

The Current Situation and Development Trends of the Solar Photovoltaic Industry in China and the United States

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Abstract. Climate change and environmental pollution have made clean energy increasingly valued, among which solar photovoltaic power generation occupies a pivotal position. In terms of the development of clean energy in the world today, major countries have mastered the core technology and occupied the main installed power generation capacity. China and the United States, the two major energy powers in the world, are also the major powers in the world today. They have completely different political systems and economic policies, and there are also many differences in the development of the solar photovoltaic power generation industry. This paper will conduct an in-depth comparative analysis of the development of the solar photovoltaic industry in China and the United States from the aspects of policy environment, key enterprises, development trends, etc., to more clearly reveal the differences and causes of the development of the solar photovoltaic industry between the two countries, and provide references for future cooperation and competition.

Keywords: Solar photovoltaic industry, China and the United States, policy analysis.

1. Introduction

As global temperatures rise and extreme weather conditions occur more frequently, environmental issues are receiving increasing attention. Many countries and international organizations around the world have proposed or are planning environmental protection goals and plans for the next few years. Among them, the IREAA1.5-degree Celsius goal proposed by the International Renewable Energy Agency (hereinafter referred to as IREA) is particularly eye-catching: that is, through a series of measures, global warming will be controlled within 1.5 degrees Celsius. To achieve this goal, by 2050, energy transformation investment must increase by 30% over the planned investment to reach 131 trillion US dollars, but these measures will generate a cumulative return of at least 61 trillion US dollars by 2050. A sharp adjustment of capital flows and a repositioning of investment are necessary to align energy development with a positive economic and environmental trajectory. The development of clean energy has considerable benefits in both economic and social benefits.

According to the 2023 World Energy Transformation Outlook provided by IREA, most of the investment in the new energy industry is concentrated in the solar photovoltaic power generation and wind power generation industries, accounting for 95% of the total investment, of which the annual new installed capacity of solar energy is 191GW, while the annual new installed capacity of wind power generation is only 75GW; according to IREA's forecast, in 2030 and 2025, these two figures will increase to 551GW/year and 329GW/year (2030); 615GW/year and 335GW/year (2050) respectively. The data shows that the importance of solar photovoltaic power generation in clean energy is second to none, and in the future, its importance will be further expanded.

The IREA report also mentioned that renewable energy investment is still concentrated in a few countries. Reports of International Energy Agency (IEA) illustrate that, China has a significant amount of solar photovoltaic power, the installed for generation in the first three quarters of 2023 was 130GW., two times the installed capacity of the United States and the European Union in the previous year, an increase of 29%. The US installed capacity in 2023 was only 34GW, an increase of 16%. Although the data shows that there is a huge difference in the installed and total solar power capacity between China and the United States, the US is still the second largest in terms of installed and total capacity [1].

China and the US have similar solar radiation intensity (mainly temperate climate, similar latitudes), and both have a good industrial base, so the reason for this difference is even more thought-provoking. Therefore, this article will analyze the policy environment, subsidy methods, market overview, and technological innovation of the photovoltaic industry development in China and the US to find out the reasons for this difference. In addition, this article aims to deeply explore the leading companies in the field of solar photovoltaic power generation in China and the US and compare and analyze the performance of these companies in terms of R&D strength, industrial chain layout, enterprise scale, and market influence, to more comprehensively reveal the reasons behind the differences between China and the US in this field.

2. Status of Solar Energy in China

2.1. Policy Environment

In general, China has fully leveraged the policy advantages of state intervention in the economy through a series of policies over the past decades to gradually develop and expand the nascent photovoltaic power generation industry. Specifically, the policies can be divided into four stages.

The first stage is to help the photovoltaic industry get started and survive the cold winter. The earliest layout of the photovoltaic industry began with the "China Bright Project" implemented in 1997. This project aims to use new energy such as wind energy and solar energy to provide light electricity for poor areas. The Chinese government combines poverty alleviation with solar photovoltaic power generation to lay the foundation and accumulate experience for the country to promote the development of the solar energy industry in the future. The Ministry of Finance and the Ministry of Housing and Urban-Rural Development published the Implementation Opinions on Accelerating the Application of Solar Photovoltaic Buildings jointly in 2009, formally proposing to provide subsidies for photovoltaic projects and strengthen investment confidence in the photovoltaic market. In 2012, the US Department of Commerce and other agencies launched a "double-reverse" action against China's solar photovoltaic industry, namely anti-dumping and anti-subsidy. By investigating photovoltaic products imported from China, the import of Chinese photovoltaic products is resisted. To overcome the industry winter brought about by the double reduction and reduce the difficulty of approving subsidies for photovoltaic projects, the Chinese government issued a large number of policies between 2012 and 2014, among which the representative ones are: in September 2012, the National Energy Administration (CNEA) issued the "Notice on Applying for Distributed Photovoltaic Power Generation Large-Scale Application Demonstration Zones", the State Council published 'Several Opinions on Promoting the Healthy Development of the Photovoltaic Industry' in July 2013. An announcement about 'Playing the Role of Price Leverage to Promote the Healthy Development of the Photovoltaic Industry' was sent out by the National Development and Reform Commission (NDRC) in August 2013, which stipulated the per-kilowatt-hour subsidy policy and clarified that the subsidy period is 20 years; a notice on interim measures for managing distributed photovoltaic power generation projects was issued by the CNEA in November 2013, which further refined the distributed photovoltaic policy. In September 2014, the CNEA announced the continuation of distributed photovoltaic systems. Power Generation Policies", and the new photovoltaic policy was implemented, further clarifying the direction of distributed photovoltaic development.

The second stage is to promote market standardization and gradually expand the scale in an orderly manner. In January 2015, the National Certification and Accreditation Administration and the CNEA established the Photovoltaic Product Testing and Certification Technical Committee to assist in the research, deliberation, and suggestions on technical issues in the testing and certification of photovoltaic product. In April 2015, the CNEA and the State Administration of Work Safety issued the "Standardized Creation Specifications for Photovoltaic Power Generation Enterprises " to guide the safe and orderly expansion of the photovoltaic industry. In March 2016, five departments issued the "Opinions on Implementing Photovoltaic Power Generation Poverty Alleviation Work". The state

plans to fully roll out photovoltaic poverty alleviation in 2016 as an important means of poverty alleviation across the country. In May 2016, the CNEA and the Poverty Alleviation Office issued the "Notice on Printing and Distributing the Outline for the Preparation of the Photovoltaic Poverty Alleviation Implementation Plan", fully preparing to implement photovoltaic poverty alleviation. In October 2016, the "Notice on Issuing the First Batch of Photovoltaic Poverty Alleviation Projects" was issued, and photovoltaic poverty alleviation was officially implemented nationwide. In April 2018, the CNEA and the Poverty Alleviation Office issued the "Photovoltaic Poverty Alleviation Power Station Management Measures", further separately listing the construction and management regulations of photovoltaic poverty alleviation power stations to promote the healthy development of poverty alleviation projects. This series of photovoltaic poverty alleviation policies provides policy endorsement for the large-scale deployment of photovoltaic power generation.

The third stage is to gradually remove the crutches of state support so that the solar photovoltaic industry can thrive independently. In May 2017, the CNEA issued the "Notice on Submitting the Annual Construction Scale Plan for the 13th Five-Year Plan (FYP) for Renewable Energy Development", which mentioned that "distributed photovoltaic power generation is not subject to the annual new construction scale limit in each region". In October 2017, the NDRC and the CNEA issued the 'Notice on Carrying out a Pilot for Market-based Trading of Distributed Power Generation'; in December 2017, the NDRC issued the "Notice on the Price Policy for Photovoltaic Power Generation Projects in 2018", requiring that the subsidy standard for distributed photovoltaic power generation projects that are put into operation after January 1, 2018 and adopt "self-generation and self-use, surplus power grid-connected" be reduced from 0.42 yuan to 0.37 yuan/kWh (tax included). On May 31, 2018, the NDRC, the Ministry of Finance, and the Energy Bureau issued the "Notice on Matters Related to Photovoltaic Power Generation in 2018", which reduced the scale based on the principle of determining the scale and reducing the electricity price at the same time. In November 2018, the CNEA held a symposium on the results of the mid-term evaluation of the 13th FYP for solar energy development and clearly stated that the country will continue to provide subsidies before 2022, and relevant policies for the photovoltaic industry will be accelerated in 2019, which will greatly increase the photovoltaic construction goals of the 13th FYP. From 2019 to 2020, the photovoltaic bidding policy was implemented in-depth, and power stations showed large-scale and large-scale development, and parity power stations appeared one after another. In January 2019, the NDRC and the Energy Administration issued the "Notice on Actively Promoting the Work of Subsidy-free and Parity Grid Access for Wind Power and Photovoltaic Power Generation", proposing a series of policies to promote the subsidy-free and parity grid access for photovoltaic power generation. In April 2019, the NDRC issued the "Notice on Improving the Photovoltaic Power Generation Grid-connected Electricity Price Mechanism", which changed the benchmark grid-connected electricity price to a guidance price and the highest subsidy standard and required qualified projects to determine the electricity price through bidding. In May 2019, the CNEA issued the "Notice on Matters Related to the Construction of Wind Power and Photovoltaic Power Generation Projects in 2019", further clarifying the implementation of a comprehensive bidding model, clarifying project classification, and completing the allocation of the total amount of subsidies for various projects. In April 2020, the NDRC issued the "Notice on Matters Related to the 2020 Photovoltaic Power Generation Grid-connected Electricity Price Policy", further reducing the subsidy standard. Through a series of policies to gradually reduce subsidies for the photovoltaic industry, photovoltaic companies have gradually adapted to energy market competition and built a mature business model [2].

2.2. Market Overview

Major companies: Based on the revenue of the photovoltaic business in 2022, the leading photovoltaic companies can be roughly divided into three competitive echelons. Among them, the companies with operating income greater than 100 billion yuan include Tongwei Co., Ltd. and Longi Green Energy, among which Tongwei Co., Ltd. ranks first with 142.423 billion yuan of photovoltaic business revenue; the companies with photovoltaic business revenue between 50 billion and 100

billion yuan include Trina Solar, JinkoSolar, JA Solar Technology, and Zhonghuan Semiconductor; the companies with photovoltaic business revenue less than 50 billion yuan include GCL- Poly, Gogreen Solar, and Akcome Technology.

Market demand: Smart photovoltaics will become the main support, and distributed photovoltaic buildings will become the mainstream

3. Status of Solar Energy Development in the US

3.1. US Policy Environment

The U.S. subsidy policy for solar energy began with the ITC (Investment Tax Credit), which is a subsidy policy that increases user benefits by deducting a certain percentage of the initial investment in renewable energy systems through income tax year by year. In 2009, the Obama administration signed the "Economic Stimulus Act", Article 603 of which stipulates that after the completion of a renewable energy project, the U.S. Department of the Treasury must return 30% of the project cost in cash within 60 days, which triggered a rush to install in 2010. However, since the anti-dumping and countervailing incident in 2012, the U.S. solar energy policy has gradually shown a confrontational feature. In January 2018, the Republican government headed by Trump decided to impose a 201 tariff on photovoltaic components imported from the US. In July 2018, the Trump administration imposed a 301 tariff on photovoltaic cells and components imported from China for four years.

After the Democratic government headed by Biden came to power, the US ' trade barriers in the photovoltaic field continued and strengthened. At the same time, the Xinjiang-related bill (Uyghur Forced Labor Prevention Act, UFLPA) was issued to conduct traceability inspections on imported photovoltaic products. From March 2022, the US conducted anti-circumvention investigations on photovoltaic cells and modules imported from Cambodia, Malaysia, Thailand, and Vietnam to prevent Chinese manufacturers from circumventing tariffs by transferring production capacity to Southeast Asia. At the same time, the Biden administration has also introduced a series of policies to support the photovoltaic industry. In 2022, the US passed the IRA Act, which subsidizes both the demand and supply sides of photovoltaics. The demand side includes investment tax credits (ITC) for the initial cost of the subsidized project and production tax credits (PTC) based on actual power generation. The above two exemptions can also increase the subsidy amount by meeting advanced conditions such as labor requirements and domestic content bonuses. On the supply side, there is the Advanced Energy Project Credit (48C ITC), which subsidizes the cost of building plants and equipment, and the Advanced Manufacturing Production Credit (45X MPTC), which subsidizes products according to sales volumes [3].

3.2. Market Overview

The U.S. solar market is fragmented. MA Mortenson Company, First Solar Inc., NextEra Energy Inc., SOLV Energy, and 8minergy Renewables LLC are all major players (without any specific order).

The U.S. solar market will be driven by factors such as falling solar PV costs and supportive government policies in the medium term. During the forecast period, the market's growth is expected to be hindered by the growing adoption of alternative clean energy sources and increasing natural gas consumption. Despite this, perovskite-based cells have become more prominent in recent years. The manufacturing of perovskite-based PV cells is very easy, efficient, and has excellent semiconductor properties. As a result, their solar power generation efficiency is like that of silicon-based solar PV. Therefore, advancements in PV cell manufacturing technology may lead to large-scale production, thereby providing growth opportunities [4].

4. Development Trends

According to the International Energy Agency, as of September 2023, 194 countries (regions) have submitted nationally determined contributions (NDCs), planning to 2030, taking into account the record annual installed capacity, the significant momentum of the new energy industry, and the increasing competitiveness of fossil fuels, especially solar photovoltaic and wind power, tripling the global installed capacity of renewable energy by 2030 is an achievable goal. Only 14 of the 194 NDCs that were previously submitted had clear targets for the total installed capacity of renewable energy by 2030. By 2030, the NDCs' renewable energy installed capacity targets total just over 1,300 gigawatts (GW), only 12% of the global triple commitment, which requires at least 11,000 GW of renewable energy installed capacity by 2030 [5].

China's goal of achieving 1,200 GW of solar photovoltaic and wind power installed capacity this decade accounts for more than 90% of all renewable energy installed capacity mentioned in the NDC. According to the China Energy Transformation White Paper, China has achieved some outstanding results in the development of the solar photovoltaic industry in the past, mainly focusing on power conversion efficiency and smart photovoltaics. The Chinese government will keep improving the energy technology system and speed up the transformation and innovation of energy technology in the future.

At the same time, the U.S. Department of Energy (DOE) has also developed the SunShot2030 plan, which promises to reduce the cost of solar power generation by 50% between 2020 and 2030. In addition, the DOE announced that it would provide up to \$65 million in funding for three new funding opportunities: the Photovoltaic R&D Program, the Technology to Market Program, and the System Integration Program, depending on congressional appropriations. The Photovoltaic R&D Program will provide up to \$25 million in funding to improve photovoltaic components and system design, including hardware and software solutions that facilitate the rapid installation and interconnection of photovoltaic systems. The Technology to Market Program has \$30 million available for projects to accelerate the commercialization of products and solutions, which will help reduce the cost of solar energy. SunShot's System Integration Program offers up to \$10 million in funding for projects that aim to improve solar irradiance and power forecasting for utility use [6].

5. Conclusion

The global energy transformation continues to deepen, although it is still mainly led and dominated by major countries. As a key component of the clean energy field, solar energy has attracted a lot of attention and investment. In the fierce competition and cooperation in the solar photovoltaic industry, the policies and plans of China and the US, as energy giants, are particularly eye-catching.

Due to its public ownership economic structure and democratic centralism, China has formed a government-controlled system. In terms of installed capacity, power generation, supply chain, and cost control in the solar photovoltaic power generation industry, China occupies a leading position. However, due to its presidential term system, the US has shown great instability in its policies (e.g. former President Trump is a staunch supporter of fossil energy, and the development of the US clean energy industry has slowed down significantly during his term) and confrontation (e.g. anti-dumping and countervailing policies, Xinjiang-related bills). This confrontation has led to many US bills focusing on how to reduce the import of Chinese components, and conducting strict audits and tariff policies, which has relatively dispersed the policy perspective on supporting and examining the country's solar photovoltaic industry. In addition, the market-driven economy has also made the US's confidence in new energy investment less firm than China's, and the scale is relatively small.

In terms of future development trends, China is more focused on smart photovoltaics and improving the quality and efficiency of the industry, while the US is more focused on cost control and commercialization. However, based on the general trend of developing clean energy and achieving the 1.5-degree Celsius target, the scale of the solar photovoltaic industry in both countries will further expand.

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