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Current Situation and Prospects of the Solar Photovoltaic Industry in China

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Abstract: Solar photovoltaic generation is an important form of renewable energy, and this emerging industry is the focus of China's current focus as it strategically develops its global competitiveness. In this paper, the authors provide a detailed analysis of the solar energy photovoltaic industry in China and abroad, review the development of present and future trends, analyze the current state of the industry and its problems, and present some suggestions and prospects for the healthy development of the photovoltaic industry.
Keywords: solar photovoltaic; solar cell; photovoltaic industry

1. Introduction

Solar photovoltaic (PV) power systems are an important form of solar energy generation. PV power generation is less dependent on non-renewable resources and manufacturing materials, and it is expected to become the main alternative to fossil fuels in the future. For nine consecutive years beginning in 2007, China has led the world in the national installed capacity of PV cells. Since the beginning of the domestic PV market, which gradually began growing in 2003, the installed capacity of PV in China has exceeded that of both Japan and the United States. In 2015, China's cumulative installed capacity of PV firstly exceeded that of Germany and became the nation with the greatest installed capacity, suggesting that China is changing from a PV production-limited application country to PV production-rich one.

2. Domestic and overseas development of the PV industry

2.1. Global development of the PV industry

GTM Research released provisional data which shows that the global PV market capacity was expected to reach 64 GW in 2016 [1]. An International Energy Agency (IEA) PV Power Systems (PVPS) study shows that, in 2015, the installed capacity of global PV was 50 GW and the cumulative installed capacity was 227 GW [2]. Regarding new-added PV installed capacity, China ranked the first in the world at 15.13 GW. Japan and the United States ranked second and third with 11 GW and 7.3 GW, respectively, and the European market followed with a total capacity of 7 GW [2]. Asia Pacific accounted for 59% of the global PV installed capacity in 2015, ranking first for three consecutive years beginning in 2013. The Asia-Pacific market grew from 1.4 GW in 2005 to 16.6 GW in 2010, and even to 50 GW in 2015 [3]. The annual contribution rate of PV power generation is more than 1% of the entire demand for electric power in 22 countries. Of these 22 countries, Italy is 8%, Greece is 7.4%, and Germany is 7.1% in annual contribution rate of PV power generation, respectively. The global PV contribution rate account for 1.3% of power demand [2]. The five countries with the greatest installed capacity in the world, China, Germany, Japan, the United States and Italy have a cumulative PV installed capacity of more than 10 GW. These five countries' cumulative PV installed capacity account for 71.4% of the global cumulative

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PV installed capacity (162 GW) [3]. In 2015, global polysilicon production continued to rise, and the total output was projected to reach 3.4×10^5 t, an increase of 12.6% from 2014. Current PV module production is approximately 60 GW, an increase of 15.4% from 2015 [4].

2.2. Domestic development of the PV industry

China's PV installed capacity grew by 15.13 GW in 2015, accounting for more than a quarter of the world's new-added PV power generation and accounting for one-third of the annual global production of PV components in China, which achieve the target of adding 15 GW for PV installed capacity in 2015 [4]. By the end of 2015, China's cumulative total of 43.18 GW installed PV capacity had exceeded that of Germany and, for the first time, China led the world in the greatest installed capacity of PV cells. Within China's installed capacity, the installed capacity of PV power station and a distributed PV was 37.12 GW and 6.06 GW respectively, which made overall annual energy output reach 39.2 TW·h [4]. The overall new-added PV installed capacity in 2015 is substantially greater than that of the new-added grid connected in 2014, which was 10.6 GW. Battery component production in China, domestic demand, export proportion are listed in Table 1.

China's produced 1.65×10^5 t of polysilicon in 2015, or 48.5% of the world's supply, making it the leading country in polysilicon production. Even so, China still needs to import about 1×10^5 t of polysilicon from other countries. Chinese polysilicon production and its share in the world are listed in Table 2.

The National Energy Administration of China released data on April 22, 2016, showing 7.14 GW of new-added installed capacity of PV power generation in the first quarter of 2016. The installed capacity of PV plant and the distributed PV is 6.17 GW and 0.97 GW respectively. The national total PV installed capacity increased to 50.32 GW, with an increase of 52% from 2015 [5]. However, the rate at which PV power generation was abandoned in Xinjiang and Gansu was serious, reaching 39% and 52%, respectively, compared with that of Ningxia with 20% [5]. North China, East China, Central China, and south China had totally accumulated 25.60 GW of PV installed capacity, surpassing the additional 23.64 GW in the northwest regions [5].

Great progress has been made in China's solar cell industry from initial technology tracking to technology synchronization and even technology transcendence. The average conversion efficiency of a poly-crystalline silicon cell, single crystal silicon cell, and some thin-film solar cell has been significantly improved to meet international standards. The certification efficiency of copper indium gallium selenide (CIGS) modules and gallium arsenide components reached 21% and 30.8% respectively [6].

3. Future development trends of the PV industry

3.1. Technology

With the improved efficiency of solar cells made with CIGS, cadmium telluride (CdTe), and silicon-based films, solar cell technology is expected to occupy an important position in the PV market in the future. Especially, China is relatively rich in indium, gallium, tellurium, and other costly inputs for solar cells, some of which, such as thin-film solar cells, give China a strong competitive advantage.

New-concept solar cells, including dye-sensitized solar cell, organic polymer, quantum dots and perovskite solar cell, are high-efficiency and low-cost, and there is huge potential for development of these types of cells. In particular, the conversion efficiency of perovskite solar cells, in a short period of 6 or 7 years, have been improved from 3.81% in 2009 to more than 22% of the recent certification efficiency in 2016 [7]. The rapid increase of the conversion efficiency suggests the development potential of the new-concept solar cells.

3.2. Cost

The cost of global PV power generation had decreased every

Table 1. Domestic production, demand, and export proportion of PV modules from 2007–2015 [5].

Year	2007	2008	2009	2010	2011	2012	2013	2014	2015
Production (MW)	1 340	2 714	4 990	12 437	22 798	25 214	25 610	35 000	41 000
Market demand (MW)	20	40	160	500	2 700	3 560	10 680	10 640	15 000
Share of Export (%)	98.51	98.53	96.79	95.98	88.16	85.88	58.30	69.60	63.41

Table 2. Polysilicon production in China and the world from 2011–2015 [5].

Year	2011	2012	2013	2014	2015
World ($\times10^4$ t)	24.00	23.50	24.60	30.20	34.00
China ($\times10^4$ t)	8.40	7.10	8.46	13.60	16.50
Share (%)	35.00	30.21	34.39	45.03	48.53

year due to technological progress and substantial industry expansion. The average cost of PV power generation on a global basis fell from about 38 US cents per unit in 2008 to 7.3 US cents in 2015 [6]. Moreover, it may continue to decrease in the next few years [7]. Technological improvements and increased industry scale can reduce the upfront investment of PV upfront investment. Additionally, the cost of electricity can also be reduced by increasing system efficiency such as improving inverters and maintenance levels. These system efficiency enhancements increase operating hours of a PV power station and improve the utilization rate of solar energy [8].

3.3. Market

The Asia-Pacific market represented by China and Japan represent accounts for 59% of the global PV market, which makes the center of the PV market transfer from Europe to the Asia-Pacific region. The scale of emerging markets such as India, Latin America, Africa, and the Middle East are gradually expanded. China's domestic market is gradually becoming saturated in the northwest region, and the scale of distributed PV in the areas of North China, Central China, East China, and south China will continue to expand.

4. Problems in the development of China's PV industry

4.1. Grid

There is an abundance of solar energy resources and a large ground PV power station located in Northwest China. However, Northwest China is at the end of China's power grid, and the solar energy resources can rarely be effectively consumed locally, which results in a high abandon rate in PV power generation.

4.2. Power station

Distributed PV power generation requires rooftop power stations, but it is generally difficult to obtain roof space for investor. The design of property right system for the power station is a major obstacle to the promotion of distributed PV power generation in the population. Establishing an energy contract management model between developers and building owners provides a win-win solution that is expected to become the basic model for large-scale and distributed PV power generation.

4.3. Double reverse tariff and trade disputes

Several countries that import PV products from China impose "double reverse" tariffs on these products, and this practice is increasing. The trade disputes caused by these tariffs have become an obstacle to exporting China's PV products to the international market.

5. Future development prospects and recommendations

With the technical progress and the accelerated expansion of the PV industry, the PV market is expected to achieve parity in the next few years. The rapid development of China's PV market has highlighted a number of issues, such as abandoning PV power generation. Therefore, it is critical to establish a business model suitable for the actual state of China's PV applications to promote the rapid and healthy development of China's PV industry. Focusing on the current problems that affect the development of the PV industry, we put forward some suggestions as follows [9].

5.1. Vigorously support independent innovation and strengthen the input of research on new-concept solar cells

China must support independent innovation urgently and vigorously by encouraging the study of technology, materials, and key theories in enterprises, universities, and research institutes. Further studies should receive financial support from the central and local government, relevant ministries, and other commissions. At the same time, the government should continuously strengthen its financial support in research projects undertaken jointly by industry and university researchers, especially groundbreaking, long-term, basic research projects. China should enlarge both the scope and proportion of researcher compensation, and strictly carry out technology acceptance criteria to ensure the effectiveness of projects.

5.2. Improve fiscal and taxation support policies to promote the rapid and healthy development of the PV industry

China should strengthen financial support for key research and development activities, technological transformation, mergers and acquisitions, power station integrated technology development, and construction project investments. Relevant tax policies should also be improved.

5.3. Strengthen the foundations of the PV industry and establish a sound system for PV services

In order to establish and improve the PV industry's standard system, the government should accelerate the revision of PV industry standards and conversion of international standards. Additionally, our country should promote the establishment of several national PV detection and empirical service platforms to improve testing capabilities of the product across the industry. Lastly, by reinforcing the guiding role of industry organizations

in its development, the China's government can promote collaboration in the industry.

5.4. Implement departmental responsibilities and strengthen the policy implementation linkage

Under the unified leadership of the State Council, relevant departments are responsible for strengthening communication and cooperation, enhancing policy linkages, eliminating the duplication of policy formulation, and other tasks. The formulation of relevant policies support preliminary research by reducing the number of policies, and improve its stability, durability, and systematization, thereby reducing the burden of enterprises. The government should revise local protection policies and regulations to promote the establishment of a unified PV market across the country.

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