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Research Article

Performance Evaluation of Reducing Consumption of Energy in the Yangtze River Delta under the Background of Low-Carbon Economy

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With global climate change and rapid environmental degradation, reducing energy consumption has attracted widespread attention worldwide. The Yangtze River Delta is a major province in China in terms of energy consumption and pollutant emissions. After adopting a series of energy-saving and emission-reduction measures, the Yangtze River Delta has achieved certain results. However, at present, the Yangtze River Delta region has a serious heavy industrial structure and many "two high and one capital" industries, which play a huge role in driving GDP growth. This situation will inevitably aggravate the contradiction between the three systems of energy, environment, and economy. In this context, a scientific and reasonable evaluation of the performance of reducing energy consumption and further promoting the implementation of reducing energy consumption in the Yangtze River Delta. It is conducive to achieving low carbon and energy conservation in the Yangtze River Basin provinces. In order to comprehensively examine and evaluate the consumption reduction performance of the Yangtze River Basin provinces, promote the scientific management of consumption reduction performance, and promote consumption reduction, this paper integrates the concept of low-carbon economy into the evaluation of consumption reduction performance of the Yangtze River Basin provinces. Combining the connotation of energy consumption reduction and low-carbon economy, this paper constructs a comprehensive and scientific evaluation index system for energy consumption reduction performance in the Yangtze River Delta region from three aspects: economy, energy, and environment. At the same time, the TOPSIS method and the full alignment polygon graphical index method are used to evaluate the energy consumption reduction performance of the Yangtze River Delta region from 2010 to 2020. Through the analysis, the following conclusions can be drawn: the overall performance level of energy consumption reduction in the Yangtze River Delta region is average; the coordination between economy, energy, and environment is poor. Through the gray correlation analysis of energy consumption reduction performance, it is found that the current energy consumption structure plays a decisive role in reducing energy consumption; therefore, energy consumption coefficient, industrial structure, and government incentives also play a key role in reducing energy consumption.

1. Introduction

President Xi Jinping's new targets at the Climate Ambition Summit to further increase the country's autonomous contribution will see China's CO2 emissions per unit of GDP fall by more than 65% by 2030 compared to 2005, the share of non-fossil energy in primary energy consumption will reach around 25%, and forest stock will increase by 6 billion cubic metres compared to 2005. How to plan the strategic of reducing consumption of energy? In mid-September 2016, the chairman of Shanghai Institute of Environment put forward the concept of "Ten Green Themes," including in-depth implementation of pollution control plan, vigorously promoting pollutant emission up to standard and total emission reduction, strengthening environmental infra-structure construction, strict prevention and control of environmental risks, and effective control of greenhouse gas emissions. This paper holds that in order to implement the proposed strategic objectives of reducing consumption of energy, in addition to the implementation of the "Ten Green Themes" plan, we should also strengthen the comprehensive evaluation of reducing consumption of energy performance.

Factors to be considered in the comprehensive evaluation of reducing consumption of energy performance are as follows.

1.1. Social Public Opinion Factor. We have also paid very large price for resources and environment. From rivers and lakes to oceans, from soil to wetlands to air quality have been polluted to varying degrees, and biodiversity has decreased sharply. Environmental problems pose a great threat to economic development, people's health, and ecosystem. In recent years, haze pollution control, pollutant diffusion, soil pollution prevention and control, reducing consumption of energy, new energy technology breakthroughs, and other issues have been mentioned many times in various fields and become highly concerned social topics. At present, most of China's agrochemical enterprises have seriously violated the "people-oriented" core of the "scientific outlook on development," threatening people's production and living environment. The rectification and innovation of agrochemical enterprises is urgent [1–5].

1.2. Environmental Pollution Factors. The economic benefits of China's agrochemical enterprises cannot only focus on short-term development. If the treatment of "three wastes" cannot be implemented in time, the development of agrochemical enterprises will threaten people's physical and mental health and cause irreversible and destructive damage to the ecological environment. These are the inevitable results of the blind pursuit of high-scale economic interests. The transfer of environmental pollution to China in process of structure transformation cannot be ignored [6–12].

1.3. Enterprise Factors. The three "stumbling blocks" to reducing energy consumption in chemical companies can be achieved through the following paths. First, the economic benefits are low. Second, it is difficult to upgrade technology. Third, policy weaknesses occur. Due to the concerns about the economic downturn under the new normal, China's requirements for reducing consumption of energy are only limited to the documents of the State Council, which do not rise to the legal level in a real sense and lack a certain mandatory binding force. The state has listed environmental protection as a policy so as to clarify the important position of environmental method in modernization and put forward "synchronous planning, implementation and development of construction, environmental method and urban and construction, so as to contribute to the unity of multiple benefits." In other words, there is a lack of an effective "comprehensive evaluation system of reducing consumption of energy performance" [12–18].

Low-carbon economic model is shown in Figure 1.

At present, the reducing consumption of energy performance evaluation system usually has three directions.

Many researchers at home and abroad have conducted in-depth research on this problem, and there are few quantitative research results. The qualitative description mainly focuses on how to set the evaluation index system of reducing consumption of energy and determine the weight of the index system (Shen et al.; Du et al.; and Cañete-Salinas et al.) [19–21]. In terms of quantitative evaluation, the evaluation scope is mainly micro fields, such as enterprises and products (Segura-Gil et al.) [14, 22, 23]. China has also carried out some quantitative evaluation studies on reducing consumption of energy in the macro field (Hammond) [24], but the main problem is that the number of selected evaluation indicators is small, the evaluation cycle is incomplete, and there are few quantitative evaluations on reducing consumption of energy at the provincial and even national levels. The performance evaluation index system of reducing consumption of energy generally includes numbers of subsystems and is divided into multilevels. Therefore, the performance evaluation of reducing consumption of energy is a typical multiobjective and multi-decision-making composite system problem. The essence of reducing consumption of energy performance evaluation is to establish a regional reducing consumption of energy index system and evaluation grade standard according to the reality of reducing consumption of energy in the study area, convert each evaluation index into a one-dimensional real reducing consumption of energy performance comprehensive index, and then comprehensively evaluate the reducing consumption of energy performance of each region. How to quickly and accurately determine the weight parameters of these evaluation indicators is the main difficulty of reducing consumption of energy performance evaluation. When determining the index weight, the traditional evaluation methods cannot fully consider some information provided by each index, and the artificial weight often lacks objective scientific basis, which is bound to leading to the wrong estimation of a certain index, so that the evaluation results cannot fully reflect the objective and actual situation of the research object. The fully arranged graphical index method is a multiobjective evaluation method. Compared with the traditional weighting method, it does not need researchers to evaluate the weight coefficient subjectively, but only needs to determine the critical value related to decision-making, which reduces a lot of subjectivity (Vesnik) [25].

2. Performance Evaluation Index System and Model Research Method

The ideas of constructing performance evaluation index system and the principles of constructing local government performance evaluation index system are carried out. Constructing a reasonable evaluation index system is of great significance to the study of performance work. Only by constructing a reasonable performance evaluation index system can we promote the work to be completed efficiently so that the staff can have something to follow in the process

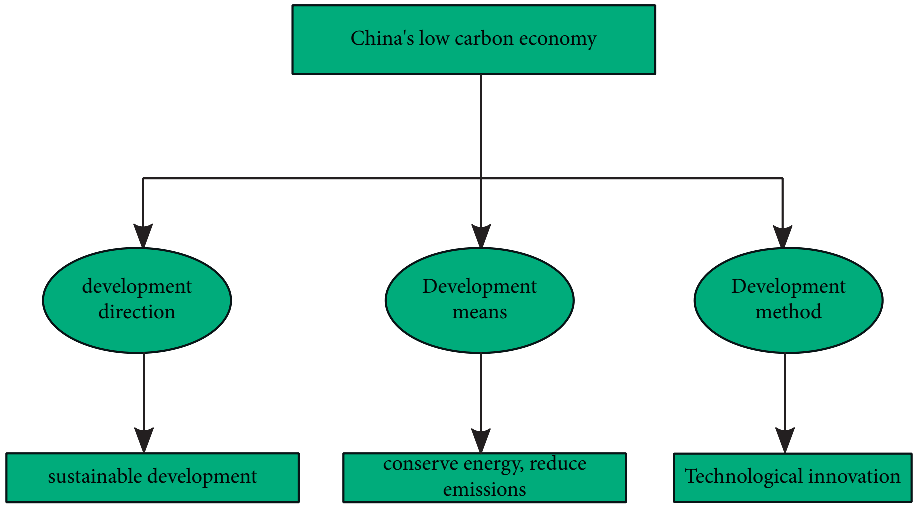

Figure 1: Low-carbon development model.

of performance evaluation and improve their enthusiasm and initiative of work. At present, performance evaluation work is not perfect, and the root cause is that China still lacks a set of reasonable and effective performance evaluation index system. In the process of performance evaluation, we should adhere to the hierarchical analysis method to obtain scientific and reasonable index weights, and on the basis of comprehensive analysis of various evaluation methods, we believe that the double-basis point method has stronger logic in the process of measuring local government performance and is more suitable for measuring local government performance. Generally speaking, we should follow the following principles in the work of performance evaluation.

2.1. Scientific and Standardized Principles. Performance evaluation should strictly implement the prescribed procedures, in accordance with scientific and feasible requirements, using a combination of quantitative and qualitative analysis method. Moreover, the determination of index weights and the selection of evaluation methods should follow scientific theoretical bases. In the process of local government performance evaluation, the evaluation should be in the process of local government performance evaluation, the evaluation should be carried out according to the prescribed steps and should not be evaluated arbitrarily without purpose, basis, or logic.

2.2. Principle of Operability. In the process of performance evaluation, we cannot make up evaluation indexes arbitrarily, but the evaluation indexes should be practical and feasible. Only on the basis of respecting the reality can the evaluation indexes be set to reflect the performance of the government more scientifically and reasonably. In the process of performance evaluation, we should pay attention to the evaluation indicators themselves.

Relevant tools can be used to measure and draw conclusions.

2.3. The Principle of Fairness and Openness. Local government performance evaluation should meet the requirements of truthfulness, objectivity, and fairness and be open and supervised according to the law. Local government performance evaluation: performance evaluation of local governments is a long-term work that accepts supervision from all walks of life so that the public can clearly understand the principles, methods, index system, and process of government performance evaluation in detail (principles, methods, index systems, processes, results, etc.). We should make use of all aspects of the evaluation public in the process of evaluation so that the public can obtain first-hand information.

2.4. Performance Evaluation System. In formulating and implementing the evaluation system, managers must decide which procedure to use. Its importance is no less than the actual content of the evaluation or the specific implementation of the evaluation. If employees think that the performance appraisal is carried out rashly or the management is hasty, they will not pay attention to the performance appraisal, and the performance appraisal will not play its due role. The nonuniform management in performance appraisal may cause legal problems, discriminatory and frequent performance appraisal will be sued, and the morale and productivity decline caused by poor performance appraisal is not conducive to the success of the organization.

The performance evaluation procedures adopted by the organization should be relatively stable and unified. The evaluation procedures should not be changed at will, and different evaluation procedures should not be adopted for the same employees. Generally, a complete evaluation procedure should include the following contents:

(1) Determine the purpose of performance evaluation.
(2) Determine the performance evaluation organization and responsibilities.
(3) Select performance evaluation method.

(4) Select the timing and time of performance evaluation.

(5) Organize performance evaluation.

(6) Sort out the results and apply and feedback the performance evaluation results.

Of course, the organization's performance appraisal procedures do not necessarily have each of the above. The performance appraisal procedures of some small enterprises are much simpler than those of large enterprises. They may combine some of the procedures into one.

In the process of performance evaluation, clarifying the content of evaluation is the first, but it is also very important to adopt a set of effective evaluation steps in order to achieve the expected effect.

2.4.1. Performance Evaluation Organization System. The enterprise performance evaluation organization system is not only a tool for the enterprise to achieve strategic objectives, but also a project management team established in the enterprise organization system to achieve objectives. The performance evaluation organization is a full-time project team responsible for performance evaluation in the enterprise performance evaluation management committee, which shall be held by senior managers of the enterprise, at least department managers. The performance evaluation organization members should be very familiar with the performance appraisal standards, be able to fairly evaluate the difficulty of each post, accurately grasp the performance appraisal index standards, effectively judge the authenticity of appraisal data, and solve various problems encountered in performance appraisal.

The realization of enterprise objectives requires joint efforts from all aspects, such as establishing an effective organization system, establishing a line management control system, formulating a scientific budget model, designing a feasible performance evaluation system and incentive system, and so on.

2.4.2. Performance Evaluation System. The aim is the guide of all actions. The setting of any enterprise evaluation system must obey and serve the overall aim of the enterprise. The establishment of performance evaluation system is first the establishment of performance evaluation standards. In terms of how to promote performance improvement, according to system theory, it is divided into input factors, process factors, and result factors. Like frying a dish, if only measured from the results, it is delicious and inexpensive. The icing on the cake is of high value and convenience (convenient to take out). However, from the process, from the perspective of input, we need economical ingredients, good chefs, hygienic stoves, and so on; from the perspective of process, we need the chef to be in a good mood and have good skills. He handles the ingredients, stove, heat, seasoning, pot, and plate very well. A position can achieve good performance only when its direction and objectives, motivation, ability, resources, and support are good. A department's performance is only when its direction and objectives, team ability, team atmosphere, resources, and support are good. A company's performance will be good only from its strategy, direction, objectives, organizational ability, organizational atmosphere, employee team, resource support, and so on. The final business model pursued is different from the format, strategy, direction, and goal, and the focus is also very different, such as fast-food restaurants and high-end restaurants. Its performance motivation is different, and its evaluation criteria are also very different. For simple sales companies, there are great differences between b and c, for example, for class B sales companies: number of customers, proportion of important customers, sales or gross profit, sales and sales of important products or new products, payment collection, and so on. The number of customers is the basis, and the proportion of important customers is the best (not all customers, but oriented customers). Important products or new products are the main push or lifting requirements, which are usually difficult and need to be assessed separately. Nonquantitative but important is the customer.

Completeness of information filling: it is very important to reserve customer information, which is an important asset of an important company; knowledge and experience sharing: it precipitates the advantages of b customers. Nonstandard products are more important. To focus on solutions, this usually requires internal cooperation and competence and customers. Tracking plan support, bidding and bid presentation support, that is, it should be included in process monitoring and assessment.

The performance evaluation system can ensure the normal operation of performance evaluation according to the process, ensure that the evaluation results of performance evaluation objects are fair and reasonable when applied to reward and punishment, promotion and employment, and ensure that the role of performance evaluation affects the healthy development of business activities, such as enterprise expansion, reorganization, and transformation.

2.4.3. Performance Evaluation Index System. The evaluation system of an enterprise can be divided into the following three levels:

(1) First of all, we should carefully consider whether we have set a good foundation for the establishment of the value evaluation system in the process of our own development and reflect on whether we have the conditions to establish the value evaluation system. When the enterprise is in a high development stage, the internal soft power will grow and grow slowly, the corporate culture will gradually become stable, and the quality of the selected employees will often be relatively high. For example, the company system, operation process, and organizational structure of the world's top 500 enterprises are relatively perfect, which has the foundation for establishing the value evaluation system, and its strong execution also ensures the efficiency and effect of the system to a certain extent. Domestic small enterprises may be in

the early stage of entrepreneurship, the internal system of the company is also very imperfect, there are many obstacles to the establishment of the value system, and the implementation process may give up halfway because of its own limitations. Of course, whether the value system is applicable to an enterprise is not limited to this, but more importantly, whether the company has the foundation and conditions to establish it.

(2) The establishment of evaluation system is not a simple establishment of assessment indicators, but the key is to find the value points that can truly reflect the postvalue through postevaluation. Which indicators can really reflect the value of the post? This requires the active participation of the leadership, core backbone, and thinking employees. If the enterprise conditions allow, it can cooperate with a professional third party, and the effect may be better. The value point is difficult to determine, but it is the basis and key for the establishment of the whole evaluation system. Only employees engaged in relevant posts will be more aware of the responsibilities and requirements of the whole post. If other people with unknown circumstances participate, they will judge more according to their own intuition and experience, which will inevitably lead to deviations and errors. The leadership is an important force to determine the macro development of the company, and they have a clear understanding of the development direction of the company. The core backbone and thoughtful employees are excellent employees in relevant positions. They have made returns by relying on their own talents and long-term struggle, so they often have constructive suggestions on the details and micro development of the company.

(3) When establishing the value evaluation system, enterprises should be linked with the incentive mechanism so that the value evaluation system can be truly implemented. People have desires, which often inspire people to make efforts to get more returns. Therefore, the value evaluation system alone is not enough. The incentive mechanism should also keep up with the pace and form an array of "adding fuel to the fire" to make the fire of employees burn more and more. Ren Zhengfei of Huawei once put forward the following view: an enterprise cannot develop if its employees are unqualified, and an enterprise cannot grow without a correct value evaluation system. It can also be seen that the value evaluation system plays an important part in development of company.

2.5. Construction Method of Index System. The construction method of data index system can be summarized into three steps, namely, clarifying business objectives, clarifying user life cycle, and behavior path and index hierarchical governance. Among these three steps, OSM (object, strategy, and measure), AARRR (acquisition, activation, retention, revenue, and referral), UJM (user, journey, and map), and MECE are involved (mutually exclusive, collectively empirical) four models, which are the methodology to guide us to build a complete and clear index system, as shown in Figure 2.

3. Type and Application of Reducing Consumption of Energy Performance Evaluation Index System

The research on the implement evaluation of reducing consumption of energy is mostly limited to extensive qualitative discussion, and the quantitative research results are rare. The qualitative description mainly focuses on how to construct the evaluation index system of reducing consumption of energy and determine the weight of the index system and convert each evaluation index in the study area into a one-dimensional real comprehensive reducing consumption of energy performance index, How to reasonably determine the weight of these evaluation indicators is one of the main difficulties in the performance evaluation of reducing consumption of energy. Therefore, this paper adopts two evaluation methods: the full arrangement polygon graphic index method and the reducing consumption of energy performance evaluation model of the improved entropy weight TOPSIS method.

3.1. Construction of Reducing Consumption of Energy Performance Evaluation Model Based on Fully Arranged Polygon Method. The specific definition of the fully arranged polygon method is as follows: set a total of N indexes (standardized values), take the upper limit value of these indexes as the radius to form a central n-sided shape, and the connecting line of each index value forms an irregular central shape. The top point of the irregular central shape is a full arrangement of N indexes connected from head to tail, and N indexes can be formed in total $(n-1)/2$ different shapes.

Hyperbolic normalization function is adopted for the standardization of index value:

$$F(x) = \frac{a}{bx + c}, \tag{1}$$

$F(x)$ is a function of index value and satisfies $F(x)|_{x=L} = -1$, $F(x)|_{x=t} = 0$, $F(x)|_{x=U} = +1$, where U is the upper limit of index x, L is the lower limit of index x, and T is the critical value of index x. According to the above three conditions, we can get

$$F(x) = \frac{(U-L)(U-T)}{(U+L-2T)x + UT + LT - 2LU}. \tag{2}$$

According to the property of $F(x)|$, the standardized function $F(x)|$ maps the index value located in the interval $[L, U]$ to the interval $[-1, +1]$. The standardized value changes the growth rate of the index. When the index value is below the critical value, the growth rate of the standardized index gradually decreases, and when the index value is above the critical value, the growth rate of the

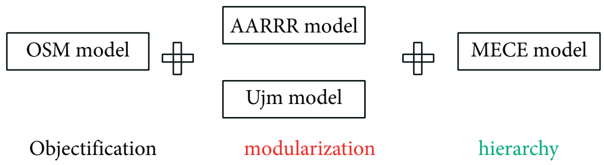

Figure 2: Development model of numerical indicators.

standardized index gradually increases. That is, the index changes from linear growth before standardization to fast slow-fast nonlinear growth after standardization, and the critical value is the turning point of index growth rate. Therefore, for the ith index, the standardization calculation formula is

$$S_i = \frac{(U_i - L_i)(X_i - T_i)}{(U_i + L_i - 2T_i)x_i + U_iT_i + L_iT_i - 2U_iL_i}, \quad (3)$$

where S_i indicates a single factor value.

According to n indexes, see Figure 3 for details.

The calculation formula of the index of arranged polygons can be expressed as

$$s = \frac{\sum_{i \neq j}^{i,j} (S_i + 1)(S_j + 1)}{2n(n-1)}, \quad (4)$$

where s is the comprehensive index value and S_i, S_j is the single index value.

According to the construction of the evaluation model, it has the following characteristics: firstly, the evaluation model is derived on the basis of the relationship between the upper limit, critical value, and lower limit of the evaluation object. Therefore, it can realize the vertical comparison between the same indicators of the evaluation object. Secondly, for the complex evaluation system with multilevel and multiobjective, the model can realize the mapping from high-dimensional space to low-dimensional space, and this mapping can reflect the classification information and ranking information of the evaluation object samples in the original high-dimensional space. Finally, when determining the weight, the objective weighting method is adopted to reduce the subjective randomness and make the weight determination of the evaluation index more scientific and reasonable. Therefore, this method is set into the evaluation of reducing consumption of energy, and the dynamic evaluation of the evaluation object is realized by comparing the performance index of reducing consumption of energy. The application field of multiobjective decision-making model is expanded. The reducing consumption of energy performance evaluation index system of low-carbon economy adopted in this paper is shown in Table 1.

We analyze and count the evaluation index values of reducing consumption of energy. The evaluation values are shown in Table 2.

Using the above index system and evaluation method, the performance of consumption reduction in different years is evaluated in four aspects: resource and energy consumption (B1), pollutants (B2), comprehensive waste utilization (B3), and environmental soundness (B4). According to the obtained comprehensive index of energy-saving and consumption reduction, the effect of energy-saving and consumption reduction in the Yangtze River Delta region in the past 10 years can be seen. The comprehensive index of resource and energy consumption (B1) shows a decreasing trend, and the total amount of resource and energy consumption gradually increases. The resource and energy consumption in the 13th Five-Year Plan period is significantly better than that in the 12th Five-Year Plan period. It can be seen that the economic growth of the Yangtze River Delta region still relies on the large consumption of resources and energy to a certain extent. Among them, the proportion of energy-consuming heavy and chemical industries in the secondary industry increased by 0.95% per year, and the proportion of low-energy-consuming light industries decreased relatively. Thermal power, building materials, petrochemicals, metallurgy, chemicals, paper, and other industries account for 25.3% of the added value, while the total energy consumption in 2015 accounted for 81% of the total industrial energy consumption above the scale. The rapid development of energy-intensive industries in the industrialization process in the Yangtze River Delta will further increase the pressure of energy consumption reduction in the province. However, energy consumption per 10,000 tons of GDP and energy processing and conversion efficiency are showing signs of improvement. Therefore, in response to the reality of increasing resource and energy consumption in the provinces of the Yangtze River Basin, we should, on the one hand, raise awareness of the strategic significance of energy conservation and improve energy efficiency; on the other hand, we should strengthen the substitution of clean energy and promote the construction of new energy sources. We evaluate resource energy

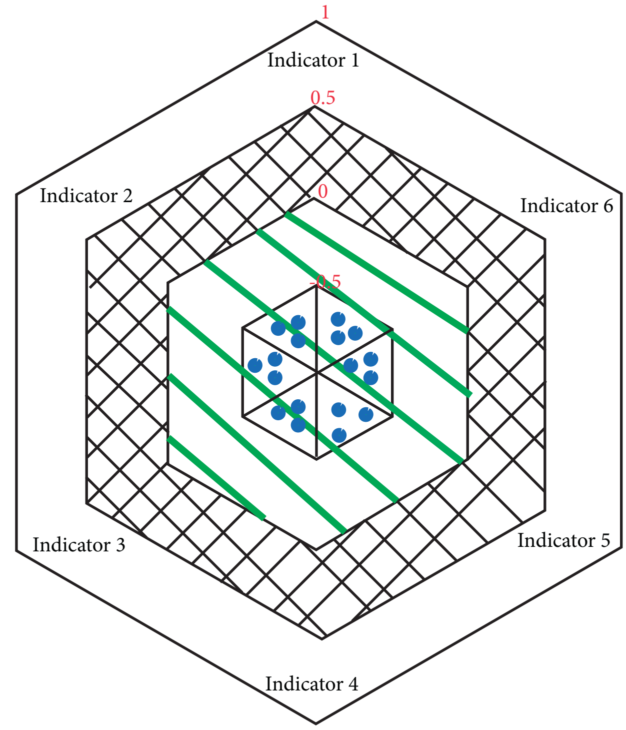

Figure 3: Graphical index method of full arrangement polygon.

Table 1: Performance evaluation indicators of reducing consumption of energy of low-carbon economy.

Target layer	Quasi survey layer	Index layer	Unit
Energy-saving and emission-reduction performance	Economic performance level	GDP growth rate x1	%
		Per capita GDP x2	Yuan
		Industrial structure x3	%
		Proportion of population in the process of urbanization X4	%
		Engel coefficient of urban residents X5	%
	Energy performance level	Energy processing and conversion efficiency x6	%
		Energy consumption structure x7	Ton standard/10000 yuan
		Energy consumption intensity x8	Ton standard/10000 yuan
		Crude oil consumption x9	Ten thousand tons of standard coal
		Raw coal consumption x10	Ten thousand tons of standard coal
		Natural gas consumption X11	Ten thousand tons of standard coal
		Elasticity coefficient of energy consumption x12	—
	Ecological environment performance level	Carbon dioxide emission intensity x13	Ten thousand tons/ten thousand yuan
		CO2 emission x14	Ten thousand tons
		COD emissions x15	Ten thousand tons
		Dust emission x16	Ten thousand tons
		Wastewater discharge x17	Ten thousand tons
		Comprehensive utilization rate of industrial solid waste x18	Ten thousand tons
		Sewage fee income X19	Ten thousand yuan
		Total investment in environmental governance X20	Ten thousand yuan

Table 2: Evaluation index values of reducing consumption of energy.

Particular year	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15	X16	X17	X18	X19	X20
2010	7.2	2.35	5.3	42.6	11.2	6.5	1170	570	1070	770	710	730	711	230	240	241	243	143	1143	2143
2011	7.2	2.435	5.1	42.8	12.1	6.8	1185	585	1085	785	745	755	721	250	242	243	221	121	1121	3121
2012	7.3	2.53	5.6	42.9	12.4	7.2	1295	595	1195	795	725	765	732	240	230	246	231	131	1131	3131
2013	7.3	2.41	5.3	43.1	11.5	7.3	1256	556	1156	856	826	726	734	260	233	236	234	134	1134	2134
2014	6.8	2.14	5.2	43.4	11.9	7.5	1235	635	1135	835	745	746	743	270	235	242	234	134	1134	2134
2015	6.9	2.25	5.1	43.6	11.8	7.6	1189	589	1089	889	779	736	744	280	234	252	253	153	1153	2153
2016	7.1	2.35	4.9	43.8	12.0	7.8	1297	597	1197	897	757	767	745	290	232	262	245	145	1145	2145
2017	7.2	2.24	4.8	43.9	11.3	8.1	1300	600	1200	800	760	734	733	310	233	253	241	141	1141	2141
2018	7.4	2.37	4.7	44.1	11.6	8.6	1331	631	1131	831	731	761	734	250	231	243	247	147	1147	2147
2019	7.1	2.32	5.0	44.5	11.9	8.8	1337	637	1137	837	737	757	766	340	228	243	243	143	1143	2143

consumption (B1), pollutant emission (B2), comprehensive utilization of waste (B3), and environmental protection treatment and harmlessness (B4) by polygonal graphical index method, as shown in Figures 4–7.

The discharge of industrial solid waste industry in the full-length triangle is mainly concentrated in nonmetallic mining and beneficiation, coal mining and washing, nonmetallic mineral products, and nonferrous metal mining and beneficiation. The discharge of three mining and nonmetallic mineral products accounts for 79.0% of the total discharge of the whole province. The solid waste generated by nonferrous metal mining and beneficiation industry accounts for 58.1% of the total amount of the province. In order to reduce the emission level of pollutants in the whole province, we should strengthen reducing consumption of energy in the industrial field, implement in-depth treatment of wastewater from papermaking, printing and dyeing, leather, chemical industry, pharmacy, petroleum processing, and other industries, improve the water reuse rate of industrial enterprises, and reduce the emission of wastewater pollutants; implement the total emission control of major pollutants in power, iron and steel, papermaking, printing and dyeing, building materials, and other industries. All newly built coal-fired units shall be equipped with desulfurization and denitration facilities, and the existing coal-fired units must be transformed through low-nitrogen combustion or put into operation denitration facilities to achieve standard emission of nitrogen oxides. The iron and

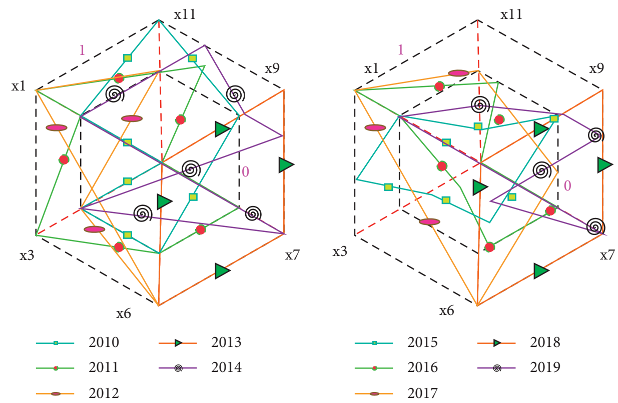

FIGURE 4: Comprehensive evaluation of energy consumption.

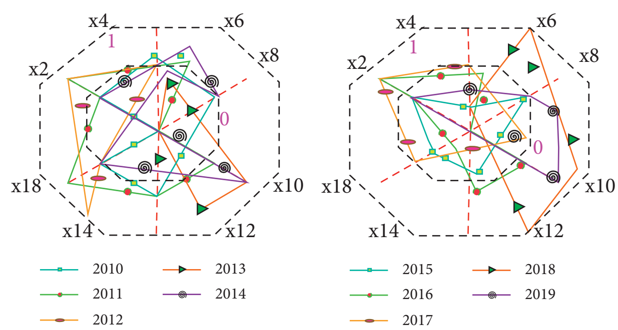

FIGURE 5: Comprehensive evaluation of pollutant emission status.

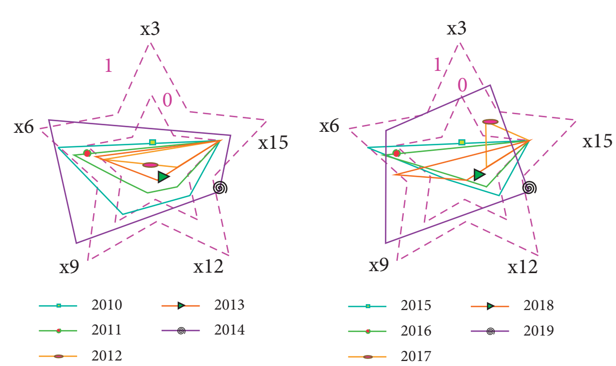

FIGURE 6: Comprehensive utilization status evaluation of waste.

steel industry shall fully implement flue gas desulfurization of sintering machine and pelletizing equipment, and key industries such as petroleum and petrochemical, nonferrous metals, and building materials shall implement desulfurization transformation. In addition, desulfurization and denitration of nonelectric coal-fired boilers shall be carried out.

3.2. Construction of Reducing Consumption of Energy Performance on Improved TOPSIS Method. The flow of the whole algorithm can be described as follows.

TOPSIS uses the distance scale to measure the sample gap. If the distance scale is used, the indicator attributes need

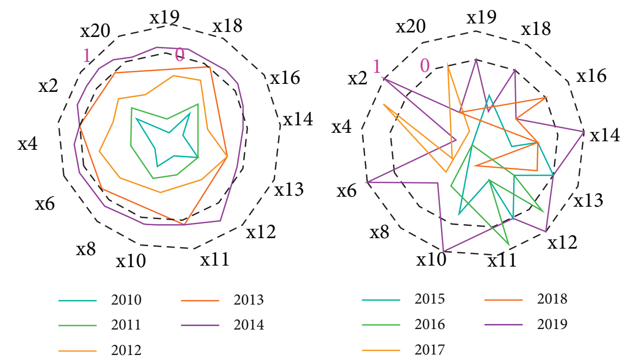

FIGURE 7: Environmental protection treatment and harmless assessment.

to be processed in the same direction (if the data of one dimension is as large as possible and the data of another dimension is as small as possible, it will cause scale confusion). Generally, cost indicators are transformed into benefit indicators (i.e., the larger the value, the higher the evaluation. In fact, almost all evaluation methods need to be transformed). In addition, all indicators need to be judged, and the advantages can be understood through the reverse sequence diagram in Figure 8.

Very small indicators: the smaller the expected indicator value, the better (e.g., morbidity, mortality, etc.):

$$x' = \frac{1}{x} \text{ or } x' = M - x, \tag{5}$$

M is the maximum possible value of index x. x' is a fractional factor.

Intermediate index: the expected index value should not be too large or too small, and the intermediate value is the best (e.g., pH value of water quality assessment):

$$x\prime = \left\{ \begin{array}{ll} 1 - \dfrac{a - x}{a - a*}, & x < a \\ 1, & a \le x \le b \\ 1 - \dfrac{x - b}{b* - b}, & x > b \end{array} \right\}, \tag{6}$$

where $[a, b]$ is the best stability interval of index x and $[a^*, b^*]$ is the maximum tolerance interval.

Construct the normalized initial matrix. Suppose there are n objects to be evaluated and each object has m indicators (attributes); then, the original data matrix is constructed as follows:

$$x = \begin{bmatrix} x_{11} & x_{12} & \dots & x_{1n} \\ x_{21} & x_{22} & \dots & x_{2n} \\ x_{n1} & x_{n2} & \dots & x_{nn} \end{bmatrix}. \tag{7}$$

Construct a weighted normalized matrix, and normalize the attribute vector (using cosine distance measurement).

$$z_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{n} x_{ij}^2}}. \tag{8}$$

Input raw dataset $x = \{x_1, x_2, \ldots, x_n\}$
Weight of each indicator $w = (w_1, w_2, \ldots, w_n)$
Process:
The indicator attributes in the original data set are normalized to x';
Construct the normalized matrix $z = \{Z_1, Z_2, \ldots, Z_n\}$ after vector reduction;
Zi do of each column of for z
The ith dimension of the worst scheme $Z- \longleftarrow Z_i$; Element minimum value
The ith dimension of the optimal scheme $Z+ \longleftarrow$ element maximum value of Zi
end for
for $Zi \in Z$ do
Proximity between Zi and the optimal scheme D_i^+; $\longleftarrow\longleftarrow$formula (10)
Proximity of Zi to the worst scheme D_i^-; $\longleftarrow$ formula (11)
Closeness of Zi to the optimal scheme Ci; $\longleftarrow$ formula (12)
end for
Sort by Ci size
Output TOPSIS evaluation results of each data sample.

ALGORITHM 1: TOPSIS algorithm flow [26–30].

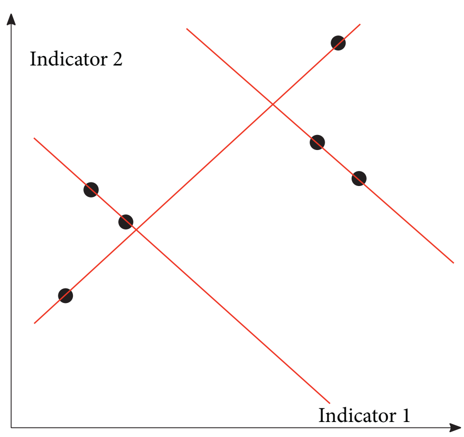

FIGURE 8: Schematic diagram of reverse sequence caused by improper relative distance.

Thus, the normalized matrix Z after normalization is obtained:

$$Z = \begin{bmatrix} z_{11} & z_{12} & \cdots & z_{1n} \\ z_{21} & z_{22} & \cdots & z_{2n} \\ z_{n1} & z_{n2} & \cdots & z_{nn} \end{bmatrix}. \quad (9)$$

Determine the optimal scheme $Z+$, that is, the maximum value composition of each list element in Z, and calculate the proximity of each evaluation object to the optimal scheme and the worst scheme:

$$D^+ = \sqrt{\sum_{j=1}^{m} w_j \left(Z_j^+ - z_{ij}\right)^2}, \quad (10)$$

$$D^- = \sqrt{\sum_{j=1}^{m} w_j \left(Z_j^- - z_{ij}\right)^2}, \quad (11)$$

$D^- D^+$ represents the distance from each decision to a positive or negative ideal value, j the weight (importance) w_j. It is recommended to determine the factor of weight according to actual situation or use the expert evaluation method. In the fourth part of this paper, two common methods and brief analysis of determining weight are also provided. Calculate the closeness C_i between each evaluation object and the optimal scheme:

$$C_i = \frac{D_i^-}{D_i^+ + D_i^-}, \quad 0 < Ci < 1, \quad (12)$$

where C_i indicates that the more superior the evaluation object.

Here, the molecule can also be set to D_i^+ to indicate the closeness to the worst scheme. At this time, C_i-0 indicates that the better evaluation object is sorted according to the size of C_i and give the evaluation results, as shown in Figure 9.

The trend of each indicator can be used to further understand the effect of energy reduction and emission reduction, as shown in Figure 10.

Through the energy-saving trend index and the energy consumption of GDP, it can be seen that with the establishment of energy-saving optimization and performance evaluation system. In the past two years, two provinces and one city in the Yangtze River Delta have attached great importance to energy conservation and emission reduction, established a working leading group, formulated implementation plans or opinions on energy conservation and emission reduction, and made great efforts in promoting industrial structure adjustment and increasing the construction of energy conservation and emission reduction projects, with remarkable results. We improved the system of policies and regulations and strengthened energy conservation and emission reduction. Two provinces and one city in the Yangtze River Delta have formulated a series of policies and regulations to make energy conservation and emission reduction work have laws to follow. Guided by energy conservation and emission reduction, it has promoted the adjustment of industrial structure. In terms of

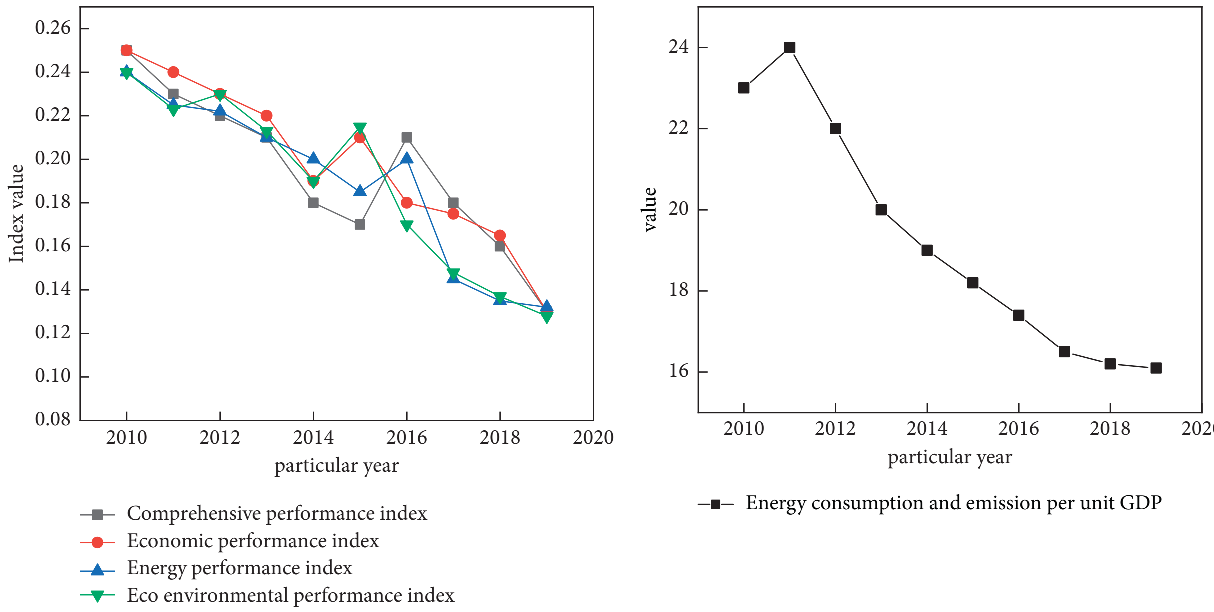

FIGURE 9: Trend index of reducing consumption of energy and energy consumption per unit GDP.

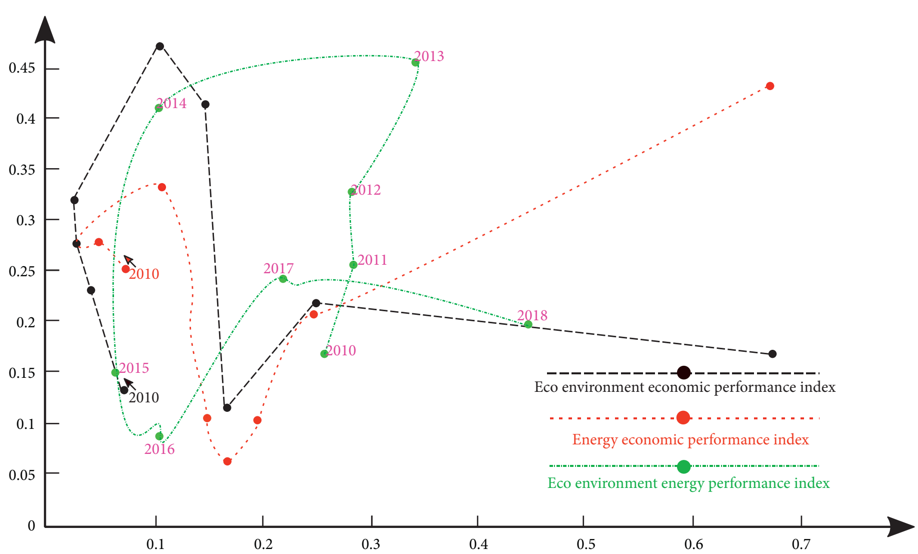

FIGURE 10: Relative changes of performance indexes.

promoting the optimization and upgrading of industrial structure and strictly controlling the excessive growth of high energy consumption and high pollution industries, two provinces and one city in the Yangtze River Delta achieved remarkable results in 2011. In 2011, the national goal of reducing energy consumption per 10000 yuan GDP by 4% was achieved. In the past two years, under the dual effects of annual GDP growth and relative reduction of energy consumption increment in two provinces and one city in the Yangtze River Delta, the energy consumption of 10000 yuan GDP has shown a downward trend[31]. In 2011, the total discharge of major pollutants decreased for the first time. Two provinces and one city in the Yangtze River Delta have stepped up efforts to control environmental pollution. Actively explore the market-oriented management mechanism of energy conservation and emission reduction. In recent years, two provinces and one city in the Yangtze River Delta have made extensive and in-depth exploration in the market-oriented management and operation of energy conservation and emission reduction, and the results are gradually showing. The energy consumption of the whole Yangtze River Delta can only be significantly reduced through optimization evaluation.

4. Summary

The performance evaluation method of reducing energy consumption is an objective and multifactor decision-making method. This paper introduces the full ranking method as well as TOPSIS to construct the evaluation model. The evaluation index system of reducing energy consumption is constructed from resource and energy consumption, pollutant emission, comprehensive utilization, environmental protection treatment, and harmlessness. And the effect of reducing energy consumption in the Yangtze River Delta region from 2010 to 2019 is evaluated. The results show that the performance evaluation of reducing energy consumption based on multiobjective decision-making is accurate. The resource and energy consumption index and pollutant emission index show a decreasing trend, and the comprehensive waste utilization index and environmental protection treatment and harmlessness index show an increasing trend year by year. From 2015 to 2016, the Yangtze River Delta region has achieved certain results in comprehensive waste utilization, environmental protection treatment, and harmlessness, but its advantage is not obvious compared with that from 2011 to 2014. There is a significant decline in resource and energy consumption and pollutant emissions, which indicates that the economic development of the Yangtze River Delta region is still at the stage of high energy consumption, which is an inherent reason for the difficulty in reducing energy consumption. Since 2011, the Yangtze River Delta region has gradually strengthened the energy conservation and consumption reduction of key industries and enterprises. It has also implemented a "comprehensive work program for energy conservation and consumption reduction." As a result, significant results have been achieved in reducing energy consumption. The evaluation results better reflect the current situation and problems of reducing energy consumption in each province of the Yangtze River Delta region and provide a scientific basis for improving the development of performance evaluation of energy consumption reduction.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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