OPERATION MODE ANALYSIS AND ECONOMIC ANALYSIS RESEARCH OF TIANJIN 8MW DISTRIBUTED PHOTOVOLTAIC POWER GENERATION PROJECT

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Thematic Certificat
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This Independent Study has been Approved as a Partial Fulfillment of the Requirement of International Master of Business Administration in International Business Management

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ABSTRACT

China's distributed photovoltaic power generation projects are still based on the EMC operation cooperation model, and the EPC operation mode is a supplementary pattern. The operation mode choice directly affects the economic analysis results of the distributed photovoltaic power generation project.

This paper collected a large amount of information on photovoltaic projects. It combined its own work experience to conduct an in-depth analysis of the operation mode and economic analysis methods of photovoltaic projects and form recommendations for selecting an operation mode of distributed photovoltaic power generation projects. New ideas for economic analysis of power generation projects and an economic analysis model for comparison and selection of operating mode income distribution options were established. This research used Tianjin 8MW distributed photovoltaic power generation project as an example. Based on the analysis of various primary conditions in the examples, specific project operation mode selection and detailed multi-scheme economic analysis comparisons were carried out, which proved that the optimized economic analysis model effectively helped distributed photovoltaic power generation projects choose the best operation mode.

Keywords: distributed photovoltaic, operating model, economic analysis, financial NPV method

Declaration

I, WANG JIBIN, hereby certify that the work embodied in this independent study entitled "Operation Mode Analysis and Economic Analysis Research of Tianjin 8MW Distributed Photovoltaic Power Generation Project" is result of original research and has not been submitted for a higher degree to any other university or institution.

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CONTENTS

1. Introduction

1.1 Research Background

With the continuous growth of the global population and economic scale, the use of coal, oil, natural gas, and other energy sources has not only brought great benefits to social development and human life but also increased the concentration of carbon dioxide in the atmosphere, leading to global climate Changes threaten the survival and development of humanity (Wang & Liu, 2015). Countries worldwide are increasingly aware of the far-reaching impact of energy issues on the sustainable development of the future economy (Wu, 2015). At this time, developing new energy sources has become an excellent way to solve these problems. Solar energy has received strong support from most countries as an unconventional energy source because of its wide distribution, cleanness of resources, and renewable energy. It has been developing rapidly in recent years (Guo, 2014).

In 2009, China successively proposed the "Interim Measures for the Management of Financial Subsidy Funds for the Application of Solar Photovoltaic Buildings," the Golden Sun Demonstration Project, and other policies to encourage the development of the photovoltaic power generation industry (Liu, 2014). The photovoltaic power generation target in 2020 has been increased from the original 1.6GW to the current 20GW. A series of policy support and long-term planning have broadened China's photovoltaic power generation development road (Zhou & Li, 2011).

Since 2013, China's PV power generation grid-connected installed capacity has proliferated. By the end of 2021, the cumulative installed capacity of PV power generation grid-connected exceeded the 300 million kilowatts mark, reaching 306 million kilowatts, ranking first in the world for seven consecutive years. From a structural point of view, the proportion of distributed PV installed capacity to total PV installed capacity increased from 14% in 2015 to 35.1% in 2021. It is expected that the future of China's distributed proportion is expected to accelerate (Jin, Jiang & Qiang, 2021).

The Central Economic Work Conference pointed out that China's carbon dioxide emissions will strive to reach a peak by 2030 and achieve carbon neutrality by 2060, referred to as the "30·60 target" (Liu, 2021).

In October 2021, the State Council issued the "Carbon Peaking Action Plan by 2030" the plan is clear: vigorously develop new energy (Shen, 2022). Comprehensively promote the large-scale development and high-quality development of wind and solar power, adhere to the simultaneous development of centralized and distributed, and accelerate the construction of wind power and photovoltaic power generation bases (Huang, 2021). By 2030, the total installed capacity of wind power and solar power will reach over 1.2 billion kilowatts (Lei, 2021).

Distributed photovoltaics, as a highly efficient method of solar power generation, advocates the principle of "power generation nearby, grid-connected nearby, conversion nearby, and nearby use." It makes full use of the local solar resources of the project. It reduces the loss of traditional power in boosting long-distance

transportation (Yang & Ma, (2015). There is no problem with grid connection difficulties, significant losses, and impacts in constructing traditional large-scale grid-connected photovoltaic power stations. It can more effectively replace and reduce fossils (Liu, 2022). Energy consumption has colossal development momentum and broad prospects (Tang & Shen, 2013). With the increasing maturity of the photovoltaic industry and the decreasing cost of photovoltaic modules year by year, distributed photovoltaic projects have increasingly shown enormous economic and social benefits (Xie & Gao, (2015).

1.2 Research Problems

Based on the complete study and reference of previous research results, this article first analyzes and predicts the current situation of the development of photovoltaic power generation at home and abroad, predicts that distributed photovoltaic will become a key area for the future development of solar photovoltaic (Zhang & Tian, 2015). summarize the project in the initial selection of the operation mode, The five main primary conditions that need to be considered; summarize and summarize the five preliminary data required for economic analysis of distributed photovoltaic projects and analyze their composition and characteristics; propose new ideas based on traditional probability analysis, and build a distributed photovoltaic power generation project An economic analysis model for the comparison and selection of specific income distribution plans for the operation mode; finally, the operation mode analysis and financial analysis research are carried out in combination with examples(Teng, 2009).

1.3 Objective of the Study

As the mainstream direction of the new energy industry in the future, distributed photovoltaic projects have broad development prospects (Oliver & Michael, 2016). However, due to the need for more experience in distributed photovoltaic projects in my country, in the actual development process of the project, enterprises need to explore and select an appropriate operation mode by themselves. Different operating ways will directly affect the final profitability of the project and the specific operational implementation (Jiang, 2016).

The objectives of this paper:

(1) To guide distributed PV projects to appropriately choose which best operation mode to provide guarantee for the normal construction and operation of the project later.

(2) To establish a set of economic analysis model for the selection of operation mode revenue distribution scheme, and to provide new ideas for future economic analysis and decision of the same type of distributed PV projects.

1.4 Scope of the Study

The theoretical scope of this paper is stakeholder theory, benefit theory and cost theory. The actual scope of the study is the operation model of 8MW distributed PV power project in Tianjin.

1.5 Research Significance

The ultimate goal of any project's construction investment is to obtain benefits. Therefore, before investing in a distributed photovoltaic project, the investor will conduct the necessary fundamental analysis, select a reasonable operating mode, make a financial forecast, and finally refer to it(Lu, 2016). Economic analysis results determine whether to invest and which income distribution method to choose. It can be seen that in the investment consulting stage of distributed photovoltaic projects, it is imperative to analyze the operation mode and economics of the project (Sun, Zhang & Yang, 2016).

Therefore, this article analyzes and forecasts the current situation of photovoltaic development at home and abroad, comprehensively analyzes various aspects of existing domestic and foreign operating modes, and proposes new economic analysis ideas based on traditional probability analysis, taking into account the development of distributed photovoltaic projects. Economic characteristics established a financial analysis model that can be used for the comparison and selection of specific income distribution schemes of distributed photovoltaic project operation mode and carried out operation mode analysis and economic analysis research in combination with actual cases for the future operation of the same type of distributed photovoltaic project in China Both model selection, and financial analysis are of great significance.

2. Literature Review

2.1 Distributed Photovoltaic

Photovoltaic power generation is a technology that uses the photovoltaic effect at the semiconductor interface to convert light energy directly into electricity (Yang, 2017). There are two main types of PV technology used today to generate electricity: stand-alone PV and grid-connected PV. Stand-alone PV requires batteries to store the energy, and the PV system is not connected to the grid. Grid-connected PV interconnects the PV system with the national grid, which can meet the demand for various types of electricity in the surrounding area and complement the electricity supply network (Lv, Cai & Wang, 2015).

A complete photovoltaic power generation system comprises four parts: photovoltaic panels (modules), photovoltaic controller, inverter, and battery pack (Yu, & Li, 2015). Among them, PV panels (modules) are the most important in the whole photovoltaic system, absorbing the sun's radiation and producing electricity to convert light to electricity (Gao, 2016). According to the actual use of needs, can also be photovoltaic panels in various forms of series or parallel connections together, forming

a photovoltaic array unit; photovoltaic controller can play the role of controlling the whole system, protecting the battery and temperature compensation; battery pack can be stored in the electrical energy, easy to choose in the actual need for power time to release electricity; photovoltaic inverter can be converted from direct current to alternating current, and then meet the needs of everyday life The PV inverter can convert DC power into AC power, thus meeting the needs of standard electrical equipment (Zhang, 2016).

Photovoltaic power plants are mainly divided into two categories: centralized power plants and distributed power plants. As the installation of the photovoltaic power plant has high flexibility compared to wind power, so compared to the traditional large-scale wind power plant, the photovoltaic power plant can not only be installed on a large scale centralized but also can be distributed in several scenarios, such as the surface of buildings, outdoor (Quan, 2016). A centralized photovoltaic power plant is to install the photovoltaic array in mountains, water, desert, and other vast areas; after the sunlight photovoltaic array can produce direct current, the inverter will then convert the direct current into alternating current through the booster station connected to the grid. The centralized photovoltaic power station scale is generally larger at more than 10MW, and more than 100MW of massive photovoltaic power stations have gradually increased (Zhou & Li, 2011). Distributed photovoltaic power plants are commonly installed on a small scale; installation is more flexible. Distributed power plants can be divided into two categories: combined with the building and not combined with the building, and combined with the building is divided into building photovoltaic (BAPV) and structure integrated photovoltaic (BIPV)(Ma , Shi & Cong, 2014).

Various analyses and projections have been made on the current status of policies and future trends in countries already leaders in the solar PV field, such as the United States, China, and Japan (Furkan, 2011).

Analyze the economic and policy status of renewable energy in countries around the world in recent years and explain that while solar technology has achieved large-scale deployment worldwide, it still needs to overcome several technical, financial, and government regulatory and institutional barriers (Govinda, Lado, & Patrick, 2012).

2.2 Operating Model

In the process of project operation, it is necessary to organize, plan and control all kinds of work in an orderly manner (Zhang & Wang, 2015). After the experience with different projects, a specific project operation model will be formed. The project operation model is to position the other participants of the project under this model, combine the participants' resource conditions and development strategies, and clarify at which stage of the project operation the participants are, what responsibilities they have, and what powers they have; and to design the project profit model, explain the revenue sources and the way of revenue distribution; finally, it focuses on the cooperation between the different participants in the project value chain(Zhang, 2016). The final

focus is on the collaboration between the other participants in the project value chain. The operating model of a distributed PV project defines, to a certain extent, the cooperation between all participants involved in the project (Jiang, 2016). Still, there is the possibility of a shift in the roles played by the participants, which adds more flexibility during the actual operation of the project (Ge, 2015).

Their views on the possible problems and risks of PV projects throughout the investment and operation cycle are presented, especially regarding land use, grid access, quota allocation, and investment recovery (Zhang & Tian, 2015).

The issue of grid parity for PV projects has been studied in depth by comparing the purchase price and average electricity price of PV power in China (Ma, Shi, & Cong, 2014).

Operation mode in China: PV industry is still a new industry in China, and although national and local support policies have been gradually clarified, the actual construction and operation of the project are still unstable, and the trading market of PV power plants is not fully active, so investors still need to explore the operation mode that best meets their interests according to the specific conditions of different projects (Sun, 2021).

Currently, the operation mode used by Chinese distributed PV power generation project owners is divided into EPC mode and EMC mode (Zhang, 2018).

EMC mode which means that the rooftop owner invests in the power station, and the builder is only responsible for the project design, construction, and grid connection, after which the power station is delivered to the owner, who holds the property right of the power station and enjoys all the income and related subsidies of the power station (Zhang, 2016). The owner himself will also bear the later maintenance.

This model is less used in reality; on the one hand, because most rooftop owners generally question the future returns of distributed projects, it is difficult to accept this form of asset investment; on the other hand, the initial investment in distributed PV projects is significant, and the management costs of operation and maintenance will also be borne by the rooftop owners themselves, causing too much burden on the rooftop owners, so few rooftop owners will directly invest in the construction of distributed Power station(Li, 2016).

The EMC model takes the form of contract energy management, in which the rooftop owner provides the roof for free, a third party is introduced to invest, and the builder is responsible for the general contract construction of the project and the implementation of subsidies and grid connection (Bai, 2014). After the project is completed, the third party will be responsible for the post-operation of the PV project with the original rooftop owner and negotiating the revenue distribution scheme. The rooftop owner can choose to enjoy the preferential tariff agreement or receive the roof rent in different ways according to their situation and bear other operation and management responsibilities accordingly (Yang & Ma, 2015).

This is currently the more widely used model, as the rooftop owner only provides

the roof with no additional input. At the same time, the third-party introduced is responsible for the investment and undertakes the main operation, minimizing the burden on the enterprise and the operational risk. In this case, it is still possible to enjoy a preferential agreed tariff or receive the benefits of the roof rent(Sun, Zhang & Yang, 2016).

The advantages of the EPC model are high capital turnover and short cash flow recovery time, which is conducive to the rapid development of the market; the disadvantages are: at this stage, the public still has questions about the stability of distributed PV revenue, there are still difficulties in the project development process, and the actual revenue may eventually be divided by other participants(Ma, 2016).

The advantages of the EMC model are: strong stability of earnings during the operation of the project, taking into account national and local preferential subsidy policies, as well as future operating costs decline or acquisition tariff increases and other possible situations, and can achieve higher economic returns; the disadvantage is: the construction period of the PV project is short, but the payback period is relatively long, with high requirements for the financing ability of investors(Liu, 2016).

Through comparative analysis, it is easy to see that the EPC model and EMC model have their advantages and disadvantages, specifically in the project application stage also need to choose according to the type of owner and its development model characteristics (Quan, 2016). Distributed PV project owners can be divided into industrial parks, individual industrial users, and residential users. Currently, the composition of Chinese distributed PV project owners, industrial parks, and single industrial users account for a more significant proportion, so China's distributed PV projects are still mainly using the EMC mode of operation (Ge, 2015).

2.3 Economic Analysis

Economic analysis refers to the system of analytical methods adopted in Western economics, which is based on the marginal efficiency analysis carried out with the help of the producer benefit optimization model and results in financial accounting at the activity level such as calculation of cash flows, approval of the balance of assets and preparation of cash flow statements (Liu & Zhang, 1993).

The role of economic analysis:

Economical analysis is the basis for business decisions.

Economic analysis is the guarantee of effective production and management activities.

Economic analysis is the scientific method to evaluate the economic efficiency of the enterprise.

Economic analysis is the display of the situation of the enterprise using economic laws (Pu & Fu, 1991).

Economic analysis is one of the most critical systems of analysis methods adopted

for construction projects, which is based on the research and forecast of various project inputs and expenditures and the calculation and evaluation of financial indicators (Zhou & Sun, 2010). The data used in the economic analysis are collected, screened, and organized through scientific methods, considering the various business model options and operational decisions that the project investors may make (Li, 2021). The different feasible options are measured, compared, and analyzed to arrive at the best possible outcome in conjunction with the investors' intended production and operational goals for the project. Based on the financial results of the finalized scenario, combined with the nature of the project's industry and empirical data, the potential problems of the system can be further identified, thus indicating the direction for improvement during the project's later operation (Wu, 2001).

Based on the conventional economic analysis methods, a new economic evaluation method and system is established based on the characteristics of PV projects, which provides new ideas for the investment decision of PV projects (Zhang & Wang, 2015).

A project economic evaluation model for cost/benefit analysis was constructed by analyzing China's PV operation model and economic evaluation system (Su, Zhou, & Li, 2013).

2.4 Financial NPV Method

Profitability mainly refers to the investor's ability to generate profit through investment and operation of the project, reflecting the level of the project's ability to create profit (Li, 2021). Profitability analysis for a specific project mainly refers to the study of the project's profitability by calculating and analyzing financial indicators such as financial net present value, internal financial rate of return, and payback period (Wang, 2019). The process of calculating the financial indicators is based on a series of statements such as the project investment estimation statement, profit, and profit distribution statement, project loan repayment statement, etc., calculating the logical relationship between various indicators within the above statements, deriving the investment cash flow statement, and finally using the calculation formula to derive the indicator values of the financial indicators related to the above profitability analysis (Chang, 2018). In the operation process, the project profitability analysis mainly selects the financial net present value, internal rate of return, and investment payback period as the solid indicators for analysis and research (Lei, 2021).

Financial NPV is an absolute indicator to examine the profitability of a project, which reflects the present value of the excess earnings that can be obtained in addition to the payments required to meet the set discount rate. The investment decision focuses on whether the value of the net cash flow of the project is more significant than its investment cost (Qu, Zhao, & Zou, 2012).

The financial net present value (FNPV), which refers to the discount rate using the industry's benchmark rate of return or the set discount rate as the discount rate during the project calculation period, discounting the net cash flow generated in each year to the base year, which is the point in time when the project investment begins, and

summing the present values calculated in each year. Financial NPV is an absolute positive indicator; only when the NPV is greater than or equal to zero is the program feasible, and the more significant, the better. Therefore, if many options are available for the project, the one with the most significant positive NPV should be chosen (Pu & Zhao, 2013).

That in the case of a project with only one option, if the calculated NPV is less than zero, which means that the project is not feasible under such an option, then this project option cannot be adopted; accordingly, if the calculated NPV is greater than or equal to zero, then the option is feasible, and this project option can be adopted. In the case of a project with multiple options, the NPV of the various options should be compared, and the project option with the highest and most positive NPV should be selected in preference (Lin, 2020).

2.5 Past Research

In the past ten years, the new energy industry has thrived. As its representative, the solar photovoltaic industry has received more and more attention from researchers worldwide (Tan, 2017). Many experts and scholars have conducted fruitful research on various aspects of the solar photovoltaic industry.

A comprehensive assessment of the cost competitiveness of electricity resources was conducted. U.S. cost data for the second half of 2011 concluded that utility-scale solar PV is not cost-competitive with fossil fuels. In a sense, cost parity has been concluded for commercial-scale PV facilities. Utility-scale PV generation facilities are predicted to become competitive within a decade, while commercial-scale facilities can achieve "grid parity" on a large scale. Utility-scale PV generation facilities are expected to become competitive within a decade, while commercial-scale facilities can achieve large-scale "grid parity" within the next decade (Stefan & Michael, 2013).

Using a solar PV project in Ontario, Canada, as a case study, they present and discuss how optimization models and technical methods can be used to develop the best plan for potential investors to invest in large-scale solar PV projects, ultimately demonstrating the practical applicability of the proposed methods and tools (Wajid, Kankar, & Claudio, 2011). Pakistan's complex distribution grid system, a region with frequent power constraints or intermittent supply and even blackouts, is analyzed. They discuss the case of a large 750 MW grid-connected PV plant from both technical and economic aspects (Tasneem, Kirn, Junaid, & Andrew, 2016). A comprehensive cost analysis study of a 1 kW off-grid PV project in New Delhi, India, was conducted to demonstrate that 1 kW solar power is off-grid from the design and installation of the solar PV system. PV projects are valuable in rural areas of India (Shahzad, Kashif, Ankur, & Mohammad, 2016).

The current status of household-distributed PV projects is discussed, their future development trends are predicted, and countermeasures and suggestions are made for daily problems (Yu & Li, 2015). The current distributed PV policy in China was

analyzed, and the economics of combining the two applications was assessed in the context of developing energy storage in China. Based on the assessment results, recommendations were made to promote its development (Lv, Cai & Wang, 2015).

Through the above analysis, experts and scholars on PV projects are more likely to analyze the problems and corresponding countermeasures generally faced by the PV industry in the current development process (Zhang & Tian, 2015). Most economic policy studies are one-sided analyses of cost composition, financial benefits, and supporting policies. There needs to be a more comprehensive analysis of different types of PV projects, and the analysis methods used need to be more relevant, especially for distributed computation (Zhang & Wang, 2015). There is no further research in the critical areas of future development of solar PV, and there are still relatively few comprehensive analytical studies combining analysis of the operation mode of distributed PV projects with economic analysis.

3. Finding and Conclusion

With the advancement of technology and the expansion of the application scale, the cost of photovoltaic power generation continues to decrease, further advancing the development of the solar photovoltaic industry (Jiang, 2021). However, considering the economic characteristics of distributed photovoltaic projects with a long payback period, prominent policy influences, and substantial investment income uncertainty, distributed photovoltaic projects have been significantly restricted in the selection stage of the project operation mode.

This paper collects a large amount of data on photovoltaic projects, combined with its own work experience, conducts an in-depth analysis of photovoltaic project operation mode analysis and economic analysis methods, and takes Tianjin's 8MW distributed photovoltaic power generation project as an example, based on the various foundations in the model The analysis and summary of the conditions, the analysis and selection of specific project operation modes and the economic analysis and selection of multiple income distribution schemes, provide a reference for the research and decision-making of the same type of distributed photovoltaic power generation projects in the future.

The main conclusions of this article are as follows:

1. With the gradual rationalization of photovoltaic policies in various countries and the continuous reduction of photovoltaic module costs, coupled with the advantages of distributed photovoltaic solar energy with high availability, no site restrictions, and flexibility and convenience, distributed photovoltaics will achieve faster growth in the future.

2. Distributed photovoltaic power generation projects need to consider the five fundamental conditions of the project site's solar resources, local scale indicators, national policies, grid connection conditions, and power consumption capacity during various decision-making analysis stages as project operation mode analysis and

economic analysis condition.

3. At this stage, the operation mode adopted by the owners of distributed photovoltaic power generation projects is roughly divided into EPC and EMC modes (Sun, 2021). In the current composition structure of China's distributed photovoltaic project owners, industrial parks, and individual industrial users account for a more significant proportion, China's distributed photovoltaic power generation projects still adopt the EMC operation mode.

4. Before the economic analysis of the project, much data related to the project need to be collected, summarized, and analyzed into primary economic data to prepare financial statements and calculate economic indicators later. Distributed photovoltaic projects mainly include five preliminary economic data: total project investment estimate, power generation estimate, project agreement electricity price, project operating cost, and tax situation.

5. In selecting the operation mode of distributed photovoltaic power generation projects, there may be multiple scenarios in the income distribution plan. You can refer to the economic analysis model constructed in this article for analysis and comparison to select the project's best operation mode.

4. Recommendation

In this paper, we have collected a large amount of information on PV projects, combined with our own work experience, made an in-depth analysis of PV project operation mode and economic benefit analysis methods, and formed recommendations for selecting operation mode for distributed PV power generation projects.

1. Full consideration of operational model inputs. In the study EMC model, in construction, operation, and maintenance, business model and other aspects of the advantages, low cost, high revenue, higher stakeholder returns, so in the distributed photovoltaic power generation model operation process need to consider the benefits and costs of participants fully, when the cost is lower, higher revenue will attract more investors and participants.

2. Full use of national policy and environment. In the study comparing the two models, national policies and the energy consumption environment were not thoroughly analyzed; national policies, especially government subsidies, will significantly enhance the motivation and initiative of participants and stakeholders, so the economic efficiency operation model still needs to take complete account of national policies and the overall economic environment in the analysis process.

3. Full consideration of the benefits of the operating model. The ultimate consideration in the study is the revenue of the model operation; when the revenue is higher, both stakeholders and participants will choose the option with higher revenue. Therefore, in the design process, the benefits of economic inputs need to be fully considered, and higher returns will increase the motivation of participants, which is beneficial to the development of the whole enterprise and industry.

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