Analysis on Economic Benefit of Nanliang-Zifangpan Distributed Wind Power Project

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Abstract. Distributed wind power is located near the load center and does not aim at large-scale long-distance transmission, and the generated electricity is connected to the local power grid for consumption. Nowadays, new energy power generation industry in Gansu Province is developing rapidly, and the economic benefit of decentralized wind power project is the primary factor which affect investors' decision-making. After analyzed the actual economic indicators of the Nanliang-Zifangpan wind power project, evaluated the economic benefit of the project, through the sensitivity analysis of its impact on economic benefit, put forward corresponding measures and suggestions.

Keywords: Analysis · economic benefit · distributed wind power · project

1 Introduction

Gansu Province is one of the provinces with abundant wind energy resources in China. Theoretical reserves of wind energy resources are 237 million kilowatts, accounting for 7.3% of the country's total reserves, ranking fifth in the country, and the technically exploitable capacity reaches 40 million kilowatts, accounting for 10.6% of the country's total [1]. During the *14th Five-Year Plan* period, according to the systematic planning of the carbon peak carbon neutrality work at the national level, the new energy industry has received unprecedented attention. To further increase the proportion of renewable energy power generation in power supply, it is necessary to vigorously develop distributed renewable energy power generation [2]. *Local balance, nearby consumption* is the most important feature of decentralized wind power, the purpose is to solve the problem of curtailment of wind power. Due to high power generation utilization hours, high level of grid-connected consumption, project economics and profitability, distributed wind power are better than General centralized wind power projects. According to the analysis of the actual operating conditions of the decentralized wind power projects that have been put into operation in Gansu Province, most of the projects have not reached the expected level of economic benefits. To further study the economics of decentralized wind power projects, this paper takes the Huaneng Nanliang-Zifangpan decentralized wind power

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project as an example, calculates the dynamic index internal rate of return (IRR) and static index total return on investment (ROI), sensitivity analysis is also carried out on indicators such as project revenue and utilization hours, electricity price, total project investment, and operating costs.

2 Key Indicators of Decentralized Wind Power Projects' Economic Benefit

2.1 Total Investment

The total investment of wind power projects is mainly composed of construction engineering, equipment and installation engineering, other expenses, basic reserve expenses and capitalized interest expenses during the construction period, and the largest part of the total investment is wind turbine equipment [3]. The main factors affect the investment: the first one is the difference in wind turbine selection and equipment price, which mainly affects the price of main equipment; the second one is the site condition and grid connection conditions, which mainly affect the on-site and off-site roads, power lines, forestry, and grass land acquisition fees, etc.; The third is the project construction period and loan interest rate, which mainly affect the capitalized interest expenses during the construction period. In recent years, new energy investment credit policies have been more favorable and inclined. In 2022, the annual interest rate of long-term loans for new energy projects in Gansu Province over 5 years can reach 3.25%.

2.2 Utilization Hours

Wind energy resources is the key factor which affects the annual utilization hours of wind turbine generating equipment, and secondly, the type of selection of wind turbine and the location of wind field also have a certain impact on the utilization rate of wind turbines. Gansu Province is rich in wind energy resources. The high level of grid-connected and consumption of decentralized wind power projects results in a low rate of wind curtailment. Effectively using wind energy resources and increasing the availability of wind turbines will effectively increase the utilization hours of equipment. At the same time, according to the trading rules of the electricity spot market for distributed wind power projects in Gansu Province, high utilization hours will bring high electricity price benefit, which will effectively improve the economic benefits of the project.

2.3 Electricity Price

The Renewable Energy Law stipulates that wind power projects implement the electricity price subsidy model and set different benchmark electricity prices according to different resource regions. On May 17, 2017, the National Energy Administration issued the Notice on Carrying out the Demonstration Work of Wind Power Parity Grid, which proposed that the government guarantee that there will be no electricity limit, and the grid electricity price will be implemented according to the thermal power benchmark electricity price of the project location. The National Development and Reform Commission's Notice on Improving Wind Power On-grid Tariff Policy, changed the benchmark

price of onshore wind power to a guide price. The pricing rules of distributed wind power projects in Gansu Province are divided into two parts. The first part is the settlement electricity price, which is the generation priority for 150 h/month and is implemented according to the benchmark electricity price (307.8 yuan/kWh) trade. The second part is renewable energy subsidies. Projects before 2022 enjoy renewable energy subsidies of 72.2 yuan/kkWh.

2.4 Operating Cost

Operating cost refers to the business cost paid in cash [4], which is often used in engineering economic analysis. It is all recurring cost expenses after depreciation, amortization and interest expenses are excluded from the total cost [5]. The operating costs of wind power projects mainly include labor costs, materials, planned maintenance and repair costs, outsourced power costs and other costs. Other costs refer to administrative fees: office, transportation, meetings, travel, and technical services.

3 Analysis on Economic Benefit of Distributed Wind Power Project

3.1 Basic Information of the Project

Nanliang-Zifangpan decentralized wind power project is in Huachi County, Qingyang City, Gansu Province, with an altitude of 1500–1700 m. The annual designed generation is 130.17 million kwh, and the utilization hours are 2153 h. The project mainly includes 14 sets of 3600kW and 3 sets of 3350kW wind turbines, with a total installed capacity of about 60.3MW. The construction of the project started in July 2021, and the 240-h trial operation completed on April 30, 2022, then put into operation formally.

3.2 Main Indicators of the Project

3.2.1 Total Investment

The total investment of the project is 401.1998 million yuan, and the unit investment is 6636.89 yuan per kilowatt. According to the estimated cost shown in Table 1, it saves 213.68 yuan/kW. Among them: the actual investment in the construction project was 60.2558 million yuan, saving 6.19%. The main reason is that the investment in fan foundation and box transformer foundation was reduced through bidding. The actual investment in equipment and installation projects is 293.6204 million yuan, which is basically the same as the management estimate. The actual investment in other expenses was 20.0211 million yuan, saving 26.50%, mainly due to the large savings in project technical and economic review fees, project inspection fees, and company management fees. The capitalized interest expenses during the construction period occurred by 6.4879 million yuan, 105.41% higher than the estimated budget. The main reasons are that the project construction period was extended by 4 months compared with the plan, and the capital funds were not fully paid during the project construction period.

Table 1. Comparison of estimated management budget and actual investment

10,000 yuan				
Engineering or Expense item	Management Budget	Actual Investment	Increase and Decrease Amount	Increase and Decrease Ratio
Construction Engineering	6,423.06	6,025.58	-397.48	-6.19%
Equipment and Installation Engineering;	29,283.25	29,362.04	78.79	0.27%
Other Fees	2,723.80	2,002.11	-721.69	-26.50%
Basic Reservation Fees	384.3	0.00	-384.30	-100.00%
Special Projects	2,281.46	2,081.46	-200.00	-8.77%
Statistic Investment	41,095.87	39,471.19	-1,624.68	-3.95%
Construction Period Loan Interest	315.85	648.79	332.94	105.41%
Dynamic Investment	41,411.72	40,119.98	-1,291.74	-3.12%

3.2.2 Utilization Hours

Based on Monthly average wind speed and power generation statistics in Table 2, according to the monthly wind speed, the power generation during the trial operation period (January-April) and the abnormal period (September) is corrected. After the correction, the monthly average power generation is 8.7073 million kwh, and the monthly average utilization hours are 144.40 h. The annual utilization hours can be calculated to be about 1733 h.

Table 2. Monthly average wind speed and power generation

m/s, 10,000 kWh												
month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Ave. Wind speed	3.97	3.73	4.72	4.36	3.99	4.26	3.64	4.62	3.25	3.79	3.48	3.96
Actual generation	55	117	410	746	794	795	790	955	567	844	777	967
ted generation	897	842	1066	985	794	795	790	955	735	844	777	967

Table 3. Composition of electricity price

10,000 kWh, yuan/1,000 kWh, 10000 yuan			
Type	Settlement electricity	Electricity price (tax included)	electricity bill
Generation priority	7793.52	307.80	2398.85
Spot in the province (positive)	2036.34	333.61	679.34
Spot in the province (negative)	-2272.24	529.22	-1202.52
Renewable energy subsidies	-	72.20	545.66
Total	7557.62	327.48	2421.33

3.2.3 Electricity Price

According to the electricity price composition of the electricity in Table 3, the average tax-included settlement electricity price of the project is 327.48 yuan/kWh, of which: the electricity price of priority power generation is 307.8 yuan/kWh, and the spot positive electricity in the province is 333.61 yuan/kWh. The spot negative electricity in the province is 511.73 yuan/kWh, and the renewable energy subsidy price is 72.2 yuan/kWh.

3.2.4 Operating Costs

According to the actual production and operation situation in the first year of the project, excluding abnormal factors, the revised annual operating cost is 4.28 million yuan, including: labor cost 920,000yuan, material cost 360,000 yuan, planned maintenance and repair cost 1.13million yuan, outsourced power cost 250,000 yuan and other expenses of 1.62 million yuan.

3.3 Profitability Analysis

Based on the comprehensive consideration of the applicability and emphasis of each economic benefit evaluation indicator, dynamic indicator internal rate of return (IRR) and static index total rate of return on investment (ROI) with strong complementary are selected for profitability analysis [6, 7].

3.3.1 Index Calculation

Internal Rate of Return (IRR): represents the expected rate of return of project investment and is defined as the discount rate when the net present value (NPV)of all cash flows of the investment is equal to zero [8]. It directly expresses the expected returns of different investment entities [9], which is applicable to examining the benefits of specific projects [10].

The net present value (NPV) annuity is calculated as:

$$NPV = A \times (1 - (1 + r)^n)/r - TI \tag{1}$$

Formula (1): A represent Annuity Net Operating Cash Flow; r is the discount rate; n is the income period; TI is the total investment cost.

Total return on investment (ROI): Refers to the annual EBIT profit during the normal operating cycle or the annual average EBIT during the operation period, for example, as a percentage of the total project investment.

The calculation formula is:

$$ROI = EBIT/TI \tag{2}$$

Formula (2): EBIT is the annual profit before interest and taxes; TI is the total investment cost.

Evaluation index calculation results: According to Table 5, the net present value (NPV) of the project when the capital cost rate is 5% is -30.95 million yuan, and the NPV is 9.19 million yuan when the capital cost rate is 4%. The internal rate of return (IRR) of the project calculated by the method is 4.23%; the total project return on investment (ROI) = EBIT (911.01) / TI (40119.98) * 100 = 2.27%. The calculation results are listed in Table 4.

3.3.2 Evaluation Index Analysis

According to Table 5, the IRR and ROI of the project did not reach the expected level of the estimated budget. The main reasons for the difference are: first, the wind resources are not as good as expectations, and the average annual utilization hours during the operation period are 19.69% lower than the estimated budget. The electricity price (including tax) is 13.82% lower than the estimated budget.

3.4 Sensitivity Analysis

Sensitivity analysis is to analyze the degree of uncertain factors' influences on the economic effect indicators of the project in the economic evaluation of the investment project. Sensitivity can not only enable decision-makers to understand the degree of uncertain factors' influences on evaluation indicators, improve the accuracy of decision-making, but also inspire decision-makers to conduct in-depth analysis of those more sensitive factors and improve the reliability of predictions [11]. This paper adopts the single-factor sensitivity analysis method, that is, keeping other influencing factors unchanged, changing the range of an uncertain factor from -10% to +10%, and the range of change is 5%. The results are shown in Table 6.

Although single-factor sensitivity uses same hours and electricity price, but due to impact of Gansu province's power market transaction policy on decentralized wind power projects, the 150 h of monthly generation priority is decomposed according to the daily average, and the daily power curve is issued. The part of the power generation level that reaches the curve is settled according to the benchmark electricity price (307.8 yuan/kWh), and the part that exceeds or falls short participates in the spot transaction

Table 4. Project IRR, ROI estimate

10,000 yuan, yuan/1,000 kWh, 10,000 kWh	
Project Indicators	Calculation Results
Total Investment Cost (TI)	40,119.98
Installed capacity	6.03
Average annual utilization hours	1,733.00
On-grid electricity price (tax included)	327.48
Operating income	3,055.01
total cost	2,615.88
Operating costs	428.00
Depreciation	1,716.00
Financial expenses	471.88
Annual Average Total Profit	439.13
Annual Average Operating Net Cash Flow	2,627.01
Average annual EBIT	911.01
NPV (capital cost 5%)	-3,095.03
NPV (capital cost 4%)	919.39
IRR	4.23%
ROI	2.27%

Table 5. IRR, ROI Comparison between estimated budget and actual situation

10,000 yuan, yuan/1,000 kWh			
Project Indicators	Estimated Budget	Actual Budget	Increase or Decrease Ratio
Total Investment	41,411.72	40,119.98	-3.12%
Average annual utilization hours	2,158.00	1,733.00	-19.69%
electricity price (tax included)	380.00	327.48	-13.82%
Operating costs	991.89	428.00	-56.85%
IRR	5.83	4.22	-27.62%
ROI	3.92	2.27	-42.09%

of the power market. The electricity price for spot trading is 150–300 yuan/kWh higher than the benchmark electricity price. As a result, whether the project operation period reaches the daily utilization hour has a decisive impact on the settlement electricity price, and it is necessary to be able to accurately predict the wind speed and power generation

Table 6. Results of Sensitivity Analysis

Variation factor	Variation factor	IRR	ROI	Sensitivity coefficient (IRR)	Sensitivity coefficient (ROI)
Reference value		4.22	2.27		
Total Investment	-10%	5.27	2.52	2.479	-1.115
	-5%	4.73	2.39	2.411	-1.059
	5%	3.77	2.16	2.137	-0.946
	10%	3.34	2.06	2.079	-0.906
Utilization hours	-10%	3.08	1.52	-2.691	3.322
	-5%	3.67	1.89	-2.588	3.319
	5%	4.77	2.65	-2.624	3.332
	10%	5.31	3.03	-2.572	3.328
feed-in tariff	-10%	3.08	1.52	-2.691	3.322
	-5%	3.67	1.89	-2.588	3.319
	5%	4.77	2.65	-2.624	3.332
	10%	5.31	3.03	-2.572	3.328
Operating costs	-10%	4.39	2.38	0.401	-0.473
	-5%	4.31	2.32	0.425	-0.476
	5%	4.15	2.22	0.346	-0.464
	10%	4.06	2.16	0.371	-0.467

curve. The sensitivity of utilization hours to project profitability is stronger than that of electricity price.

According to results of sensitive analysis above, the utilization hours of decentralized wind power projects have the strongest sensitivity to the profitability of the project, while the electricity price and the total investment have an equal degree of influence and strong sensitivity, and the three indicators are all strongly sensitive indicators.

4 Conclusion

1) The main economic indicators of the Nanliang-Zifangpan decentralized wind power projects are basically consistent with the design, and the project meets the design standards, but the profitability is greatly affected by the power generation. Therefore, striving for power generation is the first element of project profitability
2) Utilization hours, electricity price, total investment and operating cost of decentralized wind power projects is major factors which affect investment returns. Therefore, in investment's decision-making process, decision makers should concern wind resource level and wind resource stability in the location. Secondly, it is important to understand the electricity price of the project and track the local electricity price

policy. At the same time, it is necessary to strictly control the project investment cost, focusing on reviewing the selection of fan equipment, site conditions, and grid connection conditions.

3) Gansu province's electricity market trading policy has a greater impact on decentralized wind power projects. Policies are changing all the time, and the market competition is very fierce; it is very necessary to be able to accurately predict the wind speed and power generation curve.
4) According to project investment analysis, decision-makers should strengthen the management of the operation period, reasonably reduce operating costs, and maximize the economic benefits of the project.
5) Decentralized wind power projects still have economic conditions that can be developed when the utilization hours are not less than 1800.

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