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Research Article

Empirical Analysis of the Matching Degree between Energy Equipment Manufacturing and Market Demand: A Global Perspective

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The study of matching degree between energy equipment manufacturing and market demand is crucial for energy enterprises to adjust business strategies, expand market share, and develop sustainably. Considering that the current electricity market evaluation indicators are rarely selected from a global perspective and a single evaluation method may lead to one-sided results, this article takes the technology and equipment related to electric energy as the research object and selects six indicators, including technical standards, qualification certification, export methods, after-sales service, market concentration, and product concentration. By analyzing the supply and demand characteristics of major global regional markets and the situation of Chinese power enterprises in these markets, we propose matching model cluster including osculating value method, rank-sum ratio method, ideal point method, entropy value method, and efficacy coefficient method to conduct the matching degree study. The results show that the overall market matching degree of Chinese power companies is good, especially in Southeast Asia, Central Asia, and Africa. For markets with a low degree of matching, we analyze the reasons based on the matching indicators values to provide companies with corresponding strategies and recommendations.

1. Introduction

With the continuous advancement of energy technology, the world energy landscape is undergoing important changes [1]. The energy structure is gradually becoming low-carbon, diversified, and intelligent [2]; especially, the global power market is in a stage of deep transformation and rapid innovation. The interaction between supply and demand is the development trend under the new situation such as power market reform and smart grid construction, and it is also a necessary condition for building a complete, sound, and efficient power market [3]. In the background of uneven resource distribution and uneven demand, the mismatch between supply and demand has become a major energy problem in most countries around the world [4–6]. As one of the world's largest cross-border energy investment countries, China's energy companies have entered the international market with the global economic slowdown and increasing overcapacity in China. In this context, performing the matching analysis between global energy equipment manufacturing and market demand became an important research content. By grasping the trend of the global power market, China power companies can deal with the opportunities and challenges of the power market calmly, which is of great significance to expand overseas markets and achieve industrial upgrading.

In order to explore the matching degree between energy equipment manufacturing and market demand, certain evaluation indicators and evaluation models need to be selected. On the selection of power market evaluation indicators, Dunnan et al. constructed the power market evaluation system from the perspective of the market and the supplier [7]. Rahimiyan and Mashhadi assessed the market according to the duration and size of market power [8]. Hellmer and Warell evaluated the dominant position of the Nordic electricity market-based market concentration [9].

In the above studies, few evaluation indicators are selected. Wang et al. divided the power market evaluation indicators into five categories: market structure, market security, market operation, market efficiency, and market risk [10]. Xue et al. evaluated the electricity sales market from four aspects: market structure, market performance, prosperity index, and welfare index [11]. Research by Gärling et al. showed that consumers choose suppliers from four perspectives: price, quality of information, market share, and availability of "green" electricity [12]. Woo et al. pointed out that product differentiation can meet the needs of consumers and improve grid operation [13]. Through the above research, we can see that there is no unified evaluation indicator system for the electricity market, and it is rare to select relevant evaluation indicators from the perspective of product exports based on a global perspective.

As far as the electricity market evaluation methods are concerned, analytic hierarchy process (AHP), fuzzy comprehensive evaluation method [14–18], entropy theory [19–21], and so forth are used widely. AHP is often combined with the fuzzy analysis method to comprehensively evaluate and analyze the power market [22, 23]: the fuzzy evaluation method determines the index membership degree, and AHP determines the weight of each index. The gray relational analysis has also been applied in power market evaluation in recent years. It measures the factors' relevance degree according to the similarity or difference degree of factors' development trends, that is, the "gray relational degree" [24]. Li et al. used an improved gray relational analysis to evaluate the service quality of power supply companies [25]. Tao and Shengyu evaluated the electricity market through the combination of the gray relational model and fuzzy comprehensive evaluation method [26]. Due to the ambiguity or uncertainty of the evaluation indicators in the electricity market, and because these evaluation methods are subjective, single evaluation method may have one-sidedness to a certain degree. Therefore, the combination of multiple methods should be tried.

Based on the deficiencies in the above research, this article takes electric power technology and equipment as the research object and selects six matching indicators, including technical standards, qualification certification, export methods, after-sales service, market concentration, and product concentration. On the basis of this, we analyze the characteristics of the power markets of Southeast Asia, Central Asia, Africa, Latin America, the Middle East, and Europe and the construction situation of Chinese power equipment enterprises in these regions. Then, we use our proposed method integration cluster, including the osculating value method, rank-sum ratio method, ideal point method, entropy method, and efficiency coefficient method, to conduct research on the matching degree of supply and demand. Finally, we give corresponding strategies and suggestions based on the matching results.

In short, our contribution to this research work has two aspects. One is that when we select matching indicators, we add some factors that need to be considered in exporting energy equipment based on a global perspective. The second is that we propose a matching model cluster to conduct an empirical analysis of market matching, which makes up for the lack of one-sided results that a single evaluation method may bring.

The rest of this article is organized as follows. Section 2 introduces market matching indicators and proposes matching models based on the research object of this article. Section 3 is the empirical analysis of the six major market regions in the world. Section 4 summarizes the research conclusions and gives corresponding strategies and recommendations.

2. Matching Model

Based on the existing research results and combined with the actual situation of power market technology and equipment exports, we propose the corresponding matching indicators system and matching model cluster to study the matching degree of Chinese power companies' global construction and market demand.

2.1. Indicators Selection. Market matching is the practical application of matching theory in the product-market scenario, that is, the process of matching products with customer needs in the market. According to the indicators that buyers mainly pay attention to in the market and the specific conditions of overseas exports in the electricity market, we select six indicators, including technical standards, qualification certification, export methods, after-sales service, market concentration, and product concentration, and divide them into four aspects: markets thresholds, entry methods, business strategies, and market layout. Each indicator is quantified, as shown in Table 1.

2.2. Model Design

2.2.1. Osculating Value Method. The osculating value method is an optimal method for multiobjective decision-making in systems engineering. The decision-making here is essentially an analysis and evaluation process. Because of its flexible and simple calculation, intuitive and clear results, and high resolution, it has been widely used in the fields of energy, economy, society, medicine, etc. and is an effective method for comprehensive evaluation.

The basic idea of the osculating value method is to divide the evaluation indicators into positive indicators (i.e., the higher the value, the better the result, such as cure rate) and negative indicators (i.e., the lower the value, the better the result, such as the mortality rate) and standardize all indicators. Then, it finds out the "best point" and "worst point" of each evaluation index, that is, the maximum and minimum value of each evaluation indicator and calculates the distance between each evaluation unit and the "best point" and "worst point," respectively. These distances are transformed into a comprehensive index that can comprehensively reflect evaluation unit-osculating value. Finally, the order of each evaluation unit is determined according to the size of the osculating value. The smaller the osculating value,

Table 1: Matching indicators and quantification method.

Level 1 indicators	Level 2 indicators	Quantification method
Markets thresholds	Technical standards	The proportion of power projects that adopt Chinese standards in the target market
	Qualification certification	The proportion of qualification certification types met by Chinese power companies in the target market
Entry methods	Export methods	The degree of overlap between the export methods of Chinese power companies in the market and the market-led export methods
Business strategies	After-sales service	The percentage of projects that Chinese power companies have after-sales services to the total projects in the target market
Market layout	Market concentration	The percentage of Chinese power companies' turnover in the target market
	Product concentration	The degree of overlap between the types of power technology and equipment exported by Chinese power companies and market requirements

the higher the quality of the evaluation unit. The operation process is shown in Figure 1.

For a matching model including n evaluation units and m evaluation indicators, the osculating value D is calculated as equation (1), where i represents the evaluation unit and the distances of each evaluation unit to the "best point" and "worst point" are recorded as d_i^+ and d_i^-, respectively.

$$D = \frac{d_i^+}{d^+} - \frac{d_i^-}{d^-},$$
$$d^+ = \min_{1\le i\le n}\{d_i^+\}, \tag{1}$$
$$d^+ = \max_{1\le i\le n}\{d_i^-\}, \quad i = 1, 2, \ldots, n.$$

2.2.2. Rank-Sum Ratio Method. The rank-sum ratio (RSR) method is a statistical analysis method that combines classical parameter statistics and modern nonparametric statistics, which can be used for multi-index evaluation. The basic principle is to obtain the dimensionless statistic RSR through rank transformation in a n row (n evaluation units) and m column (m evaluation indicators) matrix and use the RSR value to rank the evaluation objects [27]. The RSR of the evaluation unit i is calculated as equation (2); $i = 1, 2, \ldots, n$, $j = 1, 2, \ldots, m$, R_{ij} represents the rank of the element in the row i and column j. The larger the RSR, the better the comprehensive evaluation. The operation process is shown in Figure 2.

$$\mathrm{RSR}_i = \frac{1}{n\times m}\sum_{j=1}^{m} R_{ij}. \tag{2}$$

2.2.3. Ideal Point Method. The ideal point (also known as TOPSIS, Technique for Order Preference by Similarity to Ideal Solution) method is a sorting method according to the closeness of the evaluation object to the idealized target, and the closeness is reflected by Euclidean distance. It forms a space with the positive ideal solution and the negative ideal solution in the finite scheme, and the scheme to be evaluated can be regarded as a certain point in the space, so that the Euclidean distance between the point and the positive ideal solution and the negative ideal solution can be obtained. Then, according to the Euclidean distance, the evaluated units are ranked.

The operation process is shown in Figure 3, where the closeness of the ideal solution G is calculated as equation (3). S^+ and S^-, respectively, represent the distance from the target to the positive ideal solution and the negative ideal solution. The larger the closeness value, the better the target.

$$G = \frac{S^-}{S^+ + S^-}. \tag{3}$$

2.2.4. Entropy Value Method. Entropy is a measure of uncertainty: the greater the amount of information, the smaller the uncertainty, and the smaller the entropy; the smaller the amount of information, the greater the uncertainty, and the greater the entropy. By calculating the entropy value, the dispersion degree of an indicator can be judged. The greater the dispersion degree, the greater the influence of the indicator on the comprehensive evaluation.

The operation steps of the entropy method are shown in Figure 4. For an evaluation system with n evaluation units and m evaluation indicators, $p_{ij}, e_j, d_j, w_j, s_i$'s calculation formula is as follows: the original data matrix is $X = (x_{ij})_{n*m}$, $i = 1, 2, \ldots, n$, $j = 1, 2, \ldots, m$.

$$p_{ij} = \frac{x_{ij}}{\sum_{i=1}^{n} x_{ij}}, \tag{4}$$

$$e_j = -k\sum_{i=1}^{n} p_{ij}\ln\left(p_{ij}\right),$$
$$k = \frac{1}{\ln(n)}, \tag{5}$$
$$e_j \ge 0,$$

$$d_j = 1 - e_j, \tag{6}$$

$$w_j = \frac{d_j}{\sum_{j=1}^{m} d_j}, \tag{7}$$

$$s_i = \sum_{j=1}^{m} w_j \cdot p_{ij}. \tag{8}$$

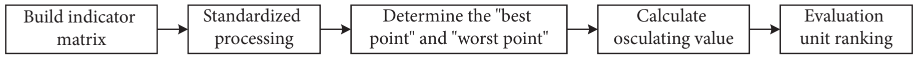

Figure 1: Osculating value method flowchart.

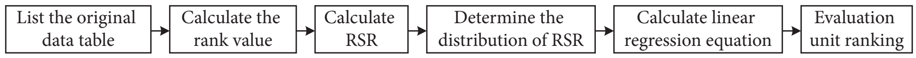

Figure 2: RSR method flowchart.

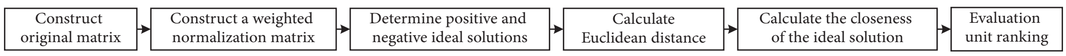

Figure 3: TOPSIS method flowchart.

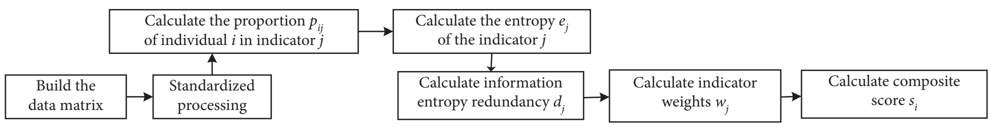

Figure 4: Entropy value method flowchart.

2.2.5. Efficacy Coefficient Method. The efficiency coefficient method is based on the principle of multiobjective planning. For each evaluation indicator, a satisfactory value and an unallowable value are determined as the upper and lower limits. The score of the indicator is determined by calculating the degree to which the indicator achieves the satisfactory value. Finally, the overall situation of the evaluated unit is obtained by weighted average.

If there are n evaluation units and m evaluation indicators, $x_i^h$and x_i^l represent satisfactory values and disallowed values, and the original data matrix is $X = (x_{ij})_{n*m}$, then the efficiency coefficient $x_{ij}^{'}$ is calculated as equation (9). The operation process is shown in Figure 5.

$$x_{ij}^{'} = \frac{x_{ij} - x_i^l}{x_i^h - x_i^l}. \tag{9}$$

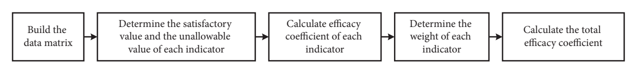

Figure 5: Efficacy coefficient method flowchart.

2.2.6. Matching Method Cluster. In order to more accurately reflect the matching relationship between Chinese power companies and the target market demand, this article adopts a multimodel integrated spouse model, which includes the osculating value method, RSR method, ideal point method, entropy value method, and efficacy coefficient method. This matching model cluster measures the overall matching degree of the evaluation unit by forming a matching space.

The advantages and disadvantages of these five evaluation models are shown in Table 2. According to the content shown, combining these five models can achieve complementary advantages.

The complete matching process is shown in Figure 6. Firstly, quantify the 6 selected matching indicators according to 2.1. Secondly, conform them to the input data format of the model by certain data processing. Then, input them into the five models. Respectively, the result value of each matching object $\mathrm{R} = \{R_1, R_2, R_3, R_4, R_5\}$ can be obtained. Normalize them and take the minimum $r_{\min}$ and maximum values $r_{\max}$ as the matching interval to obtain the final matching results.

3. Case Analysis

3.1. Data Source. We selected six regions, including Southeast Asia, Central Asia, Africa, Latin America, the Middle East, and Europe, then figured out the relevant projects in each regional power market, and analyzed the types of projects (thermal power, hydropower, wind power, photovoltaic power, and transmission and transformation.), the power technology and equipment involved, the company responsible for the project and its country, the project amount, the export method adopted (direct export, EPC, EPC + F, EPC + F + O, BOOT, BOT, joint ventures, etc.), technical standards adopted, and if there is special after-sales service organization or team. According to the power projects of Chinese power companies in these areas, we can get their specific value after quantifying six matching indicators, as shown in Table 1.

3.2. Result Analysis. According to the proposed matching model cluster, the matching results of Chinese power companies in each regional market are obtained. It can be seen that although the ranking results of different methods are not exactly the same, the overall trend remains consistent. Moreover, the length of the matching interval for each country is small, indicating that our model is feasible and effective.

3.2.1. Southeast Asia. From the results in Table 3 and Figure 7 and the specific indicator values in Table 4, it can be

Table 2: Characteristics analysis of five evaluation methods.

Method	Advantages	Disadvantages
Osculating value method	Simple principle, clear concept, an easy to implement process, and objective evaluation results	When performing multi-index evaluation, different dimension indexes should be quantified.
RSR method	Solving the problem of multiple indicators, comprehensive evaluation, and the influence of dimensions not considered	Some information of the original data will be lost when the index is converted to rank.
TOPSIS method	A selection technique based on the similarity of ideal goals, which is a very effective method in multiobjective decision analysis	The weight of each indicator needs to be determined artificially and has a certain degree of subjectivity.
Entropy value method	Determining the index weights according to the degree of variation of the index values and avoiding the deviation caused by human factors	It ignores the importance of the index itself, and the dimension of the evaluation index cannot be reduced.
Efficacy coefficient method	Calculating and scoring the evaluation object from different aspects according to the complexity of the evaluation object	The two evaluation criteria, satisfactory value and unallowable value, are difficult to decide and operate.

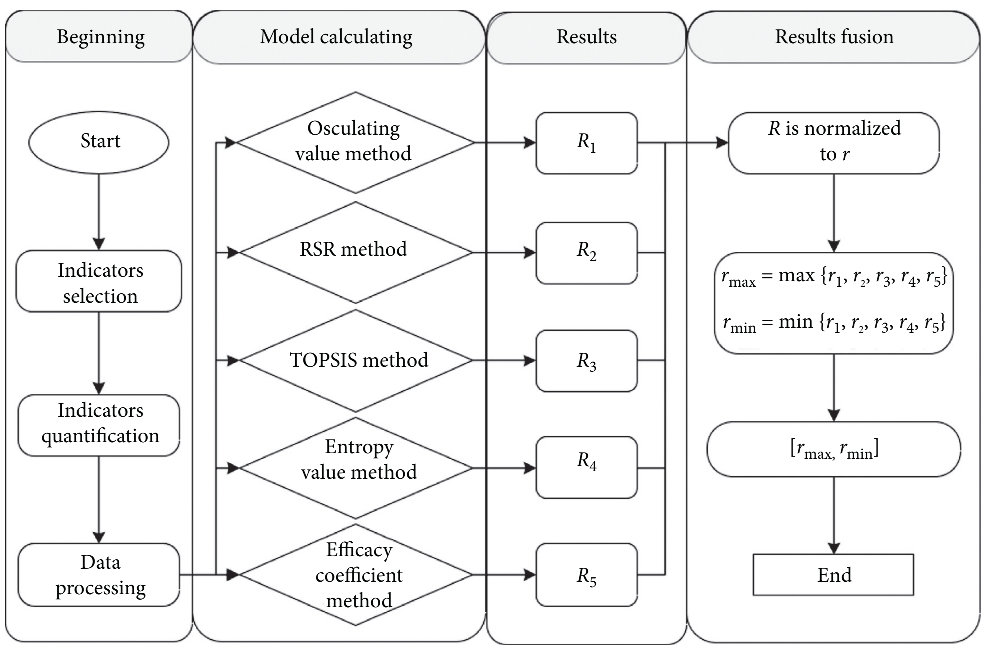

Figure 6: Matching model cluster architecture.

Table 3: Matching result of Chinese power companies in Southeast Asia.

Country	Osculating value	RSR	TOPSIS	Entropy value	Efficacy coefficient	Min	Max	Interval length
Laos	0.99	1.00	1.00	0.99	1.00	**0.99**	**1.00**	0.01
Cambodia	1.00	0.96	0.98	1.00	0.99	**0.96**	**1.00**	0.04
Indonesia	0.61	0.44	0.43	0.74	0.67	**0.43**	**0.74**	0.31
Myanmar	0.67	0.41	0.71	0.50	0.61	**0.41**	**0.71**	0.30
Philippines	0.44	0.31	0.37	0.49	0.44	**0.31**	**0.49**	0.18
Vietnam	0.43	0.29	0.36	0.39	0.41	**0.29**	**0.43**	0.14
Thailand	0.33	0.27	0.28	0.49	0.37	**0.27**	**0.49**	0.22
Malaysia	0.08	0.06	0.06	0.14	0.06	**0.06**	**0.14**	0.08
Singapore	0.00	0.00	0.00	0.00	0.00	**0.00**	**0.00**	0.00

seen that Chinese power companies have developed well in the power markets of Laos, Cambodia, Indonesia. and Myanmar. This is because the recognition and popularity of technical standards are high, the certification is perfect, the export method is in line with the local mainstream method, the after-sales service is in place, and the export products meet the market demand. In the Philippines, Vietnam, and Thailand, they need to be improved, especially in terms of technical standard, qualification certification, and after-sales service. Since Singapore and Malaysia mostly use European and American standards, and Singapore is a high-end market, the equipment required is concentrated in areas

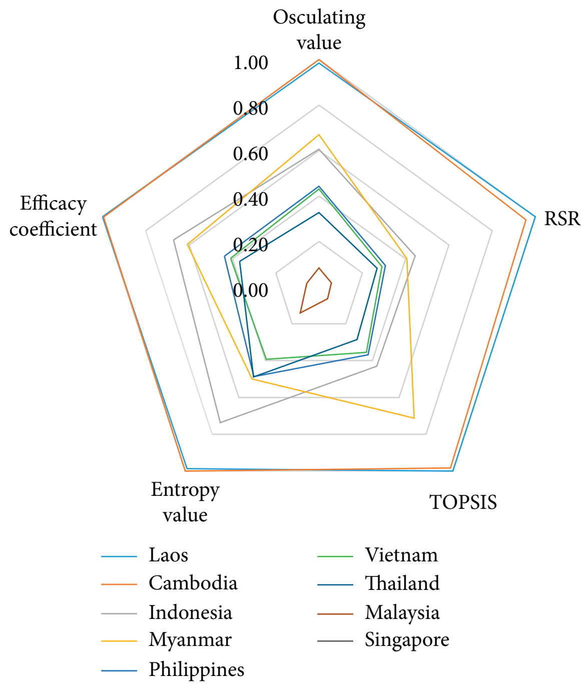

Figure 7: Matching effect picture of Chinese power companies in Southeast Asia.

Table 4: Matching indicators value of Chinese power companies in Southeast Asia.

Country	Technical standards	Qualification certification	Export methods	After-sales service	Market concentration	Product concentration
Laos	0.75	1.00	0.71	0.86	0.60	0.86
Cambodia	0.67	1.00	0.86	0.71	0.71	0.86
Indonesia	0.27	1.00	0.54	0.93	0.53	0.93
Myanmar	0.67	0.67	0.50	0.50	0.58	0.75
Philippines	0.43	1.00	0.67	0.17	0.38	1.00
Vietnam	0.43	1.00	0.43	0.25	0.44	0.88
Thailand	0.17	0.33	1.00	1.00	0.14	1.00
Malaysia	0.00	1.00	1.00	0.25	0.10	0.50
Singapore	0.00	0.33	0.00	1.00	0.20	1.00

where European and American power companies are better at control systems, automation, etc., which limits Chinese power companies development in these two countries.

3.2.2. Central Asia. From the results in Table 5 and Figure 8 and the specific indicator values in Table 6, we can see that Chinese power companies have the highest matching degree in Kyrgyzstan, but export methods need to be adjusted slightly. In Uzbekistan, Chinese power companies lack after-sales service. There are low recognition of technical standards and low market concentration in Turkmenistan and Kazakhstan, indicating that Chinese power companies are less competitive in these two countries. In Tajikistan, due to the large deviation between the export method and the mainstream export method, the overall matching degree is very low.

3.2.3. Africa. From the results in Table 7 and Figure 9 and the specific indicator values in Table 8, it can be seen that Chinese power companies have developed best in the power markets of Ethiopia, Kenya, Cameroon, and Angola, and all indicators are well matched. It is necessary to further strengthen the promotion of technical standards in Mozambique, Tanzania, and Sudan. The market concentration of electricity in Senegal, Nigeria, Morocco, and Egypt is not high, and the target market positioning is not accurate. In Algeria and South Africa, the power market development situation is relatively tense, and competitiveness needs to be further improved.

3.2.4. Latin America. From the results in Table 9 and Figure 10 and the specific indicator values in Table 10, we can see that Chinese power companies have developed well in the power markets of Ecuador, Venezuela, and Argentina, but they need to further strengthen the promotion of Chinese technical standards. Development in Cuba, Bolivia, Brazil, and Peru is in good condition. In contrast, the development in Colombia, Mexico, Chile, and Uruguay is

Table 5: Matching result of Chinese power companies in Central Asia.

Country	Osculating value	RSR	TOPSIS	Entropy value	Efficacy coefficient	Min	Max	Interval length
Kyrgyzstan	1.00	1.00	1.00	1.00	1.00	**1.00**	**1.00**	0.00
Uzbekistan	0.36	0.45	0.45	0.78	0.69	**0.36**	**0.78**	0.42
Turkmenistan	0.38	0.29	0.29	0.36	0.41	**0.29**	**0.41**	0.12
Kazakhstan	0.34	0.24	0.42	0.25	0.32	**0.24**	**0.42**	0.18
Tajikistan	0.01	0.11	0.20	0.08	0.07	**0.01**	**0.20**	0.19

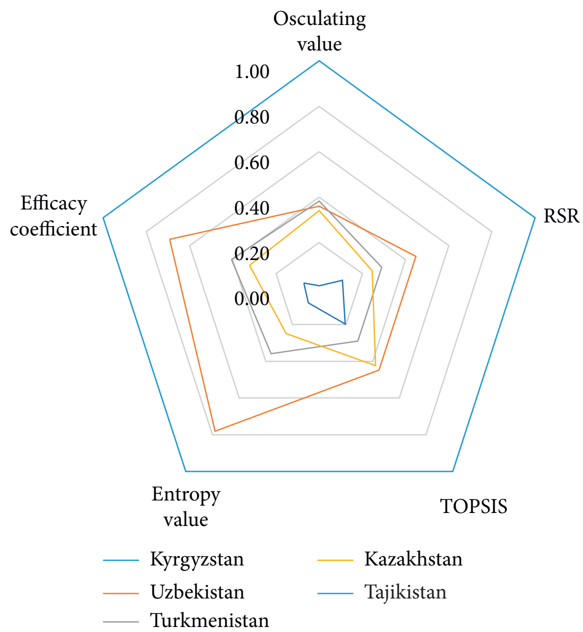

Figure 8: Matching effect picture of Chinese power companies in Central Asia.

Table 6: Matching indicators value of Chinese power companies in Central Asia.

Country	Technical standards	Qualification certification	Export methods	After-sales service	Market concentration	Product concentration
Kyrgyzstan	1.00	1.00	0.67	1.00	1.00	1.00
Uzbekistan	1.00	1.00	1.00	0.00	1.00	1.00
Turkmenistan	0.50	0.50	1.00	1.00	0.50	1.00
Kazakhstan	0.40	0.83	0.91	1.00	0.50	0.73
Tajikistan	0.20	1.00	0.33	0.83	0.60	0.83

Table 7: Matching result of Chinese power companies in Africa.

Country	Osculating value	RSR	TOPSIS	Entropy value	Efficacy coefficient	Min	Max	Interval length
Ethiopia	1.00	1.00	1.00	1.00	1.00	**1.00**	**1.00**	0.00
Kenya	0.90	0.73	0.87	1.00	0.94	**0.73**	**1.00**	0.27
Cameroon	0.66	0.63	0.66	0.91	0.88	**0.63**	**0.91**	0.28
Angola	0.74	0.53	0.68	0.83	0.77	**0.53**	**0.83**	0.30
Mozambique	0.56	0.52	0.52	0.82	0.75	**0.52**	**0.82**	0.30
Tanzania	0.67	0.51	0.66	0.76	0.74	**0.51**	**0.76**	0.25
Sudan	0.72	0.45	0.70	0.59	0.65	**0.45**	**0.72**	0.27
Senegal	0.46	0.38	0.42	0.59	0.53	**0.38**	**0.59**	0.21
Nigeria	0.45	0.38	0.36	0.60	0.52	**0.36**	**0.60**	0.24
Morocco	0.50	0.36	0.53	0.41	0.49	**0.36**	**0.53**	0.17
Egypt	0.37	0.34	0.29	0.48	0.45	**0.29**	**0.48**	0.19
Algeria	0.22	0.15	0.15	0.10	0.14	**0.10**	**0.22**	0.12
South Africa	0.00	0.00	0.00	0.00	0.00	**0.00**	**0.00**	0.00

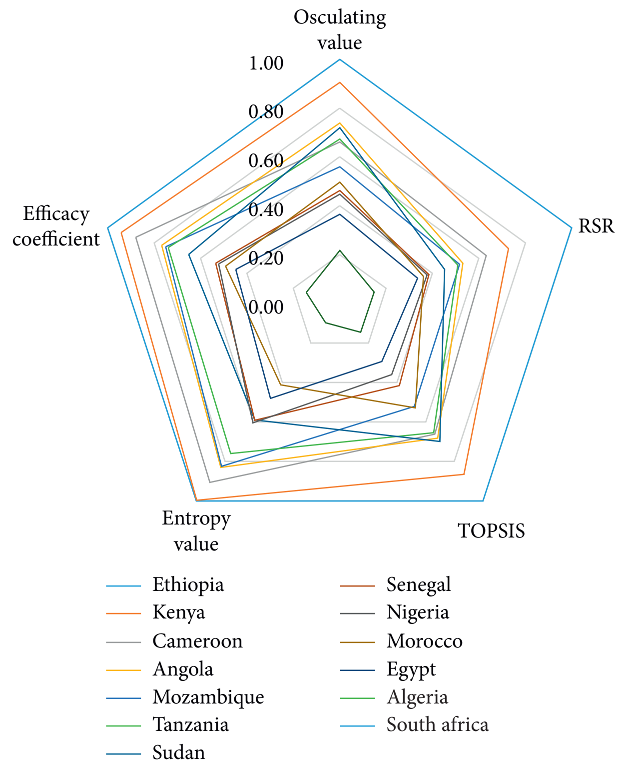

FIGURE 9: Matching effect picture of Chinese power companies in Africa.

TABLE 8: Matching indicators value of Chinese power companies in Africa.

Country	Technical standards	Qualification certification	Export methods	After-sales service	Market concentration	Product concentration
Ethiopia	1.00	1.00	0.67	0.83	1.00	0.83
Kenya	0.75	1.00	0.67	1.00	0.75	1.00
Cameroon	1.00	1.00	1.00	0.00	1.00	1.00
Angola	0.67	1.00	0.50	0.75	0.67	1.00
Mozambique	0.33	1.00	1.00	1.00	0.33	1.00
Tanzania	0.50	0.50	1.00	1.00	0.50	1.00
Sudan	0.75	1.00	0.75	0.50	0.75	0.50
Senegal	0.67	1.00	0.50	0.00	0.67	1.00
Nigeria	0.40	1.00	0.33	0.67	0.40	1.00
Morocco	0.43	0.50	1.00	1.00	0.29	0.50
Egypt	0.25	1.00	1.00	0.40	0.25	0.80
Algeria	0.11	0.67	0.50	0.50	0.29	0.50
South Africa	0.03	1.00	0.00	0.50	0.07	0.50

TABLE 9: Matching result of Chinese power companies in Latin America.

Country	Osculating value	RSR	TOPSIS	Entropy value	Efficacy coefficient	Min	Max	Interval length
Ecuador	1.00	1.00	1.00	1.00	1.00	**1.00**	**1.00**	0.00
Venezuela	0.83	0.50	0.73	0.75	0.74	**0.50**	**0.83**	0.33
Argentina	0.82	0.43	0.63	0.64	0.62	**0.43**	**0.82**	0.39
Cuba	0.72	0.51	0.79	0.72	0.76	**0.51**	**0.79**	0.28
Bolivia	0.68	0.47	0.66	0.69	0.70	**0.47**	**0.70**	0.23
Brazil	0.66	0.35	0.46	0.56	0.48	**0.35**	**0.66**	0.31
Peru	0.49	0.34	0.44	0.56	0.48	**0.34**	**0.56**	0.22
Colombia	0.40	0.26	0.32	0.46	0.33	**0.26**	**0.46**	0.20
Mexico	0.45	0.28	0.36	0.44	0.36	**0.28**	**0.45**	0.17
Chile	0.43	0.26	0.33	0.37	0.33	**0.26**	**0.43**	0.17
Uruguay	0.00	0.00	0.00	0.00	0.00	**0.00**	**0.00**	0.00

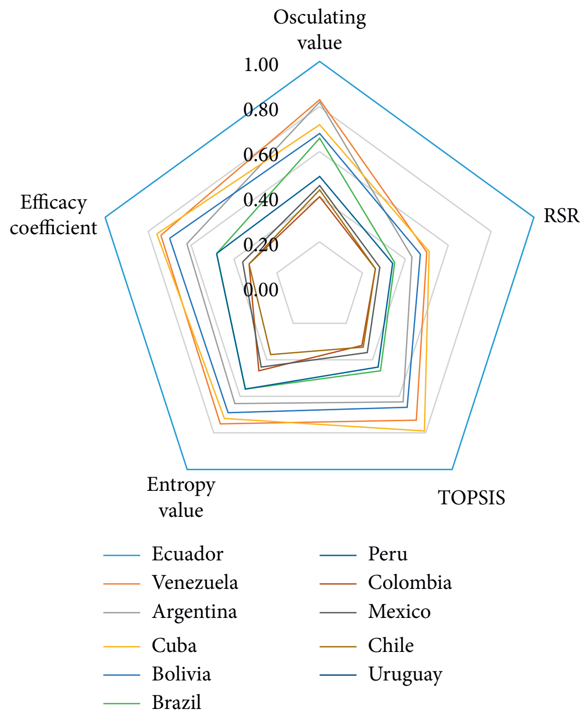

FIGURE 10: Matching effect picture of Chinese power companies in Latin America.

TABLE 10: Matching indicators value of Chinese power companies in Latin America.

Country	Technical standards	Qualification certification	Export methods	After-sales service	Market concentration	Product concentration
Ecuador	0.67	1.00	1.00	1.00	0.67	0.75
Venezuela	0.33	1.00	1.00	0.33	0.50	0.67
Argentina	0.30	0.60	0.75	0.50	0.36	0.75
Cuba	0.50	0.67	1.00	0.50	0.50	0.50
Bolivia	0.67	0.67	0.50	0.00	0.67	1.00
Brazil	0.11	0.25	0.50	0.83	0.14	1.00
Peru	0.33	0.33	0.00	1.00	0.20	1.00
Colombia	0.00	0.67	0.00	0.50	0.17	1.00
Mexico	0.11	0.60	0.00	1.00	0.18	0.33
Chile	0.25	0.50	0.00	0.50	0.29	0.33
Uruguay	0.00	0.00	0.00	0.00	0.00	0.00

TABLE 11: Matching result of Chinese power companies in the Middle East.

Country	Osculating value	RSR	TOPSIS	Entropy value	Efficacy coefficient	Min	Max	Interval length
Iran	0.91	1.00	0.74	1.00	0.99	**0.74**	**1.00**	0.26
Oman	0.69	0.66	0.51	1.00	1.00	**0.51**	**1.00**	0.49
Yemen	1.00	0.73	1.00	0.89	0.81	**0.73**	**1.00**	0.27
Kuwait	0.44	0.46	0.36	0.79	0.81	**0.36**	**0.81**	0.45
Turkey	0.63	0.47	0.46	0.79	0.79	**0.46**	**0.79**	0.33
Iraq	0.49	0.43	0.35	0.74	0.76	**0.35**	**0.76**	0.41
Saudi Arabia	0.43	0.37	0.30	0.66	0.68	**0.30**	**0.68**	0.38
Bahrain	0.42	0.34	0.30	0.63	0.66	**0.30**	**0.66**	0.36
Qatar	0.38	0.34	0.32	0.59	0.49	**0.32**	**0.59**	0.27
UAE	0.24	0.17	0.14	0.33	0.26	**0.14**	**0.33**	0.19
Israel	0.00	0.00	0.00	0.00	0.00	**0.00**	**0.00**	0.00

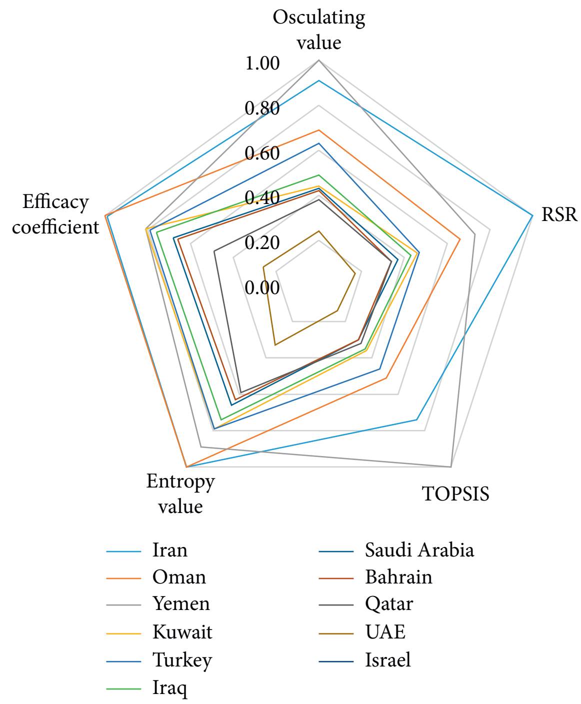

Figure 11: Matching effect picture of Chinese power companies in the Middle East.

Table 12: Matching indicators value of Chinese power companies in Middle East.

Country	Technical standards	Qualification certification	Export methods	After-sales service	Market concentration	Product concentration
Iran	0.50	1.00	0.75	1.00	0.50	0.75
Oman	0.25	1.00	1.00	1.00	0.25	1.00
Yemen	1.00	1.00	0.00	0.00	1.00	1.00
Kuwait	0.00	0.50	1.00	1.00	0.05	1.00
Turkey	0.25	0.75	0.78	0.63	0.33	0.80
Iraq	0.13	0.50	1.00	0.50	0.19	1.00
Saudi Arabia	0.00	0.67	1.00	0.20	0.26	0.83
Bahrain	0.00	0.50	1.00	0.00	0.33	1.00
Qatar	0.00	0.50	0.00	1.00	0.14	1.00
UAE	0.00	0.33	0.00	0.00	0.17	1.00
Israel	0.00	0.00	0.00	0.00	0.00	0.00

Table 13: Matching result of Chinese power companies in Europe.

Country	Osculating value	RSR	TOPSIS	Entropy value	Efficacy coefficient	Min	Max	Interval length
Poland	0.61	0.44	1.00	0.66	0.73	**0.44**	**1.00**	0.56
Belarus	0.58	0.39	0.41	0.78	0.64	**0.39**	**0.78**	0.39
Russia	0.48	0.32	0.32	0.65	0.52	**0.32**	**0.65**	0.33
Romania	0.22	0.17	0.13	0.36	0.23	**0.13**	**0.36**	0.23
UK	0.26	0.17	0.24	0.25	0.23	**0.17**	**0.26**	0.09
France	0.06	0.04	0.05	0.11	0.05	**0.04**	**0.11**	0.07
Hungary	0.00	0.00	0.00	0.00	0.00	**0.00**	**0.00**	0.00

relatively poor, and the export methods and types of products exported deviate greatly from market demand; thus, business strategies need to be further adjusted.

3.2.5. Middle East. From the results in Table 11 and Figure 11 and the specific indicator values in Table 12, it can be seen that Chinese power companies have developed well in

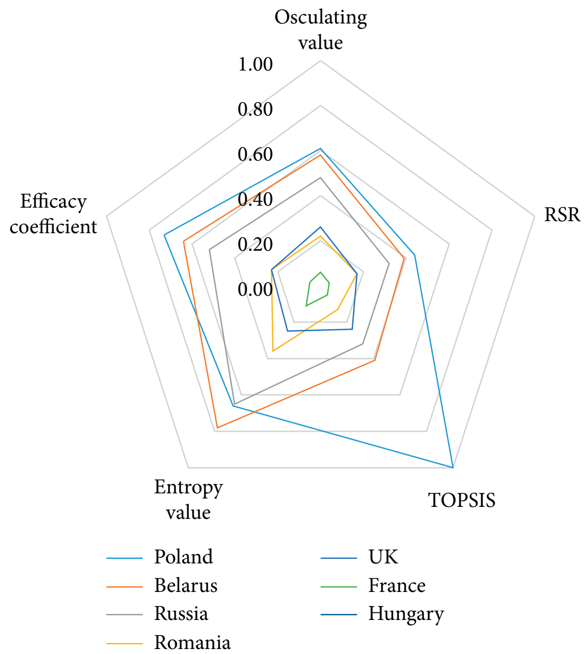

FIGURE 12: Matching effect picture of Chinese power companies in Europe.

TABLE 14: Matching indicators value of Chinese power companies in Europe.

Country	Technical standards	Qualification certification	Export methods	After-sales service	Market concentration	Product concentration
Poland	1.00	0.33	1.00	0.00	0.14	1.00
Belarus	0.00	1.00	0.60	0.40	1.00	1.00
Russia	0.00	1.00	0.66	0.33	0.50	1.00
Romania	0.00	0.50	0.50	0.00	0.33	1.00
UK	0.00	0.33	0.67	0.33	0.11	0.33
France	0.00	0.20	0.00	0.00	0.10	1.00
Hungary	0.00	0.33	0.00	0.00	0.33	0.00

the Iran and Oman power markets, and their qualification certification and after-sales service are quite complete. There is room for improvement in Kuwait, Turkey, Iraq, Saudi Arabia, Bahrain, and Qatar, especially in terms of technical standards. For the UAE and Israeli power markets, the overall matching degree is very low. China's technical standards and qualification certification need to be strengthened, and export methods and after-sales services need to be adjusted.

3.2.6. Europe. From the results in Table 13 and Figure 12 and the specific indicator values in Table 14, we can see that Chinese power companies have developed well in the Polish power market but lack after-sales services. The development in Belarus and Russia is at a general level. For the power markets of Romania, the United Kingdom, France, and Hungary, Chinese companies need to vigorously promote Chinese technical standards and improve after-sales services to expand their business.

4. Conclusion

Through the analysis of the supply and demand characteristics in major regional power markets, it is found that the global power technology and equipment market demand is dominated by hydropower, thermal power, and power transmission and transformation equipment and related technologies. The demand for wind power, nuclear power, photovoltaic power generation equipment, and technology is increasing year by year. Under the influence of the "One Belt, One Road" strategy, China has established good cooperative relations with countries along the route, especially Central Asia, Southeast Asia, and other countries, providing opportunities for China's power technology and equipment to "go global." In addition, the power infrastructure in Africa is backward. Therefore, China's power technology and equipment exports are currently mainly concentrated in Southeast Asia, Central Asia, and Africa. There are fewer equipment exports and power contracting businesses in Latin America, Europe, and the Middle East. This also reflects the fact that

Chinese power companies are less competitive in Latin America and Europe, which are with a higher level of internationalization. In terms of export method, Chinese power companies mainly export directly through project contracting, such as EPC, BOT, and BOOT. In order to share risks and increase international competitiveness, the joint venture model of cooperation with other power equipment or construction companies has also begun to appear.

Through market matching analysis, it is found that China's power technology and equipment have a relatively good global market matching, especially in Southeast Asia, Central Asia, and Africa. Due to the low degree of data disclosure in some countries, it is difficult to find comprehensive and accurate data for analysis and the electricity market barriers in some countries are relatively high, making it difficult for Chinese power technology and equipment companies to enter their markets; thus, market matching degree is low to a certain extent.

In response to the above research conclusions, the following strategic suggestions are given. Firstly, improve the dynamic tracking and analysis mechanism of power technology and equipment markets in different regions of the world. Long-term continuous tracking of market characteristics such as technical standards, qualification certifications, and key supply and demand in target markets is important for power companies to make adjustments in the business models and business strategies in time. Secondly, accelerate the internationalization of China's power technology standards. Although China's power standards have been promoted in recent years, their recognition in certain regions is still very low, making Chinese power companies lack competitiveness. Therefore, China must accelerate the establishment of a domestic power standard linkage mechanism and promote more Chinese standards to become international standards. Thirdly, communicate with relevant government departments actively. Try best to obtain government policy support, which helps create conditions for expanding the output of enterprise power technology and equipment. Fourth, before entering the target market, understand the local political situation, security issues, economic risks, etc. and establish a risk prevention and control mechanism. In the meantime, be familiar with local laws and regulations to avoid losses due to poor understanding or deviations of local laws and regulations. Fifth, cultivate high-end compound talents. The electric power technology and equipment business involve many professional fields such as electric power technology, equipment manufacturing, and law. It is necessary to further strengthen the training of talents proficient in technology and foreign languages so as to drive the high-quality and rapid development of the electric power technology and equipment business.

In future research, we will study the matching degree of internationally renowned power companies in the energy equipment market. Thus, we can learn the operation and management experience from outstanding companies in the energy market.

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 regarding the publication of this article.

Acknowledgments

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