Analysis of the Development of Photovoltaic Companies in China

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Abstract. Over past several years, China has concentrated on the methods dealing with environmental problems, bringing to a series of the photovoltaic companies, upstream and downstream. This article basically introduces the government supportive subsides on photovoltaic companies and explain the potential risk in the following future. It shows that the government has played a significant role in the process of PV industry developing. Although the PV industry is stimulated a temporary flourish in past time, leading to a great advance in both economic and environment situation, it is necessary to consider further to help the PV industry become healthier. Besides, the article also discusses the companies themselves, among which the potential process for the production capacity is highly mentioned. Not only does the article conclude previous experience, but also it delivers forward-looking perspectives. Think about the future development direction of photovoltaics and clarify it from the perspective of the enterprise itself.

Keywords: Photovoltaic companies; government supportive subsides; PV industry developing.

1. Introduction

In recent years, China highlighted the importance of dealing with climate change, in response of the oath "carbon peaking and carbon neutrality". China has experienced rapid industrial growth, which has historically been heavily reliant on coal and other fossil fuels. This growth model has resulted in substantial environmental costs and is not sustainable long-term. China, as the world's largest emitter of greenhouse gases, faces significant environmental challenges, including air pollution, water shortages, and the degradation of land and ecosystems. These environmental issues not only affect public health and biodiversity but also impact economic productivity and quality of life. Addressing climate change is crucial for mitigating these negative effects. China is attempting to enhance the low-carbon transformation of the economic, limiting the carbon dioxide emission. Not only could it be a contributor to develop the economic quality, but also it would improve the environmental conditions in China [1]. Transitioning to a greener economy through renewable energy sources and cleaner technologies is seen as essential for sustainable development. Investing in green technology and renewable energy also presents opportunities for economic growth and leadership in emerging industries. For this reason, China develops the renewable energy, releasing a great number of positive policies to support the implement of relevant industries [2]. Among which, photovoltaic (PV) technology is crucial for China to achieve carbon peaking.

2. PV industry and Environment

PV plays a vital role in achieving the ambitious goal of carbon peaking by providing a clean and sustainable energy source. Initially, Hu et al. state that the PV could generate the electricity from renewable sources, reducing the reliance on fossil fuels including coal and natural gas [3]. According to Marei et al., PV technology can be integrated into buildings (BIPV), vehicles, and other infrastructures, not only generating power but also reducing the need for additional land or resources, unlike conventional power plants. More than that, PV technology has ability to generate electricity without emitting carbon dioxide or other greenhouse gases during operation [4]. Unlike fossil fuel-based power generation, which significantly contributes to global carbon emissions, solar PV systems offer a clean alternative by producing electricity through the conversion of sunlight, thereby directly

reducing the carbon intensity of the energy sector. By transitioning to solar power, China can decrease its carbon emissions associated with electricity generation, which is a significant contributor to overall emissions. And employing more PV systems could also reduce air pollution associated with coal-fired power plants and improve public health and quality of life. Moreover, PV industry may provide technological innovation and potential exportation opportunities [3]. By investing in PV manufacturing, China could stimulate the ability to address environmental challenges, encouraging innovation and technological advancement, driving down costs and improving efficiency. This makes solar power become more competitive with traditional energy sources, furthering its adoption. In addition, PV industry presents significant economic opportunities [3]. The PV industry creates employment opportunities through the entire value chain, from manufacturing and installation to operation and maintenance. As the solar energy sector continues to grow, it generates jobs in manufacturing plants, construction sites, and service sectors, contributing to economic development and livelihoods.

3. Factors that Influence PV Industry

Nowadays, the PV industry is highly influenced by the factors below: Government subsidies, technical efficiency, and Tax incentives.

Chinese government highly support the PV companies. Firstly, The Chinese government has implemented various supportive policies, such as subsidies, incentives, and targets for renewable energy deployment. These policies create a conducive condition for PV companies to become prosperity by providing financial support, market opportunities, and regulatory certainty. More than that, China has made significant investments in research and development (R&D) for PV technology. This investment has led to technological advancements, efficiency developed, and cost reductions in PV products, more competitive in both domestic and international markets (Hu et al. 2023). China has invested in developing the necessary infrastructure for PV deployment, including grid connectivity, solar farms, and supporting industries. This infrastructure expansion could integrate the solar energy into the power grid and enables efficient deployment of PV projects across the country. Meanwhile, China has developed a skilled workforce by delivering experience practicing and technological expertise teaching in PV manufacturing and installation. The availability of trained professionals and engineers can also be the contributors to the efficiency and quality of PV production processes, effectively enabling companies to meet global demand.

To exemplify, there are many promotion policies for photovoltaic (PV) companies in China involves a range of strategies. By easing financial constraints and motivating innovation, subsidies can encourage companies to invest in new technologies and products that may enhance efficiency and competitiveness. Moreover, tax incentives can enable companies to invest in technology upgrades, increase productivity, and produce higher-quality goods and services, enhancing technical efficiency relative to foreign competitors.

However, there still exist some potential risks.

The Chinese government has offered subsidies and incentives to boost the adoption of solar energy. These policies may lead to rapid expansions in manufacturing capacity as capitalizing the companies since the condition is favourable. However, when these incentives are reduced or discontinued, there could be a sudden surplus of production capacity. In this way, although China has been a global leader in PV manufacturing, overcapacity still may become a concern due to rapid expansion and subsidies that led to inefficient and unsustainable growth. Consequently, it may bring to many drawbacks. Initially, Excess production capacity in the PV industry can lead to layoffs, unemployment, and underemployment when companies scale back operations or close facilities. Additionally, government subsidies can create market distortions that affect the allocation of resources and may not necessarily lead to improvements in technical efficiency. To exemplify, the impact of these subsidies on PV firms' performance is characterized by a U-shaped curve, according to Luan and Lin, suggesting a nuanced interaction. Specifically, if subsidies are inequitably distributed or are either

insufficient or excessively generous, it may prompt negative outcomes such as adverse selection and moral hazard, exacerbated by overproduction and lack of transparent information. These issues could potentially disrupt the harmonious progression of the supply chains within the Chinese PV industry, as noted by Zhu and Liao and Qin and Song. Lastly, Excessive reliance on government subsidies may crowd out private investment in innovation and technology development. If companies become dependent on government support, they may be less motivated to invest their own resources in R&D or pursue efficiency improvements independently, potentially hindering long-term technological progress. More than that, if subsidies are guaranteed or linked to specific technologies rather than performance outcomes, there could be less incentive for firms to innovate or improve their efficiency beyond the minimum requirements to qualify for the subsidy. This may result in backward technological, where companies would rely on existing, subsidized technologies instead of developing new, potentially more effective solutions.

China, as the world's largest producer of photovoltaic (PV) panels, has actively faced such significant challenges related to excess production capacity in the solar energy sector. The government addresses it by combining a regulatory adjustments, market-driven strategies, and international services, periodically adjusting its subsidy strategies for PV companies to prevent overcapacity and promote sustainable growth. By reducing or adjusting subsidies, the government could discourage overinvestment in PV manufacturing that exceed market supply. This approach could also motivate manufacturers to focus on improving technology and efficiency rather than expanding production capacity.

Excessive reliance on government subsidies in industries such as photovoltaics (PV) would lead to a crowding out of private investment, while companies may become dependent on state support and less driven to innovate independently, so it is essential to improve the healthier balance. Instead of abruptly ending subsidies, which could shock the PV related market, a gradual adjustment can encourage companies to start seeking alternative investment sources. This approach allows businesses to transition smoothly to a more self-sustaining model while reducing dependency on public funds, soft-landing the crisis of the PV industry. Secondly, transforming the subsidy policy to one based on performance incentives can drive companies to innovate. For instance, delivering tax breaks, or financial incentives for achieving specific technological breakthroughs or efficiency improvements could promote a more competitive and innovative environment. According to Zhang et al., Implementing market-based mechanisms such as carbon trading or renewable energy certificates can incentivize companies to reduce emissions and invest in cleaner technologies [5]. These mechanisms allow the market to set prices and drive investments, reducing the need for direct government intervention.

4. Company Itself

Xiang et al. state that PV industries exist excess production capacity in the solar energy sector. Companies in the PV sector often expand their production capacity based on optimistic forecasts for solar energy demand [6]. This optimism may basically be driven by previous trends in government policies, sudden technological advancements, and the decreasing cost of solar installations for a period. If actual demand grows slower than expected, it results in unused capacity. Such excess production capacity in the PV industry can result in overproduction of solar panels and related upstream and downstream PV enterprises, leading to waste generation. This includes the consumption of natural resources, energy, and water in the manufacturing process, which can be a contributor to pollution and environmental harm. For these reasons, "De-capacity" is necessary for China's photovoltaic (PV).

During the process of De-capacity, there are some feathers necessary to be noticed:

Large companies in the PV industry benefit from scale, allowing them to produce solar panels at lower costs per unit compared to small companies. That is because the advantageous condition for the leading enterprises. For instance, According to Hu et al., the top companies in PV industry have

formed basic internal relationship to work together and expanded the network for innovating the technology rapidly, dominant in the correlation and investment [3].
To be more specific, it is separated into several sections:

(1) Stable Internal Collaborations and Expanding Innovation Networks: Leading PV companies in China have developed stable internal collaborations that facilitate consistent innovation and technology development. Hu et al. mention that the expansion of these networks suggests that these firms are not only increasing their connections within the industry but are also likely engaging with academic institutions, research centres, and possibly international partners [3].

(2) Dominance of Kinship Collaboration in Patenting: According to Hu et al., the predominance of kinship and investment-based collaborations among patent applicants in the PV industry highlights the importance of strategic relationships in driving innovation [3]. Companies that share investment relationships or are otherwise financially interlinked may have better alignment of their R&D goals and a shared interest in the commercial success of their innovations. This kind of collaboration is often more streamlined and effective at pushing new technologies to market.

Larger companies could typically benefit from economies of scale, which allow them to produce goods at a lower cost per unit by spreading fixed costs over a larger number of units. This advantage enables them to offer competitive prices which often not easy to be matched by small companies. This cost advantage enables larger firms to offer more competitive prices, capture market share, and invest in technology innovation and research, making it challenging for smaller companies to compete on price and quality. Small companies may face challenges in securing reliable and cost-effective supply chain partners for raw materials, components, and equipment. More than that, larger players in PV industry often control significant portions of the supply chain, from raw materials to distribution networks. This control could put smaller companies at a disadvantage, as they might have less negotiating power and face higher prices for materials or limited access to critical components. Dependence on a limited number of suppliers or subcontractors can increase vulnerability to supply chain disruptions, quality issues, and price fluctuations, impacting production schedules and competitiveness.

The innovation of the PV companies is challenging. Initially, as discussed earlier, the PV industry in China suffers from significant overcapacity. This leads to price wars, reducing profit margins and leaving less revenue available for investment in research and development (R&D). With thin margins, companies might find it difficult to justify the high upfront costs associated with pioneering new technologies. Many PV companies highly depend on P-type batteries, leading to the ineffective in producing. N-type solar cells typically require more expensive materials and fabrication processes compared to P-type cells. For example, the use of phosphorus-doped silicon wafers and specialized doping techniques increases the production costs of N-type cells. For these reasons, many companies are more likely to concentrate on short-tern return, ignoring the long-tern benefit of the technology advance. Lastly, the Chinese PV industry is heavily influenced by government policies and subsidies. While this has driven growth, it also makes companies reliant on state support, which can be unpredictable and subject to sudden changes. This dependency can deter long-term planning and investment in innovation, as companies may prefer to align closely with current policy directions rather than developing disruptive technologies.

5. Conclusion

To go through such tough time, here are some suggestions. Initially, adjusting its export strategies to focus on less restrictive markets or trade agreements could help the PV companies maintain export volume. This approach helps manage excess capacity including polycrystalline silicon, silicon wafers, batteries, and modules. It is beneficial for the companies actively expanding both its domestic and overseas solar markets. Domestically, the government promotes the installation of solar energy systems in residential, commercial, and industrial sectors. Internationally, Chinese companies are encouraged to explore new markets and increase exports. Moreover, to deal with the berries to entry

and reduce competition, limiting innovation and diversity in the market especially caused by the benefit of lower costs per unit for the large companies compared to smaller companies, the government could provide proper grants, tax incentives, and subsidies specifically targeted at research and development activities in smaller firms.

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