Longzi County.

Fig 1. Construction Photo of Solar LED Street Lamp in Longzi County

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3. Advantages and Innovative Points of Solar Street Lights in High-altitude Areas

3.1 Advantages

(a) Security. Solar energy has been widely used in public lighting systems, with low voltage power supplies such as DC 12V and DC 24V, which greatly reduces the incidence of accidents such as accidental electric shock and power fire, and makes operation safer. Driven by scientific and technological progress, solar DC application technology is becoming more mature and safety is becoming more evident.

(b) Economy. The application of solar energy in highway lighting systems greatly reduces the dependence on traditional electric energy. Using renewable green energy, the power consumption in the street lamp installation area will be directly reduced by 90000 kW · h, with lower operating costs. In addition, solar street lamps use single pole independent power supply, which is simpler in line, more convenient in laying, and lower in failure rate compared to traditional power systems. Independent operation greatly facilitates maintenance work, reduces the area for troubleshooting after a fault occurs, and does not affect other street lights, resulting in lower maintenance costs.

3.2 Innovation Points

(a) Application of lighting energy in high altitude areas. Due to the long winter in Longzi County, Shannan City, and the low average temperature in winter, there are high requirements for cold resistance of batteries. However, at present, ultra-low temperature batteries have not been widely used in various fields, only in special industries, and their prices are high, which is not suitable for widespread popularization. In order to reduce battery loss, in low temperature environments, workers need to establish a 1.2m deep battery foundation pit on frozen soil in combination with the actual situation in Longzi County to provide thermal insulation through deep burial on the ground surface. At the same time, select appropriate insulation panels to provide insulation and protection against freezing, while also playing a waterproof role. Use solar dedicated gel batteries to extend their service life and ensure stable operation of the battery in low temperature environments.

(b) Reduce energy consumption. The total power consumption in the street lamp installation area can be reduced by about 90000 kW h per year. As the power consumption in this part is reduced, the resource saving effect is obvious.

(c) Solar intelligent control system. The research and application of solar intelligent control systems can achieve automatic control, monitoring, and fault alarm of lighting systems through battery charging and discharging. In addition, overvoltage protection, short circuit protection, overvoltage protection, overcharge protection, battery reverse connection protection, lightning protection, and load overcurrent are also important functions. In addition, it can also be connected to a mains power supply. If the solar battery loses power due to various adverse weather conditions, the system can automatically switch to mains power supply to ensure the stable and normal operation of the lighting system.

(d) Provides long endurance. The street lamp installation area requires about 10 hours of street lamp lighting time, which is relatively long. Therefore, it is necessary to pay attention to the expansion of battery capacity and extend its battery life. After the battery capacity expansion, the solar battery can achieve long-term full power lighting requirements in low-temperature environments, with normal charging and discharging functions, and longer service life.

4. Parameter Design of Solar LED Street Lamps

4.1 Luminaires for Street Lamps

There are two types of new energy LED street lamps: (a) only light sources; (b) DC-DC constant current power supply model. The latter is the main type of new energy lamps. Compared to urban LED street lamps, DC-DC constant current lamps have higher current efficiency. The performance

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of a light source is generally determined by its heat dissipation function, optical design, and photoelectric performance of the lamp beads. The design of lamps in different environments needs to be changed [6]. In complex environments, it is necessary to distribute light reasonably according to actual needs and give full play to lighting effects while adapting to the environment. At the same time, it is also necessary to pay attention to the improvement and innovation of the heat dissipation function, balance the heat during the operation of the lamp, and improve the working effect of the lamp [7]. In addition, compared to municipal LED street lamps, new energy LED street lamps also need to pay special attention to the improvement of lamp bead performance to ensure the smooth operation of the lighting system. The effect of solar LED street lamps in Longzi County is shown in Figure 2.

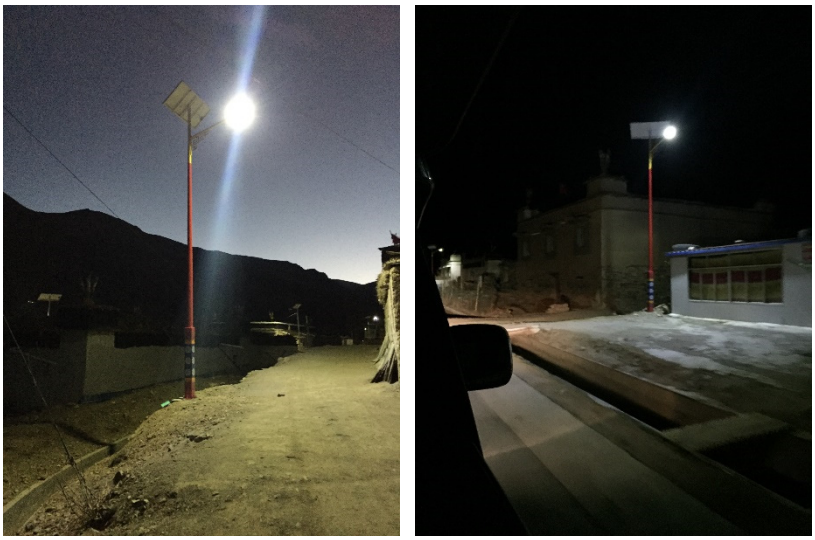

Fig 2. Solar LED Street Lamp Effect in Longzi County

4.2 Storage Battery

The battery is at the core of the new energy LED street lighting system and is a key component for storing and releasing energy. Through batteries, the lighting system can store light energy during the day and release it at night to complete lighting. Common batteries in the current market include colloidal energy storage batteries, lithium batteries, and lead acid energy storage batteries. Among them, colloidal energy storage batteries are the safest battery type, and the technology is relatively more mature [8]. In the context of scientific and technological development, the price and cost of energy storage lithium batteries continue to decline, and have become the main application scheme for new energy circuits. The advantages and disadvantages of lithium batteries are obvious: in terms of advantages, compared to colloidal batteries, lithium batteries have higher energy and power density, lighter weight, and smaller volume, resulting in lower installation difficulty and lower cost investment; In terms of disadvantages, lithium batteries lack safety and stability when used in complex environments. High or low ambient temperatures can affect the normal operation of the battery [9]. Therefore, if batteries are used in high altitude and cold regions, deep burial can be used to achieve the purpose of thermal insulation and cold protection.

4.3 Photovoltaic Module

For solar LED street lighting systems, solar photovoltaic modules are a key component for collecting and converting energy, and are typically installed at the top of the lamp pole. Silicon based photovoltaics are the core components of solar photovoltaic modules, mainly composed of crystalline silicon such as polycrystalline silicon, monocrystalline silicon, and amorphous silicon. Among them, monocrystalline silicon and polycrystalline silicon are the main components used in solar LED street lights [10]. The output power of solar photovoltaic modules can be affected by lighting conditions, so it is necessary to pay attention to the application parameters of solar photovoltaic modules under different lighting conditions to improve application effectiveness. At the same time, the pole specificity of solar LED street lamps is prominent, and they are the core support of the new energy

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LED road lighting system. They are composed of lamp arms, lamp pole bodies, component dedicated supports, and underground pipelines. It should be noted that solar modules are installed on the top of the lamp pole, which provides a more rigorous choice for the wind proof type and stability of the lamp pole. It is necessary to analyze the impact of complex environmental factors in detail, and reasonably select the material, welding degree, caliber, and thickness of the lamp pole. Figure 3 shows the solar LED street lamp in Longzi County.

Fig 3. Solar LED Street Light in Longzi County

4.4 Controller

The solar LED street lamp controller is the central controller that controls the above components, and is at the core of the lighting system, ensuring the stable and orderly completion of lighting work [11]. Constant current control all-in-one machine is currently the most common application type of LED street lights, with a maximum photovoltaic charging current of 15A and a maximum load of 150W. If the environmental conditions are relatively complex, it is necessary to fully consider the differences in temperature and lighting, reasonably regulate the lighting system at each time period, and ensure the reliable operation of the system. At the same time, try to connect to the mains power supply. If there is prolonged and severe weather affecting the battery power supply, it can be intelligently adjusted to the mains power supply mode to ensure the stable operation of the street lighting system. The controller selected in this article is shown in Figure 4.

Fig 4. Selected Controller

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5. Conclusion

The application of solar LED street lamps under complex conditions can ensure the normal life of local people, but there are also many difficulties in the application process. Not only does it require optimizing the configuration of the street lamp system, determining the key influencing factors under complex conditions, but also it requires passing multiple system tests to meet the optimal application goals. Relevant workers need to recognize the advantages of solar LED street lighting applications, reflect on complex environmental factors, continuously optimize new energy lighting systems, optimize their configuration, ensure stable and safe operation of the system, ensure adequate lighting, and provide corresponding infrastructure support for the overall development of Tibet.

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