

Application of Photovoltaic Power Generation System in Green Building

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Abstract:

The application of photovoltaic power generation systems in green buildings is a current research hotspot in the field of architecture. In building construction, photovoltaic power generation systems can improve building energy efficiency and promote sustainable development. Nowadays, the construction of green buildings in China is still in its infancy stage, and the technical level is relatively low. To avoid energy waste, it is necessary to integrate photovoltaic power generation systems with green buildings. This article briefly introduces the principles, system configuration, and classification of photovoltaic power generation systems, and expounds on the concepts and characteristics of green buildings. The article summarizes the application requirements of photovoltaic power generation systems in green buildings, analyzes the application of photovoltaic power generation systems on building exterior walls, roofs, and skylights, and provides suggestions for the application of photovoltaic power generation systems in green buildings for reference.

Keywords:

Photovoltaic power generation system
Green building
New energy

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1. Introduction

With the introduction of the concept of sustainable development in China, many industries are increasingly focusing on the green economy. The green economy can reduce costs while it can protect the environment where people live. The application of photovoltaic power generation systems in the construction industry can reduce investment in non-renewable energy sources and increase

the speed of energy recovery, which is an inevitable trend in the development of the construction industry.

Since the reform and opening up, China's construction industry has achieved unprecedented development, but it has also brought issues such as energy loss. Therefore, people need to develop more advanced technologies for use in the green building industry. Photovoltaic power generation systems can convert

solar energy into electrical energy, achieving sustainable development. These systems are characterized by simplicity, stability, reliability, and good reproducibility. Nowadays, as the depletion of non-renewable energy sources (such as coal, oil, and natural gas) continues to increase, there is an urgent need to develop renewable energy sources. Compared with non-renewable energy sources, solar energy is a new, clean, renewable, and large-scale energy source that has been developed and utilized by humans after wind energy. It not only has huge reserves but also features zero emissions and no pollution, making it key to preventing air pollution, delaying the greenhouse effect, and developing a low-carbon economy. Applying photovoltaic power generation systems to green buildings can reduce the energy consumption of the buildings themselves, while also beautifying and decorating them. Combining photovoltaic power generation systems with green buildings is a practical approach that brings the possibility of sustainable development to human society ^[1].

2. Overview of photovoltaic power generation systems

2.1. Working principle of photovoltaic power generation systems

Photovoltaic power generation systems utilize semiconductors to convert solar energy. They consist of solar cell panels, controllers, inverters, protection devices, automatic transfer switches (ATS), and other components. Among them, solar cell panels can convert solar energy into electrical energy and store the converted electrical energy; the controller is responsible for controlling the operation and automatic switching of the entire system and solar cell panels; the inverter is responsible for converting the direct current from the battery or storage panel into alternating current; and the protection device is responsible for the low-voltage protection of the system and cabinets, ensuring the stability of the system during operation ^[2].

During the day, the solar cell panels normally absorb sunlight, and the controller performs maximum power generation conversion. The electrical energy is stored in the battery and supplied to electrical appliances under the control of the controller. At night, when the solar cell

panels stop working and the battery power is insufficient or the fixed power system malfunctions, the controller automatically switches the circuit to a normal grid power supply ^[3].

2.2. Classification of photovoltaic power generation systems

Photovoltaic power generation systems are classified into independent photovoltaic power generation systems and grid-connected photovoltaic power generation systems based on whether they are connected to the public grid.

2.2.1. Independent photovoltaic power generation systems

Independent photovoltaic power generation systems, also known as off-grid photovoltaic power generation systems, are power generation systems that are not connected to the public grid. They are particularly suitable for remote areas such as mountains, islands, and deserts where the public grid cannot reach. They can be found in small electronic devices such as calculators and children's toys. Independent photovoltaic power generation systems can be flexibly deployed and are widely used in weather stations, solar lighting systems, and communication base stations. They are also commonly used for power supply in spacecraft, lunar probes, space stations, and other aerospace equipment. These systems are typically equipped with energy storage devices that can save excess generated electricity, making them self-sufficient photovoltaic power generation systems ^[4].

2.2.2. Grid-connected photovoltaic power generation systems

Grid-connected photovoltaic power generation systems are connected to the public grid and exist in two connection modes. Large-scale photovoltaic power generation systems are usually built in remote open spaces without nearby electrical loads. Therefore, the electrical energy generated by these systems does not need to pass through internal systems but is directly fed into the public grid, which has now become an important component of China's energy supply structure. Many photovoltaic power generation systems are distributed in various corners of cities and residential areas (i.e., distributed photovoltaic power generation systems).

These distributed systems are connected to the public grid through an internal network, which is the internal network of the distributed photovoltaic power generation system. The application of the internal network can save energy consumption in urban buildings and relieve the long-term power supply pressure on the public grid ^[5].

3. Overview of green buildings

Green buildings offer advantages such as being low-carbon, environmentally friendly, and pollution-free. Throughout their entire lifecycle, from construction to use, they consume low amounts of energy, conserve resources, protect the environment, and integrate with natural ecosystems. They provide people with a comfortable, healthy, and efficient working and resting environment. Green buildings represent a new concept in the construction industry, distinct from traditional buildings. They refer to buildings that fully utilize various natural energy sources and cause minimal environmental damage ^[6]. Therefore, when designing green buildings, designers need to consider energy efficiency and incorporate the concepts of energy conservation and environmental protection. The characteristics of green buildings are as follows.

Traditional buildings consume large amounts of energy such as coal, but green buildings use significantly less traditional energy and can harness clean energy sources like solar power.

Green buildings have high energy efficiency and low energy consumption. Environmentally compatible technological means are often employed in the construction of green buildings to ensure rational planning and utilization of water and soil resources.

Green buildings strive to integrate with the natural environment and cause minimal disruption to it ^[7].

4. Application requirements of photovoltaic power generation systems in green buildings

Currently, issues such as energy storage reduction and environmental damage are widespread globally, promoting the application of photovoltaic power generation systems in green buildings. Many countries

around the world are committed to the construction, development, and improvement of photovoltaic power generation systems. The use of these systems has made it possible for green buildings to generate electricity through renewable energy sources.

The construction of green buildings requires safety, comfort, convenience, and economy. Traditional power generation methods like coal-fired power plants not only consume large amounts of primary energy but also cause significant environmental pollution. Photovoltaic power generation systems avoid this problem by utilizing solar energy for electricity generation, which is highly beneficial for the construction of green buildings. These systems are characterized by their intelligence, requiring minimal supervision during operation, thus saving significant labor costs and ensuring the overall smooth operation of the building. This, in turn, enhances the comfort and convenience of people's work and life.

4.1. Strengthening energy management

A green building is a multi-technology integrated system that requires the input of various parameters related to energy, the environment, and technology. It involves conducting various ecological safety tests, establishing a symbiotic management system, calculating energy consumption, and addressing environmental and safety issues. To enhance the application effectiveness of photovoltaic power generation systems in green building construction, it is necessary to create a control model that utilizes multiple technologies to achieve energy management, thereby realizing green and energy-efficient construction.

4.2. Conducting in-depth research from multiple perspectives

The integration of green buildings and photovoltaic power generation systems is interdisciplinary, involving civil, environmental, ecological, and energy fields, as well as architecture, intelligence, and other domains. The research and development team for photovoltaic power generation systems needs to conduct in-depth studies in multiple technical areas to advance green building construction from various directions.

5. Specific applications of photovoltaic power generation systems in green buildings

Due to rapid technological advancements, the application of photovoltaic power generation systems in green buildings has become feasible. These systems contribute to green buildings in two ways. Firstly, the solar panels in the photovoltaic system can block sunlight. Secondly, improving the conversion efficiency of the photovoltaic system can save energy by absorbing large amounts of sunlight for energy conversion, thereby reducing energy consumption. Photovoltaic power generation systems are primarily used in the exterior walls, roofs, and skylights of green buildings.

5.1. Application in exterior walls

Building exterior walls are typically smooth, flat, and have a large area, which facilitates the collection of sunlight for use in green building photovoltaic power generation systems. This provides a favorable workspace and conditions for the photovoltaic system. Most exterior walls of a building are exposed to sunlight, and the contact area between the photovoltaic system on the exterior walls and sunlight is very large.

Glass curtain walls are commonly used in building facades. In practical engineering applications, designers can integrate solar panels from the photovoltaic system with building glass to create photovoltaic glass curtain walls. These specially processed curtain walls are installed on the exterior wall surface of the building, not only blocking most of the solar radiation but also converting the absorbed light energy into electrical energy in a timely manner. This supplies power to the electrical loads in the building, significantly reducing building energy consumption. The use of photovoltaic glass curtain walls in green buildings not only enhances the aesthetic appeal of the facade but also ensures the collection of sunlight, playing a crucial role in improving the efficiency of the photovoltaic power generation system and reducing energy consumption.

5.2. Application on rooftops

The contact area between sunlight and rooftops is relatively smaller compared to exterior walls. However, when installing solar panels on rooftops, there is no

need to consider the angle, making the construction of photovoltaic power generation systems on rooftops very convenient. Designers need to focus on the impact of natural disasters on the operation and lifespan of the system when installing rooftop photovoltaic power generation systems. Common natural disasters include heavy rain, thunder, and strong winds. The possibility of rainwater accumulation can be reduced by adjusting the roof diagonal method. Besides the necessary lightning protection equipment for the building, a large amount of high-strength materials must be used to protect the solar panels. When installing protective panels, equipment must be protected from strong winds, and the hardness of the solar panels must be increased.

5.3. Application in skylights

Skylights are used for daylighting in green buildings while avoiding direct sunlight. The photovoltaic power generation system adopted in skylights should not only provide lighting and shading but also ensure work efficiency. When designing the skylight photovoltaic power generation system, it is necessary to reasonably design the angle of the solar panels, utilize light refraction to achieve lighting purposes, and improve lighting efficiency. Simultaneously, to enhance the power generation efficiency of solar panels, appropriate adjustments to the skylight slope are required. Photovoltaic power generation systems can also be utilized in other parts of green buildings, such as sunshade panels.

6. Suggestions for the application of photovoltaic power generation systems in green buildings

During the initial design phase, designers should comprehensively consider the scale of energy construction or use photovoltaic power generation systems in already-built buildings to reduce energy consumption.

In the application of photovoltaic power generation systems, it is necessary to systematize the work of these systems. Designers should fully consider local environmental factors based on actual conditions to enhance the practical application effectiveness of photovoltaic power generation systems.

With the development of new materials, large-area radial resin materials can be used in the organic

integration of photovoltaic power generation systems with green buildings. Additionally, flexible thin-film cell components can be cut into various sizes and placed on the rooftops of buildings.

The initial construction cost of photovoltaic power generation systems is high, requiring national financial and policy support. Residential energy-specific subsidies can also be provided for residential buildings.

Building energy efficiency data can be adjusted and monitored in real-time through the Internet, ensuring the efficiency and safety of photovoltaic power generation systems and supporting the development of the Internet + energy industry chain. If there are problems with related facilities, maintenance personnel should be promptly contacted through the Internet. Residents can also use the Internet to control supporting facilities such as air conditioning and heating.

7. Conclusion

Environmental destruction and energy consumption are current research priorities. China is accelerating

the development of green buildings and needs to fully utilize photovoltaic power generation systems to promote sustainable development in this area. The advancement of photovoltaic power generation systems can foster innovation in architectural design, alleviate energy shortages, and reduce environmental pollution. Nowadays, China has begun to apply photovoltaic power generation systems in green buildings. With continuous improvements in these systems, decreasing costs, and increasing efficiency, green buildings have broader development prospects. Currently, there are no application standards in the green building industry, necessitating institutional development by the state. Managing the green building industry through policies and technical specifications will elevate China's ecological civilization construction to a new level, implementing the concepts of innovation, harmony, green development, openness, and common progress, and promoting green economic growth. This will enable further advancements in photovoltaic power generation systems and green buildings in the future.

Disclosure statement

The authors declare no conflict of interest.

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