

# The Application Status and Prospects of Solar Photovoltaic Power Generation Technology in China

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**Abstract:** Solar photovoltaic power generation, as an environmentally friendly energy technology that converts sunlight into electricity, directly converts sunlight into electricity through the use of solar panels, further producing clean and environmentally friendly electricity. Through the analysis of the development status of China's solar photovoltaic power generation, this article discusses the development direction of China's solar photovoltaic power generation to provide reference for the healthy development of China's solar photovoltaic power generation industry.

**Keywords:** Solar Energy; Photovoltaic Power Generation Technology; Application Status.

## 1. Introduction

The deteriorating global environment and resource scarcity are significantly limiting the progress of sustainable development. Consequently, the green and low-carbon transformation of the energy system is imperative, with further development of renewable energy and cleaner, more environmentally friendly existing energy sources as the primary focus of energy development.

When comparing various environmentally friendly energy technologies, solar photovoltaic power generation stands out with its shortest energy source path, highest conversion efficiency, vast reserves, and clean safety profile. As a result, it has emerged as a crucial component of the green and low-carbon transformation process of global energy.

China, as the world's third-largest country in terms of land area, is blessed with abundant solar resources. This advantage has positioned China as a major player in the global solar photovoltaic power generation industry. By capitalizing on its vast solar potential, China can play a pivotal role in the global transition towards a low-carbon economy and contribute significantly to the world's efforts to combat climate change and environmental degradation.

According to the China Meteorological Administration report, the region with the most annual solar radiation is: the annual radiation above 6300 MJ/m<sup>2</sup>. The region with a high annual solar radiation is: the annual radiation between 5040~6300 MJ/m<sup>2</sup>. The region with abundant annual solar radiation is: the annual radiation between 3780~5040 MJ/m<sup>2</sup>[1]. China's energy-saving and emission reduction trend is unstoppable. As the leader of the new energy industry, the solar photovoltaic power generation industry will inevitably be affected by the era and receive dividends and challenges.

## 2. Status Analysis of China's Solar Photovoltaic Power Generation Technology

The raw materials required for the production of solar photovoltaic systems are single-crystal/polycrystalline silicon wafers, PET base film, silver paste, and fluorine film. The composition of a solar panel can be roughly summarized as a solar cell, glass, encapsulation material, backboard, and

support. In the past decade of rapid development, China's photovoltaic industry has fully realized independent intellectual property rights in the entire industrial chain, which is an important source of energy revolution in the future in China[2]. With the gradual decline of fossil fuel resources such as oil and coal, the demand for electricity for living and engineering provided by solar energy, which is inexhaustible, is gradually becoming a new trend in China.

### (1) High-efficiency solar cells

On January 14, 2024, China made a groundbreaking achievement in the realm of high-performance perovskite solar cells, which has the potential to revolutionize the solar energy industry. Perovskite cells, when compared to traditional silicon cells, demonstrate numerous advantages across multiple areas. In terms of quantity, process temperature, preparation difficulty, environmental friendliness, initial investment, and production cost, perovskite cells stand out with their notable advantages.

Specifically, researchers in China have utilized a phosphate ester modified buried interface, which effectively reduces the residual tensile stress at the interface, promoting the crystallization process of perovskite. This innovative approach significantly reduces the interface energy barrier that can hinder the performance of the cell. By applying this strategy, researchers have successfully reduced non-radiative recombination and improved interface contact effects.

As a result of these advancements, after phosphate ester-modified devices, they achieved a power conversion efficiency of 24.63%, which is currently one of the highest efficiencies achieved in the air environment. This milestone underscores the vast potential of perovskite cells and their potential to transform the solar energy landscape in the years to come. With continued research and development, China's innovations in the field of high-performance perovskite solar cells will undoubtedly contribute to a more sustainable and efficient future for solar energy.

### (2) Integrated technology of photovoltaic systems

China has made significant advancements in the field of solar photovoltaic power generation with the development of the latest fourth-generation all-efficiency photovoltaic power generation integration technology. This groundbreaking technology delves deeply into the energy source of the sun, ingeniously transforming natural light into a form that is optimally suited for crystalline silicon batteries.

Through the unique artificial intervention technology, the process covers six magical effects: wide-angle light collection, scattering collection, light alignment, multi-fold concentration, wavelength optimization, and wavelength modulation. This innovative approach draws inspiration from the exquisite structure of the insect's compound eye - the compound eye - and combines it with advanced western laser technology to elevate the treatment of light to a new level.

As a result, the incident light on a single silicon cell increases by 5-10 times, and the photoelectric conversion efficiency exceeds 20%, reaching a maximum of 60%. This significant increase in the comprehensive power generation capacity has resulted in a 15-30 times increase, while the cost has dropped to one-fifth of traditional flat photovoltaics, only 0.5 yuan per kilowatt-hour in areas with abundant sunlight, and even as low as 0.3 yuan in areas with sufficient sunlight.

Moreover, this innovative technology does not require major changes to existing photovoltaic enterprises, but only needs to add an optical processor on the traditional silicon photovoltaic panel to easily achieve an upgrade. This makes it a highly adaptable and scalable solution that can be seamlessly integrated into existing solar power infrastructure, further enhancing the efficiency and cost-effectiveness of solar energy production.

China's development of the latest fourth-generation all-efficiency photovoltaic power generation integration technology represents a major leap forward in the field of solar photovoltaic power generation. By deeply exploring the energy source of the sun and ingeniously transforming natural light into a form that is optimized for crystalline silicon batteries, this innovative technology has the potential to revolutionize the solar energy industry and contribute to a more sustainable and efficient future for solar power.

### **3. Analysis of the Application Status of Solar Photovoltaic Power Generation in China**

The solar photovoltaic power generation market in China has been experiencing robust growth in recent years, exhibiting a clear upward trend. As technology continues to advance and the domestic market matures, China's solar photovoltaic power generation capacity has emerged as a global leader in terms of volume.

In 2022, China's installed capacity reached an impressive 87GW, accounting for 36% of the global 240GW. By the end of 2023, it is projected that China's new solar power capacity will reach 200GW. The strong support from the Chinese government for renewable energy, coupled with the urgent domestic demand for clean energy, has provided a significant impetus for the development of the photovoltaic power generation industry.

The continued investment in research and development, the introduction of advanced technologies, and the ongoing policy support from the government have all contributed to China's growth and success in the solar photovoltaic power generation market. As the world's largest energy consumer, China's commitment to renewable energy and its pursuit of a more sustainable energy future have positioned it as a global leader in solar photovoltaic power generation, playing a crucial role in the fight against climate change and the transition to a low-carbon economy.

Distributed photovoltaic power generation refers to the use of photovoltaic cells on the user side to convert solar energy

into electricity and directly supply it to users or grid-connected power supply. Distributed photovoltaic power generation can be divided into single-household distributed photovoltaic power generation and centralized distribution photovoltaic power generation[3].

Regardless of the type, China has achieved remarkable accomplishments in both areas. Numerous large-scale photovoltaic power stations have successfully connected to the national grid, providing a robust assurance for the stable operation of the power system. Concurrently, distributed photovoltaic power generation has also flourished, with distributed photovoltaic power generation not only helping to improve energy self-sufficiency but also contributing to local economic growth and environmental protection. As the country continues to prioritize clean energy and sustainable development, photovoltaic power generation will undoubtedly remain a critical component of China's energy strategy, driving innovation, growth, and a greener future for all.

### **4. Prospects for the Application of Solar Photovoltaic Power Generation**

As new energy technology becomes increasingly popular, the application directions of solar photovoltaic power generation in China should gradually become more fine-tuned and nuanced. In the current wave of large enterprises merging into the grid, newly established small enterprises should concentrate on serving individual households, villages, or specific individuals.

In the future, as new energy technology becomes more widespread, it will be crucial for China's solar photovoltaic power generation industry to adapt and evolve. This could involve focusing on niche markets, such as off-grid solar power solutions for rural communities or individual households, as well as exploring innovative business models and partnerships with other industries.

By refining and diversifying its development goals, China's solar photovoltaic power generation industry can ensure a more sustainable and comprehensive approach to solar energy development. This will allow the industry to capitalize on the growing global demand for clean, renewable energy sources and contribute to a more sustainable and environmentally friendly future.

#### **(1) Application of solar energy in rural areas**

According to the latest census data, China's urbanization rate of permanent residents is 65.22%. The process of urbanization and the transformation of rural areas are still ongoing. The topography of rural areas features open terrain and low-density houses, which is in stark contrast to the densely populated urban landscape. This unique characteristic of rural areas provides abundant solar energy utilization space.

In rural regions, solar energy can be harnessed through the use of photovoltaic power systems, which can effectively address the challenge of limited access to traditional power infrastructure. By utilizing the vast solar resources available in rural areas, these systems can provide a reliable and sustainable source of energy, enhancing the quality of life for the local communities.

Rural grids are located at the end of the grid, with scattered electricity consumption, concentrated electricity consumption peaks, and strong seasonality. As a result, during peak electricity consumption periods, the voltage at the end of rural

grid lines is low. The rural grid lines are usually overhead lines, with old and outdated power supply equipment and low operating and maintenance levels. In addition, wind, thunder, trees, and other environmental factors can also affect power supply reliability[4]. In areas with small populations, poor transportation, such as deserts, small islands, and mountainous regions, the cost of constructing grid lines is prohibitively high and challenging. In these regions, establishing photovoltaic power systems can effectively address this issue. Especially in remote areas, the cost of establishing photovoltaic power systems is considerably lower than that of building traditional power facilities.

Setting up photovoltaic power systems can not only enhance the quality of rural electricity but also bring about benefits for farmers. These systems can help reduce energy costs and provide a reliable and sustainable source of power, which can contribute to improving the overall living standards in these rural communities.

Moreover, the use of photovoltaic power systems in remote areas can also help in reducing carbon emissions and mitigating the impact of climate change. By harnessing the power of the sun, these systems can provide a clean and renewable energy source, which is essential for promoting environmental sustainability and combating global warming.

The establishment of photovoltaic power systems in remote and rural areas can significantly improve the quality of life for the local communities, reduce energy costs, and contribute to environmental sustainability. By leveraging the vast potential of solar energy, these systems can play a vital role in the transition towards a low-carbon future and help ensure a better quality of life for all.

Currently, the most common application in rural areas is to provide daily electricity. In residential buildings, photovoltaic power systems can convert solar energy into electricity through solar panels installed on rooftops, walls, or windows, providing electricity for families. This clean energy is not only environmentally friendly but also saves household electricity bills.

In addition, in agricultural irrigation, photovoltaic power systems can provide electricity for water pumps, achieving automatic irrigation. This system can automatically adjust irrigation water volume according to weather and soil moisture levels, improving irrigation efficiency and reducing labor costs.

With the gradual maturation of greenhouse technology and the growing preference for seasonal fruits and vegetables among people, more and more farmers are inclined to set up greenhouses on their own land. In greenhouses, photovoltaic power systems can provide electricity for greenhouses, used for lighting, ventilation, heating, and other equipment. By reducing the energy consumption of greenhouses, improving production efficiency, and reducing the impact on the environment.

If it is some villages close to a water source. People may also engage in the business of fish pond farming. In fish pond farming, photovoltaic power generation systems can provide electricity for fish ponds, for purposes such as increasing oxygen, pumping, and lighting. It can improve the efficiency of fish pond farming, reduce the cost of farming, and reduce the impact on the environment.

#### (2) Application of solar energy in urban communities

The street lamps in urban residential areas play an essential role in the urban landscape, and the incorporation of photovoltaic power into lighting systems can introduce new

functions to the lighting system. For example, photovoltaic power generation systems can be used to supplement lighting for buildings and plants, making green light blend with buildings, improving environmental quality[5].

By integrating photovoltaic power generation technology into street lighting, urban areas can harness the power of the sun to provide a sustainable and clean energy source for their lighting systems. This innovative approach can help reduce energy costs and carbon emissions, as well as contribute to the overall goal of creating a more environmentally friendly and sustainable urban environment. Moreover, the use of photovoltaic power generation in street lighting can also provide additional functions such as bidirectional charging and discharging, allowing residents to access electricity for their daily needs.

In addition to the integration of photovoltaic power generation into urban street lighting systems, these systems can also be combined with energy storage solutions to achieve self-sufficiency in electricity use. During the day, the electricity generated by solar panels can be stored in energy storage systems for use by residents in the community at night or on rainy days. This approach can enhance the stability of the power system and reduce reliance on the grid.

With the increasing implementation of new energy vehicles, concerns about convenient charging options for electric car owners have arisen. In this context, in urban communities, photovoltaic power generation systems can be combined with electric vehicle charging stations to provide charging services for electric vehicles. This system can decrease the operating costs of electric vehicles, increase their popularity, and promote green travel.

By combining photovoltaic power generation with energy storage and electric vehicle charging solutions, urban communities can significantly reduce their dependence on traditional power sources and contribute to the broader goal of promoting renewable energy and sustainable urban development. This innovative approach not only enhances the functionality of urban infrastructure but also contributes to creating a more environmentally friendly and sustainable urban environment for all.

## 5. Conclusion

The deterioration of the global environment and the scarcity of resources have accelerated the transformation of the energy system towards green low-carbon, and solar photovoltaic power generation, as a clean and environmentally friendly energy technology, is bound to become an important part of the global green low-carbon transformation process. China, as a country with abundant solar resources, still needs to strengthen innovation in the development of the solar photovoltaic power generation industry. At the same time, we should also realize that the green low-carbon transformation of the energy system is a long-term process that requires the joint efforts of the whole society. Therefore, we should continue to strengthen scientific and technological innovation, promote the further development of solar photovoltaic power generation technology, and make greater contributions to achieving the goal of carbon neutrality and promoting sustainable development.

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