Research on financing mode of photovoltaic power generation based on big data assisted decision

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Abstract. After 2011, Europe and the United States conducted a “double-reverse” survey on China's PV products. After two years of industry mergers, exploring emerging markets, lowering production costs and government online pricing, China's PV industry finally renewed in 2013. The rise of China's photovoltaic power generation annual installed capacity exceeds Germany and other European and American countries, becoming the world's largest photovoltaic industry. However, the key factors affecting the development of the photovoltaic industry still exist, such as difficulty in financing, high cost of power generation per unit, and difficulty in accessing the Internet. Based on the above problems, this study gives a solution and solution.

1. Introduction

With the depletion of fossil resources, the development of new energy is on the agenda. As an important part of new energy or clean energy power generation, photovoltaic power has received the attention and attention of all countries. As early as the early 1990s, in order to develop renewable energy, Germany launched thousands of large-scale initiatives to encourage rooftop photovoltaics [1], which greatly promoted the development of the photovoltaic industry. The 2011 nuclear power plant leakage incident in Japan further made Germany aware of the importance of developing photovoltaic power generation. And publicly announced that all nuclear power plants will be shut down by 2022 [2].

China's photovoltaic industry has risen since the 1980s and 1990s. The photovoltaic industry has finally risen again after experiencing a series of measures such as industry mergers or elimination of excess capacity, exploring emerging markets, lowering production costs, and government online pricing. For five consecutive years, surpassing Germany and other European and American countries, it has become the first new installed capacity of photovoltaic power generation in the world. In 2017, the cumulative installed capacity reached 130.25GW, an increase of 68.23% (Figure 1-1).

2. Characteristics of the photovoltaic industry

Photovoltaic power generation is one of the most important solar energy utilization technologies in the photovoltaic industry. Photovoltaic power generation is mainly divided into independent operation and online network. Independent operation requires battery storage; and the online network mainly transmits power directly to the grid to the user terminal, and there is a small amount of line loss on the transmission line. In the investment of photovoltaic power generation projects, Complexity, many influencing factors. The following characteristics are generally presented:

(1). Natural factors: Photovoltaic power generation is greatly affected by natural factors such as regional and weather. For example, sunny days, cloudy days, rainy days and hail weather, power generation efficiency and power generation will be greatly affected.

(2). Market factors: At present, the state implements a bidding online mechanism for power generation and power generation such as thermal power, hydropower and nuclear power, and the cost of photovoltaic power generation is much higher than that of thermal power, hydropower and nuclear power, and there is no market competitiveness.

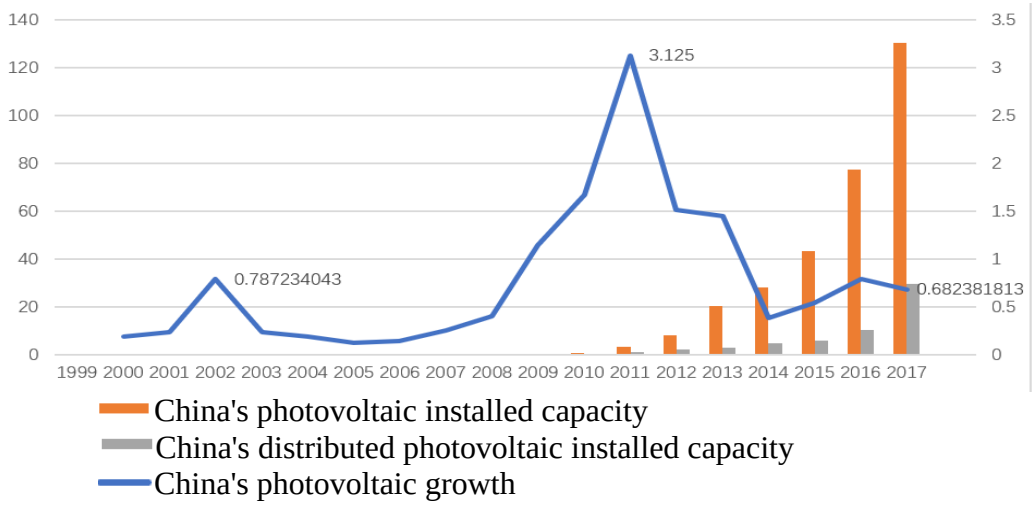

Fig. 1 Cumulative installed capacity of photovoltaics in China from 1999 to 2017.

Source: Energy Bureau

(3). Technical factors: Photovoltaic power generation technology is mainly based on new technologies and new materials, with poor technical economy and uncertain future development of technology. Foreign photovoltaic power generation has been developed for more than 20 years. China's government policy subsidies for 10 years, but the cost of photovoltaic power generation is still higher than the cost of traditional thermal power and hydropower.

(4). Environmental factors: Global warming, countries all over the world are developing low-carbon economy, and the Chinese government has also vigorously promoted carbon reduction, which is conducive to the further development of photovoltaic power generation.

(5). Policy factors: The world and even China have obvious policy biases and policy funding support for more than ten years. However, due to the heavy asset characteristics of photovoltaic power generation, the investment is large, the cycle is long, the cost is high, and it is greatly affected by the region and climate. It is difficult to compete with traditional power generation for market competition, and there has not been a large-scale industrialized profit.

(6). Capital factors: The inherent heavy assets, high cost and weak market competitiveness of photovoltaic power generation are difficult to finance.

(7). High technical dependence and high degree of regulation

Photovoltaic power generation projects are characterized by technology dependence. In the processing of silicon materials upstream of the photovoltaic industry chain and the production of battery chips, there are a large number of cutting-edge technologies, whether they are distributed photovoltaic power generation projects or centralized projects. It is also relatively high.

In general, the investment in PV power plant projects is characterized by complexity, irreversibility, investment timing flexibility, lack of investor experience and high standardization. In terms of the design of financial instruments, the investment characteristics of the project itself also provide design ideas and directions for financial innovation.

3. Development status of the photovoltaic industry

3.1. The effect of government subsidies is not obvious, and overcapacity in the middle and lower reaches has become a common problem in the industry.

Since 2009, China has launched the Golden Sun Demonstration Project and the licensing of photovoltaic power plants [3]. In 2011, due to the “double-reverse” investigation conducted by the United States and Europe against China, in order to support the development of China's photovoltaic industry, the state has increased its support, and has issued a series of policy support documents: 2012 “12th Five-Year Plan for Solar Power Development” In July 2013, the State Council's “Opinions on

Promoting the Healthy Development of the Photovoltaic Industry" clearly stated that by 2015 China's PV installed capacity will reach 35GW or more, and at the same time regulate the subsidized electricity price, subsidy period, and electricity bill accounting. In August 2013, the notice issued by the National Development and Reform Commission clearly defined the subsidy standard for distributed power stations of 0.42 yuan/kWh. According to 2017, China's PV installed capacity reached 130GW, and the national policy subsidy for photovoltaic power generation reached 100 billion. On May 31, 2018, the Energy Bureau released new PV regulations, lowered the subsidy range, and reduced the scale of ordinary ground power plants. Since then, PV development has faced new challenges. In 2018, the Central Committee of the Communist Party of China and the State Council launched a photovoltaic poverty alleviation project. It can be seen that the state's policy support for photovoltaic power generation is very strong, and it has basically achieved breakthroughs in various industries.

The cost per unit of electricity generated by photovoltaic power generation is much higher than the cost of traditional thermal power. Most of the photovoltaic power generation at home and abroad is sustained by government subsidies. Most of the photovoltaic power generation at home and abroad is sustained by government subsidies.

LIUXimei and others believe that the state's centralized investment in the photovoltaic industry has indeed played a positive role in the early days, but the persistence is not good, resulting in a lack of funds in the core technology industry, and blind investment has led to overcapacity.

Yu Donghua (2015) analyzed the overcapacity of the photovoltaic industry. He mainly focused on three factors: government subsidies, land price distortions, and financial support levels. He believed that the government had too much intervention in energy conservation and emission reduction, and too many subsidies led to local The government's rushing PV projects have resulted in land price distortions and overcapacity [6].

All in all, domestic and foreign governments have been supporting the photovoltaic industry. For ten years or so, the photovoltaic industry has not been able to participate in market competition and has been relying on government subsidies to survive.

3.2. Shenwan Photovoltaic Equipment Index

As a indicator reflecting the stock price changes of listed companies in the industry, Shenyin Wanguo Industry Index can objectively reflect the development of the industry and investors' views and expectations on the current industry, company and economic situation. Therefore, this study mainly selects photovoltaic equipment (The Shenwan Index is used as the research object to identify and manage financial risks.

Table 1 shows the comparison between the PV index and the Shanghai Composite Index, the SSE Public Utilities Index, wind power equipment, and thermal power equipment. In 2017, the PV equipment index performed well, and the 2015 and 2016 revenues were lower than the large-scale utilities. index.

Table.1. Comparison of the ups and downs of photovoltaic equipment (Shenwan) (unit: %)

Date	Shanghai Composite Index	SSE Public Utilities Stock Index	Wind Power Equipment (Shen Wan)	Thermal Power Equipment (Shen Wan)	Photovoltaic Equipment (Shen Wan)
2015-12-31	-5.5756	-10.3062	11.3008	-2.7138	-12.2005
2016-12-30	-12.3064	-14.4654	-25.4733	-18.0735	-16.1480
2017-12-29	6.5579	-0.3724	0.2199	-22.7789	14.4054
2018-08-17	-19.2976	-21.0302	-42.7087	-14.2368	-40.0807

3.3. PV industry chain listed company

For the PV industry stocks listed on the Shanghai and Shenzhen Stock Exchanges, combined with the main business of each company, the photovoltaic industry is divided into three sub-sectors: silicon materials, batteries and components, and power station operations.

Judging from the market value attributes of various industries, the total market value of batteries and components exceeds 200 billion yuan, but the market value is 10.23 billion yuan, which is lower than the average value of silicon market value, reflecting the large number of companies in the battery component industry and the competition in the enterprise market. Features. The total market value of silicon materials has sung 150 billion yuan, with an average value of nearly 20 billion. It has a large market value in the photovoltaic industry. The total market capitalization and market capitalization of power plant operations are among the lowest in the three sub-sectors.

From the valuation of each sub-industry, the TTM P/E ratio of the battery components is the highest, the market-weighted average is close to 123 times, and the market-weighted TTM P/E ratios of power plants and silicon materials are 35.6 times and 25.3 times, respectively, and the valuation is high.

3.4. Financing difficulties

As a heavy asset project, photovoltaic power plants have high investment costs, large capital requirements, long payback period, higher cost than market prices, and high investment risks. Central enterprises and state-owned enterprises are easily supported by the state's financing, but a large number of private enterprises are difficult to obtain financing support through conventional financing channels. Therefore, the key to promoting the further development of the photovoltaic industry is to solve its financing problems.

There are many conventional financing channels. Photovoltaic power generation can choose suitable financing channels such as financial leasing, asset securitization and real options according to its own characteristics.

4. PV power plant financing model design

Taking the construction and operation of downstream photovoltaic power plants as an example, this paper designs three financial instruments: financial leasing, asset securitization and real options.

4.1. Financial leasing model

The financing leasing mode of photovoltaic power plants mainly includes direct leasing of photovoltaic equipment, sale and leaseback of photovoltaic equipment and operating lease of photovoltaic equipment.

First, direct leasing is a lease agreement between a PV equipment supplier and a lessee to directly sign a power station component and pay a certain amount of rent.

Second, after-sales leaseback is the way in which the PV equipment supplier sells the power station to the employer and leases it back.

Third, operating lease refers to the photovoltaic equipment supplier who, after completing the power station, contracts to the employer or a third party to operate and collect the rent.

Once the photovoltaic power station is connected to the Internet, the revenue is stable and it is a high-quality asset. No matter which kind of rental mode, it can effectively alleviate the financing problem of photovoltaic power suppliers.

4.2. Asset securitization

At present, the latest and most efficient distributed photovoltaic power plant financing model in the US market is the “Yieldco” (fixed income growth listed fund) model and the ABS model. In 2013, SolarCity began to obtain millions of dollars in financing through the asset securitization model, financing hundreds of millions of dollars for the US photovoltaic industry. “Yieldco”'s fixed-income growth listed funds received $10 billion in financing in 2014.

In China, there are more and more renewable energy subsidies. In 2014, the China Securities Regulatory Commission changed the asset securitization system from the prior approval system to the after-the-fact filing system. The asset securitization of photovoltaic power plants is mentioned on the agenda [8].

Considering the financing factors of distributed PV power plants at present, this study adopts the dual SPV model transaction structure, which is designed as follows:

(1) Establishing a trust plan
(2) Establish a special asset management plan□□
(3) Transfer of basic assets
(4) Formulating a securitization plan
(5) Credit enhancement
(6) Sales Asset Support Securities
(7) Payment consideration
(8) Power station operation and maintenance management
(9) Paying investors compensation for investment
(10) Termination of asset securitization

4.3. Real Options

Real options are the choice and adjustment rights of photovoltaic power station manufacturers to use the photovoltaic equipment products they hold to invest in photovoltaic equipment with changes in market information and investment environment. Real options can use the PV power plant investment timing decision model as a real option model to obtain the best time for investment.

5. Photovoltaic power plant big data applications provide support for financing decision support

5.1. Establishing a photovoltaic power plant business big data credit system

The photovoltaic industry is a high-risk, high-yield industry. In the era of data-driven decision-making, to improve the financing ability of photovoltaic enterprises, big data technology can be used to prove the profitability of photovoltaic enterprises. It can not only reduce the risk of investors, but also enable enterprises to understand their strengths and weaknesses. An effective big data credit rating system can improve the financial leasing ability of photovoltaic companies, develop real options and asset securitization.

To establish a photovoltaic power plant business big data credit system, it is necessary to quantify the assets of photovoltaic power plant manufacturers, including but not limited to registration information, financial strength, operating environment, power generation indicators, sales indicators, labor indicators, risk indicators, inventory indicators, Product development indicators, financial indicators (borrowing, guarantees, repayments, etc.), customer indicators, order indicators, evaluation indicators and other factors affecting corporate credit are included, and scored one by one.

The data is processed by PCA denoising and dimensionality reduction, and the PCA factor with cumulative load greater than a certain value is selected for clustering. The AHP method is used to assist qualitatively and quantitatively determine the weight value of each element of the credit score. Mainly use the weighted scoring method, machine learning and other mining algorithms for comprehensive analysis, and carry out effective credit rating.

5.2. Using remote sensing big data to predict illumination data and site selection geological data

Photovoltaic power generation is greatly affected by regional climate and weather [4], sunny, cloudy, cloudy and rainy days have a great impact on the power generation of photovoltaic power generation [5]. In the era of big data, using the meteorological data of the last 10 or 20 years for big data mining analysis and prediction, it is possible to predict the average sunshine situation of photovoltaic power plants in a certain area and predict the approximate power generation after the operation of the photovoltaic power station. Can be used for investment and financing analysis and online network electricity price support.

The photovoltaic power plant has a long operating cycle and a large investment. Calculated by investment and financing theory and practice, it is roughly converted into about 25 years. The

situation of the geomorphology of the location of the PV power plant needs to be predicted in advance. Otherwise, the site selection is improper, and the cost and sunk cost of PV power plant relocation will be high. At present, the use of satellite remote sensing image data for spatial and temporal big data analysis can effectively predict future geological and geomorphological changes, which can be used for precise location of photovoltaic power plants and avoid unnecessary cost waste.

5.3. Reduce the cost of photovoltaic power generation to the level of traditional thermal power, and solve the technical problems of grid-connected photovoltaic power generation

Electricity belongs to the basic industry. The cost of power generation is high, the price of on-grid is increasing, the cost of other industries will rise, and the overall economy may decline. The subsidy for photovoltaic power generation has dropped from the earliest yuan/degree to the current subsidy of 0.42 yuan/kWh. The on-grid tariff of traditional thermal power is about 0.22 yuan / kWh. For the long-term stable development of the photovoltaic power generation industry, it is not feasible to rely on state subsidies. Europe's 20-year subsidy for photovoltaic power generation has not stimulated the photovoltaic industry, but it has caused energy poverty in Europe.

Nowadays, China's overall economic environment and manufacturing industry are sluggish. The country's photovoltaic power generation subsidies have lasted for ten years. The photovoltaic industry still cannot operate independently and has been supported by national policies and subsidies. It is recommended that the state change the support policy to an incentive or incentive policy to encourage photovoltaic power generation enterprises and other hydropower and thermal power to participate in market competition, gradually increase government subsidy thresholds, and reduce or cancel government subsidies. The use of market-based competition will force photovoltaic power generation enterprises to reduce costs, improve technology research and development capabilities, improve core competitiveness, and eliminate or integrate non-competitive photovoltaic power generation enterprises.

Huang Dongdong (2015) collected data from 1996 to 2011 for 15 years, and analyzed the factors affecting the PV industry by total factor productivity regression. The government subsidies were not significant for the development of the PV industry. To some extent, the incentives for government subsidies were explained. The effect did not meet expectations. The R&D investment is not significant for the development of the photovoltaic industry, and it also indicates that the direction of R&D investment is biased. The scale of the enterprise is significant, indicating that the development of the photovoltaic industry may have a scale effect [7]. Although this argument data is a bit outdated (1996-2011), it can also explain some problems. The development of China's photovoltaic industry started late and has been studying and imitating European countries. Looking at the development of the European photovoltaic industry, government subsidies are not less than in China, but the only difference is that their industrial chain is not long enough and there is no scale effect. This result confirms the possible failure reasons for the development of photovoltaic industry in Europe over the past 20 years, and the scale capability is weak.

The development of the state-owned capital to the photovoltaic industry is significant, but it is negative, indicating that the development of the photovoltaic industry should reduce the participation of state-owned capital. However, the cross-term of R&D investment and state-owned capital is significant for the development of the photovoltaic industry, and it is positive, indicating that the R&D investment of state-owned enterprises is effective. It is recommended that the government establish a large-scale state-owned research and development system to improve the technological innovation capability of the entire industry and promote industrial upgrading

Taking photovoltaic power generation grid-connected technology as an example, the State Grid has created 800,000 and 1 million volt high-voltage ultra-high voltage transmission and distribution lines in the world, and its technology is leading the world. Photovoltaic power generation currently has low load, poor stability, and poor power quality. Then, is it a high-voltage network, or is it another way to set up a low-voltage smart grid that houses photovoltaic power generation? With the research and development capabilities of the national grid for more than 20 years of transmission and distribution lines, as long as the country invests sufficient R&D funds, it should be able to solve the

problem of grid-connected photovoltaic power generation. Of course, the premise of solving the problem of grid-connected power generation for photovoltaic power generation is that the power generation cost of photovoltaic power generation should be reduced. Otherwise, the more electricity on the Internet, the higher the cost of all industries in the country and society, and it is not excluded that energy poverty is the same as in Europe. . Therefore, it is the key to the marketization of photovoltaic power generation to overcome the core technology of photovoltaic power generation and reduce the cost of photovoltaic power generation.

Throughout the last 20 years, the technological innovation of the foreign PV industry has been the most successful in Japan, the UK and the Netherlands. Watanabe, Wakabayashi and Miyazawa discovered that Japan's photovoltaic industry technology innovation completely follows the progressive innovation model of Japan's manufacturing industry in the 1970s (including but not limited to PDCA and lean production, etc.): Formed “R&D investment –market expansion – price reduction – R&D A virtuous cycle of progressive innovation [9]. Marigo, Foxon and Pearson (2008) compare photovoltaic systems innovation systems in the UK and China: the UK is committed to cutting-edge PV technology research and development, while China is committed to meeting existing product needs and lacking long-term technological innovation and product innovation strategies [10] . Kamp, Negro and Vasseur (2009) compare photovoltaic power generation innovation systems in the Netherlands and Japan: Japan has a strong domestic interest alliance with strong sustainability capabilities. The influence of the Dutch interest alliance is relatively small. In addition, photovoltaic power generation is in the early stage of development, the market is not mature, the development of the industry innovation system is constrained, and the capacity for sustainable development is weak [11].

From the research on the development of foreign photovoltaic industry, the product research and development capability of China in the past 10 years is to meet the existing market demand, and it is effective in the short term, but the sustainability development capability is weak. China's photovoltaic power generation has a whole photovoltaic industry chain with obvious advantages. It is recommended that the state launch a national progressive technological innovation system to overcome the core technical problems of photovoltaic power generation, and drive the entire PV industry chain to upgrade and transform the industry and achieve sustainable development.

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