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Research Article

Dynamic Evaluation of Carbon Emission Performance of New Energy Enterprises based on Orthogonal Projection Method

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The rapid development of economic society causes people to increase the energy demand, produce more and more carbon dioxide, environmental pollution is becoming more and more serious, to solve the problem of carbon peak is imminent. Under the same and complete evaluation system, the carbon emission performance varies slightly according to different R&D directions of new energy enterprises. Therefore, it is particularly important to select evaluation indicators. In fact, each enterprise has different efforts to control carbon emissions. While studying the performance of carbon emissions, the direct and indirect impacts of carbon dioxide produced by each enterprise in the process of production on the ecological environment should be considered. In order to guarantee systematic and scientific outcomes, carbon emissions performance evaluation indicator system for new energy enterprises is constructed. With new energy enterprises as examples, based on the construction of carbon emissions performance evaluation indicator system of new energy enterprises, orthogonal projection method is used to carry out an empirical analysis of the dynamic evaluation of carbon emissions performance of thirty new energy enterprises. Through the questionnaire survey of thirty new energy enterprises, the indicator weight of carbon emission performance evaluation of new energy enterprises was determined, and the carbon emission performance of new energy enterprises was analyzed. The results will reflect the actual situation of China's new energy enterprises, and provide the data support and references for future research on carbon emission control by the country and enterprises.

1. Introduction

In order to reach the consensus on global sustainable development, "low-carbon Economy" has virtually become a principle, with less emissions, less pollution, and lower energy consumption gradually becoming the goal pursued by major enterprises. Renewable and clean energy, such as biomass, solar, wind and water, has long been studied to replace non-renewable fossil energy, in order to minimize the direct and indirect environmental impact of the large number of greenhouse gases emitted by enterprises in the production process. The so-called new energy refers to energy like solar energy, ocean energy, geothermal energy, nuclear fusion energy, wind energy, and so on, which have just begun to be researched and utilized or are actively researched and developed and needs to be promoted urgently. The enterprises that mainly focus on the development and utilization of new energy are called new energy enterprises, and the new energy industry refers to a series of procedures engaged in the activities of institutions or units engaged in the development of new energy. Sustainable development, huge storage, and environmental protection as the biggest characteristics of new energy are widely known and attracted much attention. A large amount of energy consumption aggravates carbon emissions, leading to the deterioration of the ecological environment, global climate warming, and the exhaustion of non-renewable resources. Countries all over the world take new energy as the breakthrough point to vigorously develop new energy enterprises to combat the carbon emissions caused by traditional energy and further promote economic development to a certain extent. Irrational use of energies and extravagances have certain impacts on China's national economy. Many scholars and experts no longer blindly pursue rapid economic growth but began to tilt toward economic growth in quality. In order to practice the concept of sustainable development, energy conservation, and emission reduction, the state gives strong support to the development of new energy enterprises. A new energy has become an important measure to cope with environmental change. Therefore, a batch of new energy enterprises began to develop. In the Decision of The State Council on Accelerating the Cultivation and Development of Strategic Emerging Industries issued by the government, new energy enterprises are regarded as an important enterprise of the country's seven strategic emerging industries in the future, and will soon become the country's leading and pillar industry. In response to the national call, most enterprises begin to stride forward in the field of new energy and begin to research and develop new energy systems with clean, environmental protection, safe and sustainable development, so as to achieve the purpose of reducing carbon emissions. Since then, new energy enterprises continue to expand. Although the development of new energy can significantly reduce carbon emissions, it is very difficult to implement. As the government's policy on new energy is variable, and new energy enterprises have high operational capital and operational risks, as well as huge investments, which leads to the interests of many groups, investors in all fields of society are very concerned about the actual situation of their carbon emission performance. Therefore, to satisfy all stakeholders, the reasonable construction of the carbon emission performance evaluation system for new energy enterprises is also a problem that cannot be ignored. Low-carbon economy is playing an increasingly important role in China's economy. In terms of solving environmental problems, controlling carbon emission performance within enterprises has become the focus of the government's inspection of carbon emissions. In view of this problem, the emergence of new energy can effectively alleviate it. Fossil energy, as non-renewable energy, is not only rare but also produces far more carbon than the clean energy of new energy. Replacing non-renewable energy with new energy can greatly reduce carbon emissions. At this time, new energy enterprises become the main force to reduce energy consumption. For a long time, the emission of carbon dioxide and other greenhouse gases has seriously polluted the atmospheric environment and thus has an irreversible impact on the healthy and harmonious development of human society. It is urgent to solve the problem of carbon emission. Without energy, human beings cannot carry out normal production activities. With the rapid development of China's economy in recent years, in order to cope with the constantly developing and changing economic situation at home and abroad, China's energy consumption keeps rising. China's total energy consumption is one-fifth of the world's total energy consumption. The main reason for the high energy consumption is the large population base and population density, but the per capita energy consumption is relatively low, one-third of Japan's and one-sixth of the United States. On the whole, such a result will undoubtedly have a serious impact on China's environment. Although the overall trend of new energy enterprises still has some shortcomings, but after this period of development, China's wind power equipment and photovoltaic cells occupy a place in the international market, the development speed of new energy enterprises gradually climbed to the forefront of the world. In the new era of increasingly important new energy, the efficiency of the impact of resources on the environment can reflect the quality of economic growth to a certain extent. Scholars put emphasis on the importance of carbon emission performance of new energy enterprises, the relevant research results of carbon emission performance evaluation indicator system and evaluation model of new energy enterprises are relatively few, the relevant research results of the dynamic evaluation of carbon emission performance of new energy enterprises based on orthogonal projection method are also relatively few. As the most basic elements of nature, carbon emission performance is of great theoretical and practical significance to new energy enterprises. The theoretical and empirical analysis results will reflect the actual situation of China's new energy enterprises, and provide the data support and references for future research on carbon emission control by the country and enterprises.

2. Literature Review

In recent years, in order to accelerate the completion of the national strategic transformation goals, government departments and the CPC Central Committee have always been very concerned about carbon emission reduction, and attach great importance to the introduction and implementation of relevant policies. Many experts home and abroad regarding the carbon emission performance of new energy enterprises as a hot research issue. The key to studying this problem is to construct a scientific and reasonable carbon emission performance evaluation indicator system and select appropriate and effective evaluation methods. Compared with developing countries, developed countries carry out research on energy performance evaluation earlier. Up to now, widely used evaluation systems in the world mainly include the EU energy efficiency indicator system, UK energy industry indicator system, IAEA sustainable development energy indicator system, and WEC energy efficiency indicator system. In our country, the construction of a carbon emission performance evaluation indicator system is based on the above international common evaluation system. Research method and indicator system are equally important.

As for the research methods, Li et al. [1] used "Vertical distance" instead of "Euclidean distance" to calculate the closeness of the scheme, and then constructed a dynamic evaluation model considering the time factor to calculate the comprehensive evaluation value of the object to be evaluated under the condition of the different degree and increase the degree of the indicator value. Finally, the evaluation value of each time period is comprehensively calculated by the quadratic weighting method, and the comprehensive evaluation result of the program to be evaluated is obtained. Li et al. [2] studied the projection decision method for hesitating fuzzy information. The vector expression of the scheme and positive and negative ideal points is defined under hesitating fuzzy information, and the vector projection measure method for hesitating fuzzy information is constructed. The calculating formula of closeness degree based on positive and negative ideal points is proposed. An attribute weight determination model based on Jaynes maximum entropy principle and scheme fair competition is constructed. Huang et al. [3] proposed an improved TOPSIS multi-attribute decision-making method VSPA-TOPSIS based on the vertical surface distance of the relation vector under the condition of unknown attribute weight. This method will set positive ideal point and negative ideal point as a contradictory and uncertain system, fully considers the measure target plan, positive ideal point, negative ideal point of connection degree, the existence of collection of opposites, introduces the connection vector of vertical surface with the help of distance concept, calculates relative closeness to some certain extent, and overcomes the deficiency of the SPA-TOPSIS method of inverse order. Chen et al. [4] introduced vertical distance into intuitionistic fuzzy decision theory, and proposed an intuitionistic fuzzy multi-attribute decision rule based on vertical distance by replacing vertical distance with Euclidean distance. Based on the IFE minimum principle and vertical distance minimum idea, an attribute weight determination model combining subjective and objective information preferences was constructed. In [5], hesitation intuitionistic fuzzy sets and language function are defined on the basis of the average-standard deviation preference Hamming distance and put forward based on intuitionistic fuzzy language hesitation sets from the multiple attribute decision-making method of TOPSIS and TODIM, further use of the two methods of the bidding scheme, for instance, problem builders. The sensitivity analysis of preference parameters to ranking results is also discussed. Research on the problem of indicator system, domestic experts, and scholars have also made favorable findings after many studies. Guo [6] pointed out that in the era of global low carbon, with the end of the Copenhagen Climate Conference, countries all over the world began to play a secret game in low-carbon development, and new energy enterprises should take measures to actively respond. In order to take advantage of the changing energy market, enterprises should increase the research and development of low-carbon technologies and products, and enhance their own low-carbon core competitiveness. Zhuang [7] believed that with the gradual development of urbanization in China, it was necessary to speed up the finding of the sustainable development path to reduce greenhouse gas emissions. The development of a low-carbon economy was essential to improve the efficiency of energy use. Continuous institutional and technological innovation was needed to find out a feasible way to reduce carbon emissions, and then accelerate the achievement of the ambitious goal of sustainable development. Li et al. [8] argued that the low carbon mode of development should carry out the low carbon product production by taking into consideration of each process, which mainly included four links, respectively, low carbon production, circulation, distribution, and consumption, the enterprise fused into the development of clean energy, energy conservation and emissions reduction, low carbon technology, continuously saved energy and renewable energy technologies in order to achieve the low-carbon process of production, circulation, distribution and consumption, and to promote the rapid development of the low-carbon economy. Zhu et al. [9] believed that the development concept and development mode of low-carbon economy was a comprehensive issue, which was determined by many different factors interwoven together, and these factors also affected and constrained the development of low-carbon economy. Therefore, all factors should be taken into consideration when developing the country's low-carbon economy. Sun et al. [10] indicated that carbon emission management was an important guarantee for the development of the national low-carbon economy. Performance management of carbon emissions was a very important aspect of national competitiveness. In order to improve carbon management, European countries constantly introduce carbon emission policy standards, and the level of carbon emissions has become an important aspect to reflect the level of carbon management of an enterprise. Its position in the international economy depends on the development of a low-carbon economy to some extent. Improving carbon management can not only deal with climate negotiations and improve the national carbon competitiveness but also reduce the cost of energy conservation and emission reduction and improve the competitiveness of enterprises, which affects the long-term development of enterprises and is of great significance. Shi et al. [11] analyzed the connotation and characteristics of corporate carbon emissions through internal requirements and external measures of energy conservation and emission reduction measures of various enterprises, and put forward systems and policies to implement energy conservation and emission reduction and reduce carbon emissions from the perspectives of society, enterprises, and the government. Wang [12] pointed out that the indicator system of carbon emission could be elaborated from six aspects, namely, the key areas of energy consumption, energy efficiency and structure, industrial and agricultural water consumption and water saving, pollutant discharge, pollutant treatment and utilization, and environmental quality. Wang and Shi [13] studied the electric power and chemical industry and combined process and result indicators to list in detail how to calculate each indicator, so as to construct a relatively complete carbon emission indicator system for major projects with high energy consumption and great potential for energy conservation and emission reduction. Liu and Zhang [14] constructed a carbon emission indicator system mainly for the carbon emission of the construction industry. They pointed out that enterprises could not ignore the existing problems while developing. Sun and Shi [15] followed the principle of sustainable development, combined with relevant data, referred to relevant literature home and abroad, and used the evaluation method of sustainable energy development level to conduct an empirical analysis on low-carbon development of energy conservation and emission reduction in China. Yang and Jiang [16] proposed a dynamic evaluation method based on the orthogonal projection method to construct evaluation indicators and systems from the dimensions of resource consumption, harmless, pollutant discharge, comprehensive utilization, and supporting capacity. The method can scientifically and systematically evaluate the overall development level of different research objects at different times.

To sum up, from the micro point of view, the carbon emission research of new energy enterprises has just started. By comparing the above literature, the conclusion can be drawn: compared with the study of carbon emissions from the macro and medium perspectives, there are few studies from the micro perspective, especially the specific enterprise as the research object. The research of relevant experts and scholars only stays on the connotation and concept of new energy enterprises, especially the carbon emission performance evaluation system is not detailed and comprehensive. The existing literature shows that the current evaluation indicator system cannot be well connected with reality, and further research is needed to investigate the operability of the study. Therefore, this study further studies the carbon emission performance evaluation of new energy enterprises.

3. Carbon Emission Performance Evaluation Indicator System Construction

3.1. Principles of Evaluation Indicator Selection. The principle for new energy enterprises to construct carbon emission evaluation indicator system is to select appropriate indicators reasonably and scientifically, and these indicators can comprehensively and objectively reflect the development status, trend and potential of carbon emission performance. In the systematic screening of evaluation indicators, the principles of comprehensiveness, representativeness, pertinence, independence, comparability, combination of quantitative and qualitative indicators, and data availability are mainly followed. Due to the short development time of new energy enterprises, it is difficult to obtain data in various aspects, which makes it difficult to control the selection of indicators in the evaluation system and the scope of application of indicators. In order to determine the effectiveness of the purpose of this study, the equilibrium data and indicator of the comprehensive precision, after careful research and design of the carbon emission performance evaluation indicator system of new energy enterprises, the external research investigators cannot direct contact to the enterprise internal data, the indicator system not only can carry on the comprehensive evaluation of carbon emissions performance, data can also be easily manipulated and measured [17–24].

3.2. Evaluation Indicator System Construction. According to a series of studies of the carbon emission performance evaluation, the analysis of the actual development situation of China's new energy enterprises, the different division of labor workers of new energy enterprises, based on the previous scholars, experts, combined with the theory of stakeholders and the principle of indicator selection, the evaluation indicator system of carbon emission performance of new energy enterprises is determined [25–32]. The measurement instruments are developed and adapted by previous research results and achievements [25–32], finally, five indicators of enterprise self-awareness (environmental protection), enterprise emission reduction awareness, low-carbon technology R&D investment, environmental protection investment increase rate, enterprise system management and environmental protection investment effect are selected as the evaluation indicators in the overall evaluation indicator system of this study. The final carbon emission performance evaluation indicator system can be seen in Table 1.

4. Evaluation Model Construction

4.1. Key Points and Principle Analysis. The orthogonal projection method improves the defects of the traditional ideal solution, that is, the closer the Euclidean distance between the ideal solution and each evaluation scheme, the closer the Euclidean distance between the negative ideal solution and each evaluation scheme is. Therefore, it is not accurate to evaluate each scheme by arranging the Euclidean distance of each scheme with the traditional ideal method [33–35]. The orthogonal projection method uses Vertical distance instead of Euclidean distance to judge the degree of closeness of each scheme. Vertical distance refers to the distance between two planes, which is calculated by connecting the two target points that perpendicular to the ideal solution and the negative ideal solution, respectively. The two planes take the connecting line as normal vectors [1–5].

Suppose that points A and B are positive and negative ideal solution points respectively, and the corresponding vectors are A and B respectively. Suppose the points where AB intersects the two planes with AB as normal vectors are M and N, and the points X and Y are arbitrary points on the two planes, and the corresponding vectors are X and Y, respectively. According to the above-known points, the distance between points X and Y can be calculated as follows [36–41]:

$$\frac{|(a-b)\cdot(x-y)|}{\|a-b\|}. \tag{1}$$

Among them: stands for the absolute value, stands for the norm, and stands for the dot product.

4.2. Problem Description. Assume that there are m evaluation schemes, evaluation indicator number is n, m corresponds to evaluation scheme "$A_1, A_2, \ldots, A_m$," evaluation indicator corresponds to "$C_1, \ldots, C_n$." The original data are $x_{ij}(t_k)\,(i = 1, 2, \ldots, m; j = 1, 2, \ldots, n; k = 1, 2, \ldots, N)$. Weights of indicators "C_j" are "w_j," and $\sum_{j=1}^{n} w_j = 1\,(i = 1, 2, \ldots, m; j = 1, 2, \ldots, n)$. Time is right to reuse "W_k," $W_k = (k/\sum_{k=1}^{N} k)\,(k = 1, 2, \ldots, N)$.

4.3. Calculation Steps. Let $x_{ij}\,(i = 1, 2, \ldots, m; j = 1, 2, \ldots, n)$ be the original data values. The calculation steps of the orthogonal projection method can be divided into five steps:

Table 1: Carbon emission performance evaluation indicator system.

Indicators	Number	Code
Enterprise self-awareness (environmental protection)	1, 2, 3	X1
Enterprise emission reduction awareness	4, 5, 6	X2
Low carbon technology R&D investment	7, 8	X3
Increase rate of environmental protection investment	9, 10	X4
Enterprise system management	11, 12, 13	X5
Environmental protection investment effect	14, 15, 16	X6

constructing normalized matrix, calculating weighted matrix, simplifying the calculation process and finding out positive ideal solution, determining negative ideal solution, and calculating the "vertical surface" distance between ideal solution and each scheme. The specific calculation methods are as follows [1–5]:

Step 1: Construct normalization matrix $Z = (z_{ij})_{m\times n}$.

$$z_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}} \ (i = 1,2,\ldots,m;\ j = 1,2,\ldots,n). \quad (2)$$

Step 2: Calculate the weighted matrix $R = (r_{ij})_{m\times n}$.

$$r_{ij} = w_j z_{ij} \ (i = 1,2,\ldots,m;\ j = 1,2,\ldots,n). \quad (3)$$

Step 3: Simplify the calculation process by taking the ideal solution point as the origin of coordinates.

Ideal solution can be obtained at $S^+ = \left\{S_j^+ | j = 1,2,\ldots,n\right\}$ and change after the origin of coordinates matrix $Q = (q_{ij})_{m\times n}$, namely:

$$S_j^+ = \begin{cases} \max\limits_{1\le i\le m}\left\{r_{ij}\right\}C_j \text{ for efficiency criterion, namely positive indicator,} \\ \min\limits_{1\le i\le m}\left\{r_{ij}\right\}C_j \text{ for cost criterion, namely reverse indicator,} \end{cases}$$
$$q_{ij} = r_{ij} - S_j^+ \ (i = 1,2,\ldots,m;\ j = 1,2,\ldots,n). \quad (4)$$

Step 4: Determine the negative ideal solution H_j^-. In this case, the ideal solution is $\{0,0,\ldots,0\}$.

$$H^- = \left\{H_j^- | j = 1,2,\ldots,n\right\},$$
$$H^- = q_{lj}q_{lj} \text{ meet } \left|q_{lj}\right| \ge \left|q_{ij}\right| (1\le l\le m, i = 1,2,\ldots,m;\ j = 1,2,\ldots,n). \quad (5)$$

Step 5: Calculate the vertical distance P_i, Compute $|(a-b)\cdot(x-y)|$, namely:

$$P_i = \left|H^- \cdot Q_i\right| = \sum_{j=1}^{n} H_j^- q_{ij}. \quad (6)$$

The final scheme is inversely proportional to the value of P_i.

4.4. Evaluation Steps. The evaluation is divided into two cases. The first case is without considering the increasing degree of the indicator value, and the steps are as follows:

Step 1: The standardized method is adopted to process the indicator value of the original data, and the standardized matrix $Z = (z_{ij})$ is obtained. The larger the standardized indicator value is, the better the data is.

Step 2: Determining the weight through the entropy method, and then calculating the weighted standardized matrix.

$$Y = \left(y_{ij}\right) = \left(w_j z_{ij}\right) (i = 1,2,\ldots,m;\ j = 1,2,\ldots,n). \quad (7)$$

Step 3: Finding positive and negative ideal solutions.

The maximum value after the normalization of the matrix, namely the most satisfactory value, is the positive ideal solution of all schemes on the indicator. The positive ideal solution point can be taken as the origin of coordinates, and the positive ideal solution Y^+, the matrix $V = v_{ij}$ after changing the origin of coordinates can be obtained.

$$Y^+ = \left(\max_{1\le i\le m}\max_{1\le k\le N} y_{ij}(t_k)\right) = \left(y_1^+, y_2^+, \ldots, y_n^+\right),$$
$$v_{ij}(t_k) = y_{ij}(t_k) - y_j^+. \quad (8)$$

After changing the origin of coordinates, the ideal solution becomes $\{0,0,\ldots,0\}$. The negative ideal solution can be obtained:

$$\left|y_j^-\right| \ge \left|v_{ij}(t_k)\right| (i = 1,2,\ldots,m;\ j = 1,2,\ldots,n;\ k = 1,2,\ldots,N),$$
$$Y^- = \left(y_1^-, y_2^-, \ldots, y_n^-\right). \quad (9)$$

Step 4: Find the distance between each solution and the ideal solution P_i: the distance between positive and negative ideal solutions and each solution is constant, so it can be obtained by V_i (the "i" row vector of the matrix "V").

$$P_i(t_k) = \left|Y^- \times V_i(t_k)\right| = \sum_{j=1}^{n} y_j^- v_{ij}(t_k). \quad (10)$$

In order to get a better solution, P_i will be smaller.

Step 5: Find out the normalized matrix P_i^*, contrary to the previous, the larger the value, the more reasonable the scheme.

In the second case, the increase degree of the indicator value is considered, and the calculation steps are as follows:

Step 1: Find out the growth matrix.

Standardizing the matrix $Z = (z_{ij}(t_k))$, the calculated growth matrix $d_{ij}(t_k)$ is as follows:

$$d_{ij}(t_k) = z_{ij}(t_k) - z_{ij}(t_{k-1}) (i = 1,2,\ldots,m;\ j = 1,2,\ldots,n;\ k = 1,2,\ldots,N). \quad (11)$$

Step 2: Weight out the matrix.

$$\Delta Y = \left(\Delta y_{ij}\right) = \left(w_j d_{ij}\right). \quad (12)$$

Step 3: Find out positive and negative ideal solutions.

The positive ideal solution ΔY^+, the matrix $\Delta V = \Delta v_{ij}$ after changing the origin of coordinates.

$$\Delta Y^+ = \left(\max_{1\le i\le m}\max_{1\le k\le N}\Delta y_{ij}(t_k)\right) = \left(\Delta y_1^+, \Delta y_2^+, \ldots, \Delta y_n^+\right),$$
$$\Delta v_{ij}(t_k) = \Delta y_{ij}(t_k) - y_j^+. \tag{13}$$

Negative ideal solution:

$$\left|\Delta y_j^-\right| \ge \left|\Delta v_{ij}(t_k)\right| (i = 1, 2, \ldots, m; j = 1, 2, \ldots, n; k = 1, 2, \ldots, N),$$
$$\Delta Y^- = \left(\Delta y_1^-, \Delta y_2^-, \ldots, \Delta y_n^-\right). \tag{14}$$

Step 4: Calculate the distance between the ideal solution and each scheme (all constant).

$$\Delta P_i(t_k) = \left|\Delta Y^- \times \Delta V_i(t_k)\right| = \sum_{j=1}^{n}\Delta y_j^- \Delta v_{ij}(t_k). \tag{15}$$

Similarly, to get a better scheme, the ΔP_i will be smaller

Step 5: Find the standardized matrix ΔP_i^*. On the contrary, the larger the value is, the more reasonable the scheme is. Comprehensive evaluation value is obtained to $q_i(t_k) = \alpha P_i^*(t_k) + \beta \Delta P_i^*(t_k)$, in which $\alpha + \beta = 1$.

After determining the time weight, the comprehensive evaluation value of each scheme can be calculated, namely

$$g_i = \sum_{k=1}^{n} w_k q_i(t_k). \tag{16}$$

You can arrange them according to what you find.

5. Empirical Analysis

5.1. Evaluation Objects. The top 50 listed enterprises of China's new energy industry are selected as evaluation objects and evaluation samples. By repeatedly comparing and reading the materials of different new energy enterprises, detailed information on the input and output of carbon emissions of each enterprise is extracted. Finally, 30 comparable and comprehensive new energy enterprises are identified, including 12 solar energy enterprises, 7 wind energy enterprises, and 11 other new energy enterprises. The new energy enterprises' details are shown in Table 2.

5.2. Sample Data Acquisition

(1) Time range selection. Data in this paper are mainly obtained from the statistical results of the questionnaire survey of thirty new energy enterprises and the energy Bulletin of 1,000 enterprises from 2017 to 2021, China Statistical Yearbook, China Economic Network Industry database, Directory of China's new energy enterprises and other public information.

(2) Sample data acquisition of thirty new energy enterprises. The sample data in this study derive from thirty new energy-listed enterprises. The reasons for choosing new energy listed enterprises are as follows: First, the importance of data is considered. New energy is an important substitute for coal, and the data are representative. The second reason is to consider the reliability of the data. The selected Chinese new energy enterprises are all large listed enterprises, and the data obtained are true and reliable. Based on the orthogonal projection method, the dynamic evaluation method is used to study the dynamic evaluation of carbon emission performance of new energy enterprises. This study makes the scales of evaluation indicators into questionnaire, distributes the questionnaire with the printed paper editions, conducts and implements the actual field questionnaire survey and on-site questionnaire survey of thirty new energy enterprises to obtain data. There are six qualitative evaluation indicators in the evaluation indicator system, and all evaluation indicators are judged by using Likert 7-point scales. The Likert 7-point scales correspond to 7 levels of strong disagreement, disagreement, relative disagreement, general, relative agreement, agreement and strong agreement, *1* level stands for strong disagreement, 2 level stands for disagreement, 3 level stands for relative disagreement, 4 level stands for general, 5 level stands for relative agreement, 6 level stands for agreement, 7 level stands for strong agreement. The overall Cronbach's value of evaluation indicators scales are 0.902, which is greater than the threshold value of 0.7, the scales pass the reliability test. The overall KMO value of evaluation indicators scales is 0.861, which is higher than the threshold value of 0.7. The factor loadings of evaluation indicators scales are 0.882, 0.854, 0.831, 0.827, 0.792, and 0.778, respectively, which are all higher than the threshold value of 0.7. The overall KMO value and the factor loadings indicate that the scales pass the validity test.

5.3. Case Study. According to each indicator in Table 1, the carbon emission performance of 30 new energy enterprises in China from 2017 to 2021 is evaluated based on the orthogonal projection method. For parameters α and β, different values are taken to analyze the comprehensive evaluation value of each scheme, and at the same time, the data is weighted twice to make the analysis results more reliable.

(1) Only the differences among indicators are considered, without considering the growth degree of indicators, that is, when $\alpha = 1$, $\beta = 0$, the evaluation results and ranking of each new energy enterprise are shown in Table 3

(2) The difference between indicators is not considered, only the growth degree of indicators is considered, that is, when $\alpha = 0$, $\beta = 1$, the evaluation results and ranking of each new energy enterprise are shown in Table 4

Table 2: New energy enterprises.

Code	Name	Type
1	Wuxi Suntech Power Holding Co. Ltd	Photovoltaic industry
2	Byd Automobile Co. Ltd	New energy vehicle
3	Sinovel Wind Power Technology (Group) Co. Ltd	Wind power industry
4	Xinjiang Goldwind Technology Co. Ltd	Wind power industry
5	Yingli Green Energy Holdings Co. Ltd	The solar energy
6	LDK Solar Technology Co. Ltd	The solar energy
7	Huang Ming Solar Energy Co. Ltd	Solar-thermal industry
8	Avic Huiteng Wind Power Equipment Co. Ltd	Wind power enterprise
9	Guangdong Mingyang Wind Power Industry Group Co. Ltd	Wind power enterprise
10	Suzhou Atsi Sunshine Electric Power Technology Co., Ltd	Photovoltaic industry
11	Jiangsu Sunrain New Energy Group Co. Ltd	The solar energy
12	Hefei Sungrow Power Supply Co. Ltd	Photovoltaic (pv) power
13	Ja Solar Pv Technology Co. Ltd	Photovoltaic industry
14	Xemc Group Co. Ltd	Wind power industry
15	China Guangdong Nuclear Power Group Co. Ltd	Wind power, photovoltaic, clean energy
16	Enn Group Co. Ltd	Biomass energy, photovoltaic
17	Changzhou Trina Solar Energy Co. Ltd	Photovoltaic industry
18	China National Nuclear Corporation	Nuclear power, nuclear power industry
19	Longyuan Electric Power Group Co. Ltd	Wind power industry
20	Gcl-poly Energy Holdings Co. Ltd	Poly silicon, photovoltaic industry
21	Nanjing Gaojing Gear Group Co. Ltd	Wind power industry
22	China Datang Group Corporation	Biomass energy, photovoltaic, wind power
23	Zhejiang Chint Solar Energy Technology Co. Ltd	Amorphous silicon thin film cell
24	Zhongtong Bus Holding Co. Ltd	Hybrid large bus
25	China Huaneng Group Corporation	Wind and solar energy
26	Changzhou Yijing Photoelectric Technology Co. Ltd	Photovoltaic industry
27	Jiangsu Linyang New Energy Co. Ltd	The solar energy
28	China Power Investment Corporation	Clean energy, smart grid
29	Shengli Power Machinery Group Co. Ltd	Renewable energy generating set
30	China General Nuclear Research Institute Co. Ltd	Nuclear energy, nuclear power technology

Table 3: Evaluation results of carbon emission performance of 30 new energy enterprises from 2017 to 2021.

Code	Value of comprehensive evaluation ranking					Double weighted	
	2021	2020	2019	2018	2017	Comprehensive value	Evaluation value
1	21	20	20	20	20	−0.00106	20
2	14	14	14	14	14	−0.00091	14
3	3	3	3	3	3	−0.00057	3
4	14	14	14	14	14	−0.00091	14
5	23	23	23	23	23	−0.00114	23
6	9	9	9	9	9	−0.00071	9
7	7	6	6	6	6	−0.00061	6
8	20	20	21	21	21	−0.00106	20
9	14	14	14	14	14	−0.00091	14
10	25	25	25	25	25	−0.00133	25
11	24	24	24	24	24	−0.00116	24
12	6	6	6	7	7	−0.00061	6
13	13	13	13	13	13	−0.0009	13
14	17	17	18	18	18	−0.00095	17
15	28	28	28	28	28	−0.00185	28
16	8	8	8	8	8	−0.00064	8
17	11	11	11	10	10	−0.00078	11
18	1	1	1	1	1	−0.0004	1
19	26	26	26	26	26	−0.00153	26
20	22	22	22	22	22	−0.00109	22
21	10	10	10	10	10	−0.00076	10
22	12	12	12	12	12	−0.00082	12
23	5	5	5	5	5	−0.00057	3
24	3	3	3	3	3	−0.00057	3

Table 3: Continued.

Code	Value of comprehensive evaluation ranking					Double weighted	
	2021	2020	2019	2018	2017	Comprehensive value	Evaluation value
25	18	19	19	19	19	−0.00098	19
26	29	29	29	29	29	−0.00203	29
27	1	1	1	1	1	−0.0004	1
28	30	30	30	30	30	−0.00235	30
29	27	27	27	27	27	−0.00167	27
30	18	18	17	17	17	−0.00096	18

Table 4: Evaluation results of carbon emission performance of 30 new energy enterprises from 2017 to 2021.

Code	Value of comprehensive evaluation ranking					Double weighted	
	2021	2020	2019	2018	2017	Comprehensive value	Evaluation value
1	29	29	28	28	29	0.000272	29
2	13	13	14	12	14	0.00034	13
3	7	7	7	6	7	0.000366	7
4	12	12	12	11	12	0.000347	12
5	19	19	19	18	19	0.000319	19
6	6	6	6	5	6	0.000373	6
7	23	23	23	22	23	0.000304	23
8	8	8	8	7	9	0.000354	8
9	17	17	17	17	17	0.00033	17
10	30	30	30	30	30	0.000238	30
11	22	22	22	21	22	0.000313	22
12	11	10	9	8	8	0.000351	9
13	2	2	2	1	2	0.000402	2
14	13	13	13	12	13	0.00034	13
15	28	28	29	24	28	0.000275	28
16	3	3	3	2	3	0.000381	3
17	9	10	11	10	11	0.000351	9
18	4	4	4	3	4	0.000377	4
19	25	25	25	25	25	0.000291	25
20	24	24	24	23	24	0.000298	24
21	13	13	14	12	14	0.00034	13
22	9	9	9	9	9	0.000351	9
23	21	21	21	20	21	0.000316	21
24	16	16	16	15	16	0.000337	16
25	19	20	20	19	20	0.000318	20
26	27	27	26	26	26	0.000282	26
27	4	4	4	3	4	0.000377	4
28	1	1	1	29	1	0.000618	1
29	26	26	27	27	27	0.000281	27
30	18	18	18	17	18	0.000324	18

(3) At the same time, the difference between each indicator and the growth degree of the indicator are considered, that is, when $\alpha = 0.9$, $\beta = 0.1$, the evaluation results and ranking of each new energy enterprises are shown in Table 5. The ranking results of comprehensive evaluation value of carbon emission performance of all new energy enterprises with different values of parameter α are seen in Figure 1 and Table 6. All the values of parameter α and β are determined by the relevant literature results and achievements [1–5], which meet the actual situations, development tendencies, essential requirements, and standard criteria of new energy enterprises.

According to Table 3 and Table 5, the closer the parameter α is to 1, the smaller and negative the comprehensive evaluation value is; the closer the parameter α is to 0, the larger and positive the comprehensive evaluation value is. Quadratic weight is to reflect the overall level of enterprise carbon emissions performance in five years. Tables 3–5 and Figure 1 show that most of the comprehensive evaluation of enterprise value ranking change is small, one of the main solar new energy co. LTD and Jiangsu Linyang's main nuclear power industry of China national nuclear corporation value sorting difference is less than 1 At the same time, the comprehensive evaluation value difference between BYD Auto Co. LTD., which specializes in new energy vehicles,

Table 5: Evaluation results of carbon emission performance of 30 new energy enterprises from 2017 to 2021.

Code	Value of comprehensive evaluation ranking					Double weighted	
	2021	2020	2019	2018	2017	Comprehensive value	Evaluation value
1	21	20	20	20	20	−0.00092	20
2	15	14	14	14	14	−0.00078	14
3	3	3	3	3	3	−0.00047	3
4	13	14	16	16	14	−0.00078	14
5	23	23	23	23	23	−0.001	23
6	9	9	9	9	9	−0.0006	9
7	6	7	6	6	6	−0.00052	7
8	20	20	21	21	21	−0.00092	20
9	15	14	14	14	14	−0.00079	16
10	25	25	25	25	25	−0.00117	25
11	24	24	24	24	24	−0.00102	24
12	6	6	6	6	6	−0.00051	6
13	13	13	13	13	13	−0.00077	13
14	17	17	17	17	18	−0.00082	17
15	28	28	28	28	28	−0.00164	28
16	8	8	8	8	8	−0.00054	8
17	11	11	10	11	10	−0.00066	11
18	1	1	1	1	1	−0.00032	1
19	26	26	26	26	26	−0.00135	26
20	22	22	22	22	22	−0.00095	22
21	10	10	10	10	10	−0.00065	10
22	12	12	12	12	12	−0.0007	12
23	4	4	5	5	5	−0.00049	5
24	4	4	4	3	4	−0.00048	4
25	18	19	19	19	19	−0.00085	19
26	29	29	29	29	29	−0.0018	29
27	1	1	1	1	1	−0.00032	1
28	30	30	30	30	30	−0.00205	30
29	27	27	27	27	27	−0.00147	27
30	18	18	17	17	17	−0.00083	18

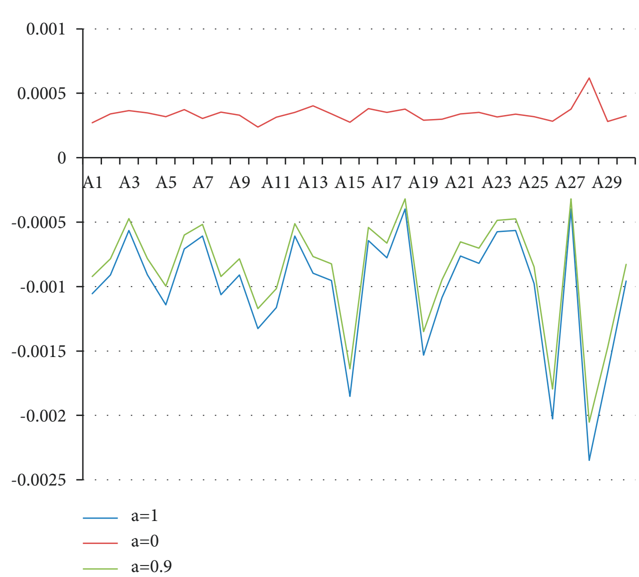

Figure 1: Comprehensive evaluation value of enterprises with different parameters.

Xinjiang Goldwind Technology Co. LTD., which specializes in wind power industry, and Guangdong Mingyang Wind Power Industry Group Co. LTD., which specializes in wind power industry, is also very small. Jiangxi LDK Solar High-tech Co. LTD. and Jiangsu Sunrain New Energy Co. LTD. are the main solar energy industry, and the comprehensive evaluation of new energy enterprises such as the ranking difference is large.

Table 6: Ranking of comprehensive evaluation value of carbon emission performance of all new energy enterprises with different values of parameter α.

Code	Comprehensive sort value				Maximum sort
	$\alpha = 0.2$	$\alpha = 0.4$	$\alpha = 0.6$	$\alpha = 0.8$	
1	25	24	25	25	1
2	14	15	13	15	2
3	3	3	4	3	1
4	15	14	14	16	2
5	19	21	21	21	2
6	6	6	6	6	0
7	11	10	11	11	1
8	18	18	17	18	1
9	16	16	16	14	2
10	27	27	27	27	0
11	24	25	24	24	1
12	5	5	5	5	0
13	8	8	8	8	0
14	17	17	18	17	1
15	30	29	29	29	1
16	4	4	3	4	1
17	10	11	10	10	1
18	1	1	1	1	0
19	26	26	26	26	0
20	23	23	23	23	0
21	12	12	12	12	0
22	13	13	15	13	2
23	9	9	9	9	0
24	7	7	7	7	0
25	20	20	20	20	0
26	29	30	30	30	1
27	1	1	1	1	0
28	22	22	22	22	0
29	28	28	28	28	0
30	21	19	19	19	2

It can be seen from Table 6 that with different values of parameter α, the ranking results of the comprehensive evaluation value of each new energy enterprise have slight differences, but the overall trend does not change greatly. In addition, Jiangsu Linyang New Energy Co. LTD., China National Nuclear Corporation, Sinovel Wind Power Technology Co. LTD., Zhongtong Bus Holding Co. LTD., and Zhejiang Chint Solar Energy Technology Co. LTD always occupy the top five in the comprehensive evaluation value of carbon emission performance. Through data analysis, it can be proved that the ranking result of comprehensive evaluation value of carbon emission performance of each new energy enterprise has little relationship with the value of parameter α. Therefore, it can be further proved that the sensitivity of parameters is low and the dynamic evaluation method based on orthogonal projection is stable.

6. Conclusions and Suggestions

Research and analysis of carbon emissions performance of new energy enterprises should be to reduce carbon emissions, reduce energy consumption and reduce the pollution to the atmospheric environment as the foundation. Through using the systematic, scientific, comprehensive integration methods of a series of indicators and requirements, carbon emissions performance evaluation indicator system of new energy enterprises is constructed. With new energy enterprises as examples, based on the construction of carbon emissions performance evaluation indicator system of new energy enterprises, orthogonal projection method is used to carry out an empirical analysis of the dynamic evaluation of carbon emissions performance of 30 new energy enterprises. Through the questionnaire survey of 30 new energy enterprises, the indicator weight of carbon emission performance evaluation of new energy enterprises was determined, and the carbon emission performance of new energy enterprises was analyzed. The results will reflect the actual situation of China's new energy enterprises, and provide the data support and references for the future research on carbon emission control by the country and enterprises. New energy enterprises carry out a complete study of the performance evaluation of carbon emissions, cannot leave the investor to the supervision of subsidies, positive incentives, reasonable and rational investment, make the carbon emissions performance situation appear in front of the followers, have certain powers of persuasion in order to promote the development and continuous improvement of new energy enterprises. The theoretical results and empirical analysis results will provide practical enlightenment and application value for enhancing carbon emission performance and reduce the carbon emission of new energy enterprises.

It is found that the comprehensive evaluation value of different new energy enterprises in the same evaluation indicator system is not the same. When evaluating and analyzing the carbon emission performance of different enterprises, it is necessary to adopt more targeted solutions for new energy enterprises with different development directions and speeds. Each enterprise has a large room for improvement and progress. Each enterprise has rich experience and advanced technology. They should actively make full use of their technical experience to formulate relevant plans and take effective measures. In this way, we can actively promote the orderly and healthy development of new energy enterprises, and at the same time, we can also coordinate the economic quality of enterprises and the ecological benefits of society to achieve a balanced state. Through analysis and research, enterprises can systematically identify the defects and deficiencies of their own development, clarify the ultimate goal of energy conservation and emission reduction at the current stage, and actively improve their own measures in energy conservation and emission reduction. The evaluation and research on carbon emission performance of new energy enterprises can not only provide a reference for the construction of industrial norms and standards but also serve as a guarantee for national and local government departments to actively respond to the carbon emission of new energy enterprises in the external environment. Facilitate the realization of energy saving and emission reduction targets of each enterprise mechanism optimization and the smooth implementation of national low-carbon policy. But at the same time, in the outbreak era, with various environmental resource constraints, new energy enterprises carry out the process of actively developing carbon reduction technology, which is not perfect, there are still many defects that need to perfect, mainly in two aspects: first, hardware facilities, new energy companies in addition to advanced technology also need machine facilities and equipment, etc.; Second is soft technology, good management can make the effect twice the result with half the effort. Current research methods are not mature enough, and there are still deviations in data acquisition and processing, resulting in incomplete final evaluation results. Similar new energy enterprises can cooperate to take advantage of others to make up for their own shortcomings, to achieve mutual benefits and form win-win situations, work together to reduce carbon dioxide emissions, construct the low carbon society, and then reduce the carbon emissions of the whole country, and enter a new stage.

Data Availability

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Conflicts of Interest

It is declared by the authors that this article is free of conflict of interest.

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