Research on Investment Efficiency Evaluation of Wind Power Projects under Supply-side Reform

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Abstract. In recent years, China's wind power has developed rapidly, with increasing installed capacity, and it is gradually entering a stage of large-scale development, which has broad potential for future development. However, China's wind power investment projects have low investment efficiency, which is not conducive to the healthy development of the wind power industry. Therefore, improving the overall investment efficiency of wind power projects is an inevitable direction for the development of wind power companies in the future. This paper first takes wind power projects as research objects, combines the characteristics of wind power projects, and constructs a suitable comprehensive investment efficiency evaluation model based on DEA theory. Then it conducts an empirical analysis based on the development status of power enterprises in Xinjiang of China, and combines the evaluation conclusions to promote wind suggestions on the development of investment efficiency in power generation projects.

1. Introduction

Wind energy is a widely distributed and renewable clean energy. The rational and effective development and utilization of wind energy resources can play a role in protecting the ecology, saving resources, promoting energy structure adjustment, promoting industrial transformation, and promoting sustainable development [1]. Since 2011, China’s high-speed development and utilization of wind energy has been continuously improved, and its installed capacity has doubled in successive years [2]; in 2014, China’s cumulative installed capacity reached 114609MW, accounting for 31.01% of the global total installed capacity, and has been maintained in recent years. Higher growth rates. However, China's wind power investment projects exist: high wind abandonment rates, uncoordinated power and grid construction, and long capital turnaround time for wind power projects, which lead to difficulties in business operations and other low investment efficiency, which is not conducive to the healthy development of the wind power industry [3]. Therefore, improving the overall investment efficiency of wind power projects is the inevitable development direction of wind power companies in the future. This paper takes Chinese wind power projects as the research object, through the study and review of the existing literature, a reasonable summary of various aspects of the wind power project investment efficiency factors, combined with the characteristics of the wind power project to build a suitable comprehensive efficiency evaluation method model Based on the empirical analysis of Xinjiang's wind power enterprises as the research object, and combined with the evaluation conclusions, put forward suggestions to promote the development of wind power projects.
2. Analysis of factors affecting investment efficiency of wind power projects

The comprehensive investment efficiency of wind power projects is affected by many factors, such as the internal competitiveness of enterprises, the level of social and economic development, wind turbine manufacturing technology, and national macro policies. This paper divides the comprehensive efficiency factors of wind power generation into two parts of internal factors and external factors through research and analysis, and conducts a comprehensive analysis from the perspective of internal and external perspectives to provide a reference for the selection of evaluation indicators later.

2.1. Internal factors

Internal factors are the resource conditions of the enterprise or the project itself, and factors that are closely related to the future development of the enterprise, such as management level, capital profile, internal personnel advantages, production technology level, financial index factors, etc., they are all evaluation projects Relevant indicators of the importance of internal factors.

2.2. External factors

External factors are factors that will produce unknown results for the development of the enterprise due to the uncertain changes in the current external conditions. There are many types of external factors, some of which will have a positive effect, and some of them will have a negative effect. Changes in external conditions have little or no effect on internal changes in the enterprise. Sex, that is, human factors cannot be eliminated.

3. Research on comprehensive efficiency evaluation system for wind power projects

3.1. Evaluation Index System Construction

This article should consider comprehensively when selecting input indicators and output indicators: (1) whether the indicators can fully reflect the investment efficiency of wind power projects; (2) whether the indicators meet the methods used; (3) whether the source of the data for the input indicators has operability. Taking into account the limited data source channels of this article, only some indicators that are easy to quantify and have a high degree of importance are selected for argument analysis. The indicators that are difficult to quantify or have less influential factors have not been considered for the time being. After comprehensively considering the above principles and influencing factors, the indicators initially selected in this article are shown in Table 1 below:

| classification | index | Explanation of indicators |
|---------------|-------|---------------------------|
| Input indicator | Period-end installed capacity | Sum of rated power of generator set |
| Average utilization hours | Genset average working time |
| average wind speed | The average value of the average value of several observations of wind speed within a certain time, unit: m/s |
| Power limit | Loss of electricity due to suspension of operation of the fan due to other reasons under normal circumstances |
| Average capacity of power generation equipment | Installed capacity of power generation equipment |
| Output indicator | Wind power production | Electricity from generator set |

3.2. Construction of comprehensive evaluation model based on DEA theory

The DEA evaluation model is a comprehensive efficiency evaluation model suitable for analysis and evaluation of enterprises with multiple inputs and multiple outputs. It can more accurately and comprehensively reflect the relationship between input and output indicators. The investment
efficiency evaluation of wind power enterprises is a comprehensive analysis and evaluation of multiple inputs and multiple outputs. The basic principle is as follows:

If \( n \) wind power companies are assumed to have \( n \) decision units (DMU), each decision unit has \( m \) kinds of inputs and \( s \) kinds of outputs. Suppose \( X_{ij} \) represents the \( j \)-th input of the \( i \)-th DMU, \( Y_{ir} \) represents the \( r \)-th output of the \( i \)-th DMU, \( v^T \) and \( u^T \) represent the weight vector of each input and output index, and the vectors \( X_i \) and \( Y_i \) represent the inputs and outputs of each DMU, then:

\[
T_{im} = \sum_{k=1}^{m} v_k X_{ik}, \quad \ldots, \quad T_{s} = \sum_{r=1}^{s} u_r Y_{ir},
\]

Then define the \( i \)-th DMU efficiency evaluation index as:

\[
h_i = \frac{\sum_{r=1}^{s} u_r Y_{ir}}{\sum_{k=1}^{m} v_k X_{ik}}
\]

Assume that the \( i_0 \)-th DMU is evaluated and recorded as DMU0. The input is \( X_{in} \) and the output is \( Y_{i_0} \). The relative efficiency evaluation model of the \( i_0 \)-th DMU is:

\[
\max \sum_{r=1}^{s} u_r Y_{ir} \quad \text{subject to} \quad \sum_{k=1}^{m} v_k X_{jk} \geq v_i, \quad i = 1, 2, 3, \ldots, n.
\]

\[
\sum_{k=1}^{m} v_k X_{jk} = \sum_{r=1}^{s} u_r Y_{ir} \quad \text{for all} \quad i = 1, 2, 3, \ldots, n.
\]

We limit the value of all DMU evaluation indexes \( h_i \) to no more than 1, that is, \( \max_{h_i} \leq 1 \), which indicates that if \( h_k = 1 \) of the \( k \)-th company, the company is relatively compared with other companies under the conditions of relative The production efficiency is the highest; if \( h_k < 1 \), compared with other enterprises, the productivity of this enterprise still needs to be improved, or this production system is not yet effective.

4. Empirical analysis

4.1. Basic Information

In this paper, by selecting the relevant indicators in the analysis factors above, looking for relevant literature and information, and the National Energy Administration's preliminary conclusions, the total power generation of a branch of a power generation company in Xinjiang's Dabanchong, Balikun, Altay and Hami in 2017, Table 2 shows the data of installed capacity at the end of the year (accumulated annual installed capacity), average capacity of power generation equipment, average utilization hours, wind speed, and limited power.
Table 2 Index data of Xinjiang.

| company name | Cumulative annual power generation, 10,000 kWh | Installed capacity at the end of the period, 10,000 kilowatts | Average capacity of power generation equipment, 10 thousand kilowatts | Average utilization hours | Average wind speed, m / s | Electricity limit, 10,000 kWh |
|--------------|---------------------------------------------|---------------------------------------------------------------|-----------------------------------------------------------------|--------------------------|--------------------------|----------------------------|
| Dabancheng   | 10628                                       | 4.95                                                          | 4.95                                                             | 2147.1                   | 6.073636                 | 3735.07                    |
| Barikun      | 44600                                       | 24.95                                                         | 24.95                                                            | 1787.6                   | 6.572955                 | 25938.63                   |
| Aletai       | 6605                                        | 4.95                                                          | 4.95                                                             | 1334.3                   | 5.647273                 | 5384.797                   |
| Hami         | 114333                                      | 59.9                                                          | 59.9                                                             | 1908.7                   | 5.630000                 | 37986.47                   |

4.2. DEA evaluation calculation

According to investment-oriented DEA-BCC model paper selected to input and output data indicators of a company's power generation branch in Xinjiang four regions based on the regional branch as a decision-making unit, using the software to empirical DEAP2.1 Research estimates, the preliminary estimates four branches overall efficiency 2017 is shown in Figure 1:

![Figure 1 DEA evaluation of the comprehensive efficiency of wind power projects in Xinjiang.](image)

From the analysis of the above table and figure, we can see that the average comprehensive efficiency of the four regions of Xinjiang Dabancheng, Balikun, Altay and Hami is 0.894, of which only the Altay area has not reached the average of 0.651. The overall efficiency and scale efficiency of the Altay area The aspect obviously did not reach the relative average. According to the analysis of the DEA model, only when the pure technical efficiency and scale efficiency of the decision unit DMU reach 1 at the same time, the comprehensive efficiency of the decision unit is 1, and the decision unit is relatively effective at this time, otherwise It is relatively ineffective. Through the analysis of the above table, it is not difficult to find that the only areas that have reached the effective level in 2017 are Dabancheng and Hami. All three indicators are 1, which are relatively effective. Although the areas of Balikun and Altay are not effective, However, the scale benefits of these two regions are increasing, indicating that as long as the input to the Barikun and Altay regions is increased, the added value of output will be greater than the added value of inputs.

4.3. Analysis of Evaluation Results

According to the evaluation results of DEA, it is not difficult to find that the comprehensive efficiency of Dabancheng Branch and Hami Branch is the highest, and its comprehensive efficiency, pure technical efficiency and scale efficiency have reached 1.000.
Reasons for the relatively high comprehensive efficiency of Dabancheng area: (1) the geographical advantage is more obvious than other areas; (2) the wind speed is distributed evenly throughout the year; Compared with other cities, electricity consumption has a greater demand.

The installed capacity and power generation in the Hami area are the highest among the four branches, and the comprehensive efficiency is also 1.000. The reasons for this analysis are as follows: (1) The wind energy conditions are superior. (2) Hami area is China's future power and energy base. (3) The Hami region has adopted an advanced power transmission model. Compared with other regions in Xinjiang, Hami has a huge power demand, so the amount of abandoned wind power and the limited power are relatively low as a whole.

5. Conclusion
This article conducts in-depth theoretical research on the improvement of investment efficiency of wind power projects. An index system for evaluating the overall efficiency of wind power projects was constructed, and an empirical analysis was performed using Xinjiang's wind power companies as an example in combination with a DEA input-oriented model. The research results can provide a certain reference for comprehensively improving the investment efficiency of wind power projects in China.

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