

Study on Real Option of Wind Power Generation Considering Energy Saving Value

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Abstract. Taking the wind power generation's pollution-free, easy access and other characteristics into account, Wind power has made great progress in China's renewable energy industry. But because the wind is not controllable, wind power can not guarantee a stable power output, bringing uncertainty in the operation of the distribution network. In this paper, combined with the existing literature on wind power investment decision-making research, then the real option model of wind power investment is established on the basis of the net present value added to the value of energy conservation. Finally, the empirical analysis is carried out to verify the feasibility of the model and the software simulation is concluded that the improved model provides more accurate decision support.

Introduction

In recent years, with a large number of energy consumption, environmental pollution caused more and more attention. The wind energy resources not only have the characteristics of cleaning, and the amount of resources is relatively rich, so it has great potential in China's renewable energy industry. Therefore, the construction of the fan caused widespread concern in the country and society, the scale of investment also will continue to grow. Due to the unstable characteristics of wind power generation technology itself, a more accurate investment decision-making model will play an increasingly important role in the development and construction of wind turbines, laying the foundation for a virtuous cycle of wind power generation.

Some scholars have made extensive research on wind power investment decision. On the one hand, the influencing factors of wind power generation are analyzed. On the other hand, the investment decision of wind power is studied. Literature [1] taking a wind power project in Jiangsu Province as an example, makes use of the internal rate of return in the financial evaluation method to make project investment decisions, and provide decision support for wind power projects. Without taking environmental constraints into account, it is impossible to estimate the environmental value of wind power projects. Based on the consideration of wind power generation, electricity price, investment policy and other factors, literature [2] establishes a more targeted investment decision-making model of wind power projects, and the present cost value of wind power investment is obtained by using the real option method. In [3], the application of real option method in wind power project investment decision was studied, and the Black-Scholes model and binary tree model were established. Due to the introduction of the real option method, the investment flexibility value of the project has been increased. In [4], the real option method is also studied, and the risk caused by the uncertain factors in the project is simulated by Monte Carlo simulation. In [5], the compound real option idea and model are introduced into the investment decision of wind power project, which solves the multi-stage and multi-period problem of wind power project.

There are many factors influencing the investment decision of wind power project, which mainly focus on its own characteristics and market environment, including the uncertainty of wind power technology, the level of electricity price, investment policy, investment and running cost. Based on the previous research on wind power generation, this paper analyzes the basic factors of multi-stage investment decision-making of wind power from the economic point of view, and then the impact

of these factors on investment decision-making is studied. The advantage is that the improved net present value model can estimate the impact of energy savings on investment decisions, especially in the case of severe energy consumption, energy savings can make investment decisions more scientific. Finally, through simulation analysis, it can provide more accurate decision support for wind power investment decision-making.

Analysis on the Influencing Factors of Investment Decision

There are many influencing factors of wind power generation, and it is a prerequisite for investment decision.

Technical Factors. At present, the technical bottleneck of wind power is mainly concentrated in the project power generation efficiency and power generation stability, the amount of electricity generated and the quality of power directly affect the project investment income, which has a significant impact on investor investment decisions. From a technical point of view, the discontinuity and instability of wind power generation have posed challenges to the planning, management and operation of the grid. As the wind is not controllable, resulting in instability of the fan output power, in this case the number of years available for the equipment will be the entire project investment income status plays a vital role.

Economic Factors. In the continuous development of the economy, energy demand also increased. For the demand side of the response, gave birth to the continuous development of wind power. From an economic point of view, although the wind farm investment is higher, but it can be used for a long time, and the operation and maintenance costs are relatively low, so it is feasible from the point of view of efficiency. There are many economic factors in wind power investment decisions, such as investment cost, electricity price, investment policy and so on, which will influence the investment decision of wind power projects.

Environmental Factors. With the pollution concerns, environmental costs have been included in the operating costs, therefore, environmental policy changes will affect the operating costs of power generation investors, and then affect the investment decision-making of wind power projects. With the deepening of the concept of green, wind power generation will be more favored, which will bring comparative advantages for wind power financing. Compared with the traditional thermal power generation's high energy consumption, pollution emissions and many other characteristics, The energy-saving value of wind power is included in the net present value model, so that the net present value model of wind power generation will be more practical and more valuable for the decision-making reference provided by investors.

Improve the Investment Decision Model

As a traditional investment decision-making method, the net present value reflects the difference between the total income and the total cost, and its size determines the investment economy is good or bad.

Traditional Net Present Value Model. As a traditional method of investment decision, the net present value method discounts the inflow of funds and the outflow of funds to obtain the net present value of the program, if the net present value is greater than zero, the plan is feasible, and the greater the net present value, the better the investment benefit of the scheme. The net present value model of wind power projects is described as follows:

$$NPV = \sum_{t=0}^n (CI - CO)_t \frac{1}{(1+r)^t} \quad (1)$$

CI represents cash inflow; *CO* means cash outflow; *n* represents the cost payback period (life).

This model only calculates the net present value based on the cash flow statement, and can not fully estimate the impact of various factors on the net present value, and there are unpredictable problems with the cash flow. What is more important is the inability to estimate the impact of energy savings on net present value indicators.

Energy Saving Value. Due to the difference of power generation efficiency between wind power generation and thermal power generation, so the wind power generation will be converted into thermal power generation by the adjustment factor, then the energy consumption of thermal power generation is used to estimate the energy saving value of wind power generation, and the amount of wind power is calculated in terms of annual power generation. Build energy-saving value model as follows:

$$V_c = P \cdot \eta \cdot q \cdot \alpha \quad (2)$$

V_c represents the energy saving value of reducing energy consumption; P represents annual power generation; η indicates the efficiency ratio of thermal power generation to wind power generation; q indicates the unit of thermal power consumption of standard coal, g/kw · h; α represents the unit coal price, yuan/kg.

Improved Net Present Value Model. The improved net present value model is as following.

$$\begin{cases} ENPV = -M + (R + V_c) \cdot \frac{(1+i)^n - 1}{i \cdot (1+i)^n} \\ R = C_p \cdot 1950 \cdot (\bar{p} - \underline{p}) \\ M = C_p \cdot C_f \end{cases} \quad (3)$$

$ENPV$ represents the expected net present value; M represents the initial one - time completion of the fixed - cost investment, yuan; R represents an annual value of fixed income, C_p represents the total capacity of the investment, MW; \bar{p} represents the expected level of electricity price for electricity generation; \underline{p} represents unit operating costs, yuan / kw; C_f represents unit investment cost, yuan / kw; 1950 means that the number of hours available for the year ; i takes 10%.

Option Value. Real options make up for the shortcomings of net present value, taking into account the role of flexible value in investment decision making. In this paper, the classic Black-Scholes model is used as follows:

$$NPV = \sum_{t=0}^n (CI - CO)_t \frac{1}{(1+r)^t} \quad (4)$$

$$d_1 = \frac{\ln(S/X) + (r + \sigma^2/2)T}{\sigma\sqrt{T}} \quad (5)$$

$$d_2 = d_1 - \sigma\sqrt{T} \quad (6)$$

In the formula, S represents the present value of the expected return; X represents the total investment of the project; σ represents the market volatility of the project value; T represents the exercise period of the option; r represents risk-free interest rate; $N(d_1)$ 、 $N(d_2)$ respectively represent the cumulative probability distribution function of the standard normal distribution.

Total Value of the Project. In addition to the intrinsic value of traditional projects, the total value of the project also includes strategic flexible values. Formula is as follows:

$$NPV_{tot} = ENPV + C \quad (7)$$

In the formula, C represents the deferred option.

Empirical Analysis

The total installed capacity of a proposed wind power plant is 30MW. The annual power generation is 51 million kw · h. Unit thermal coal consumption is 326 g/kw · h. The efficiency ratio of thermal power generation to wind power generation is 1.02. Construction cycle is 2 years.

According to model two, the energy savings can be calculated as:

$$V_c = 5100 \times 10^4 \times 1.02 \times 326 \times 0.3 \times 10^{-3} = 5087600 \text{ yuan.}$$

The basic parameters of wind power investment are as follows:

Table 1 Basic Parameters in Investment

power generati on type	parameters				
	unit cost (yuan/k W)	investm ent capacity (MW)	life expecta ncy (year)	electricity price(yuan/ kw·h)	Operating costs(yuan/ kw·h)
windpo wer	7284	30	20	0.47	0.045

From the model three can be seen, when energy saving value is not included, expected net present value is

$$ENPV_1 = -30000 \times 7284 + (30000 \times 1950 \times (0.47 - 0.045) \times 8.513) = -6865537.5 \text{ yuan.}$$

When energy saving value is included, expected net present value is

$$ENPV_2 = -30000 \times 7284 + (30000 \times 1950 \times (0.47 - 0.045) + 5087600) \times 8.513 = 36445201.3 \text{ yuan.}$$

Table 2 Basic Parameters in Deferred Option

power generati on type	parameters				
	market volatilit y σ	risk-free rate r	option period T (year)	Income present valueS (million yuan)	Total investment in the projectX (million yuan)
wind power	9%	6%	2	218.1784	218.5200

To sum up, if the net present value as a reference to investment decisions, when not included in the energy value, the project losses, and when included in the energy value, the project loss is relatively small. But the two cases are not suitable for investment, so the project should be postponed, then you can use real options to calculate the project's options, $N(d_1) = 3.1789$ and $N(d_2) = 2.7764$ can be calculated from the model four. The deferred option can be obtained by substituting the formula, so $C = 218178400 \times 3.1789 - 218520000 \times e^{-0.06 \times 2} \times 2.7764 = 155473637.6$ yuan.

At this point, the total value of the project is

$$NPV_{\text{tot}} = 36445201.3 + 155473637.6 = 191918838.9 \text{ yuan.}$$

Conclusion

Wind power generation is an effective way to solve the problems of economic development and energy consumption. From the value of energy saving, wind power generation saves a great deal of standard coal consumption in the process of generating electric energy. With the continuous expansion of the scale of the fan, the community will gradually get rid of a lot of energy consumption at the expense of economic development, clean wind power will be more favored. In addition, excluding the value of wind power generation, the net present value of wind power is less than zero, which is not suitable for direct operation. From the deferred option we can see that the delayed operation of the project will get more flexible value, then the total value of the project is far greater than zero, the project worth investing. Therefore, in the current market situation, the project is not suitable for direct operation, it should be put into operation after 2 years, and then a very considerable investment risk value will be obtained.

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