

# Analysis of market access for power seller under the policy of selling electricity

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## Abstract

The power market access mechanism under the policy of selling electricity is the basic link of the reform of the power system. First, combining related policy, this paper constructs the evaluation index system of market access for power sellers, and defines the access conditions of the power sellers. Then, AHP and entropy weight method are applied to empower each index. Finally, the standard data and comprehensive evaluation method are used to evaluate and sort the power sellers. And according to the actual situation of electricity market and market capacity, select the appropriate enterprises to participate in the electricity transaction by ranking results.

*Keywords: Retail side reform, power seller, entropy weight method*

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## 1. Introduction

In March 2015, related national department issued "opinions on further deepening the reform of the electric power system". The biggest change is the gradual opening of the selling side. With the deepening of the new electricity reform, independent sale of electricity companies has been set up in the market [1-3]. By the beginning of 2016, 250 sale of electricity companies had been registered in Guangdong, Jiangsu, Shandong, Heilongjiang and other provinces. At the same time, many other companies are entering the registration process and preparing for registration. This indicates that our traditional mode of selling electricity business dominated by Power Grid Corp will be broken [4-7]. In this context, it is an urgent problem to approve the approval of qualified sellers to enter the market.

## 2. Evaluation Index System of Market Access for Power Seller

For power seller, its essence is the selling side users. So, the saturation of the power market should be considered. And the maturity in different stages of power market is different, limiting the quantity of sale of electricity providers. So, even if the power sellers meet the user side access conditions, it still need to refine the access standards, build a more reasonable evaluation index system, sorting power sellers that meet the entry conditions and optimally choosing more competitive providers into electricity power market. The market access evaluation index system is mainly constructed from two aspects, including the internal evaluation index and the external evaluation index.

### 2.1. Internal evaluation index

Combining with the enterprise ecology theory, evaluate power sellers from the level of internal and external environment. Among them, the internal environment level mainly considers some parameters of big users, including qualification rationality, credit level, voltage level, available electricity, user scale and enterprise assets [8-11].

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### (1) Qualification rationality

Qualification rationality refers to whether the power seller has the qualification to participate in the direct transaction, whether it has the corporate qualification, whether its financial level is up to the standard, and whether it has the economic entity that can bear civil liability. And only quality reasonable power sellers can participate in the direct trading market.

### (2) Credit level

Credit level reflects the reputation of the power seller, and the credit level is mainly based on the tax registration situation of the electricity supplier in the past years, and the rating is carried out. Only the seller with the standard of credit is able to enter the direct market of electricity and ensure the smooth development of the electricity market.

### (3) Voltage level

The voltage level of the seller is related to the customer category of the seller. According to the regulation of priority electricity purchase in the electricity reform document, and the provisions of the matching documents for the access conditions of the selling electricity providers, we should give priority to the release of the high voltage rated electricity providers, and gradually expand the electricity suppliers of low voltage level after the development of the electricity market.

### (4) Available electricity

According to the amount of the total assets of the seller, the quantity of electricity sold by the seller is controlled. The corresponding relationship between the total assets and the sale of electricity is shown in Table 1[12]. As far as the total assets of the seller are concerned, the reliability of the related costs and responsibilities is higher, and it should be given priority.

Table 1. The relationship between the registered capital and the electricity sale

Total assets (\$100 million)	Annual electricity sales limit (billion KWH)
0.2-1	No more than 6-30
1-2	No more than 30-60
>2	None

### (5) User scale

The user scale refers to the number of users that choose the same sale of power seller. When the larger the user scale of the electricity supplier is, the higher the power it will promote the development of the electricity market. And considering the scale effect of the power grid, it can be seen that the smaller the cost of the unit with large users, the lower the price of the unit.

### (6) Enterprise assets

Enterprise assets reflect the risk bearing level of power sellers. The enterprises with higher asset sales should give priority to the entry into the electricity market, which is conducive to protecting the interests of customers and avoiding the risk of electricity consumption caused by the change of electricity price.

## 2.2. External evaluation index

The external environmental level mainly evaluates the degree of agreement between the seller and the national policy and the economic environment, including the following indicators: customer categories, the output value of the region in which the seller is located, electricity supply in the area where the seller is located, the reliability of the power grid in the area where the seller is located, power generation cleanliness in the area where the seller is located and so on[13-16].

### (1) Customer categories

Customer category refers to the industry category mainly owned by the customer group supplied by the seller. For those power sellers which belong to encouraged industry, they should give priority to the entry into the electricity market. While for those in the restricted or eliminated industries, they should try their best to reduce their evaluation level, so as to respond to the national policies and establish a healthy electricity market environment.

### (2) The output value of the region in which the seller is located

The sale of electricity can be guaranteed for the seller with higher output value. Therefore, for this type

of electricity providers, they should also improve their evaluation level and give priority to entering the electricity market. For those with low output value, the proportion of entry should be controlled to reduce the risk.

(3) Electricity supply in the area where the seller is located

For the power sellers in high electricity consumption region, the electricity sale volume is large enough, and the scale effect of the users is obvious. Therefore, this kind of seller should give priority to the electricity market, which is beneficial to reduce the cost of electricity consumption and improve the efficiency of electricity market.

(4) The reliability of the power grid in the area where the seller is located

Whether or not a regional power seller is suitable for participating in the direct trading market should be based on the safety of power supply. And the reliability of power grid is one of the important factors to ensure the safety of power supply. So, the access to the seller should take into account the safety of the grid structure of the electric network access point and the seller that causes unstable factors is not allowed to access.

(5) Power generation cleanliness in the area where the seller is located

The category of regional power generation is also an important factor affecting the results of the seller's evaluation. Regional clean power generation efficiency is higher, which means the seller that has higher proportion of clean electricity should give priority into the electricity market, consumptive clean energy is higher and pollutant emissions is lower.

In conclusion, the evaluation index system of power seller in this paper includes two aspects, as shown in Fig. 1.

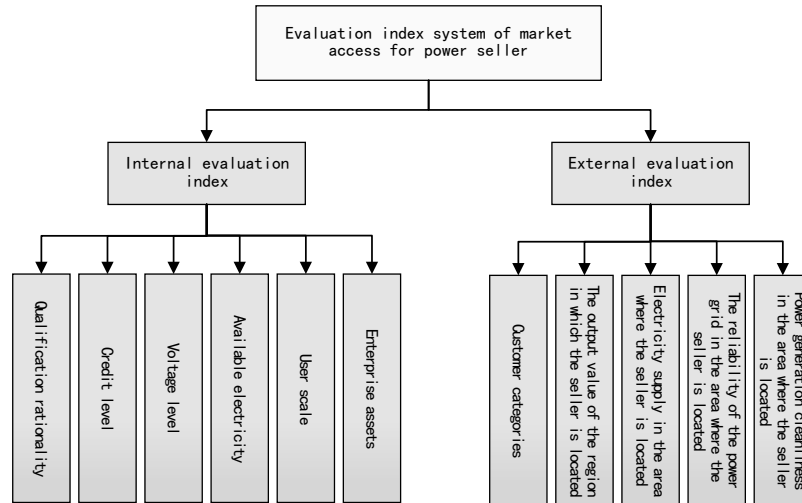


Fig. 1. Evaluation index system of market access for power seller.

### 3. Evaluation Model of Market Access for Power Seller

For the construction of evaluation model of market access for power seller, based on the evaluation index system, the weight of each index is calculated, considering the advantages and disadvantages of subjective and objective weighting methods. In this paper, the weight of index is calculated by the weighting method combined with subjective and objective view. The subjective empowerment method adopts the analytic hierarchy process (AHP), and the objective empowerment method adopts the entropy weight method.

#### 3.1. Weight calculation

##### (1) Subjective weighting method

There are many ways of subjective empowerment, including analytic hierarchy process, network

analytic hierarchy process, ordinal relation method and unique reference comparison judgment method. The analytic hierarchy process (AHP) is used to make subjective empowerment of each index. The steps of the analytic hierarchy process are as follows:

1) Construction of hierarchical structure. Through the in-depth study of the evaluation object, the hierarchical structure of the related indicators is constructed, and its hierarchical structure includes the target layer, the standard layer and the index layer. This paper has formed 4 first level indicators and 15 two level indicators.

2) The judgment matrix is constructed. By using the 1-9 scale method, the judgment matrix is constructed through the comparison of the importance of each level and the judgment matrix is constructed. And the meaning of 1-9 scale method is shown in Table 2. Assuming that there are  $n$  indexes at a level, and the  $I$  index is recorded as the degree of importance to the  $j$  index, then, the judgment matrix is expressed as  $P = (a_{ij})_{n \times n}$ .

Table 2. The scale of judgement matrix and its meaning

Scale value	Meaning
1	Compared two factors, it is the same importance
3	Compared two factors, one factor is a little more important than the other one
5	Compared two factors, one factor is more important than the other.
7	Compared two factors, one factor is much more important than the other
9	Compared two factors, one factor is extremely important than the other
2,4,6,8	The median of two adjacent scale values

$$a_{ij} > 0, \quad a_{ij} = 1/a_{ji}, \quad a_{ii} = 1$$

3) Calculate the weight of the index. To calculate the weight of the index, it is necessary to solve the maximum characteristic root and the characteristic vector according to the judgment matrix.

a: The normalized matrix  $P$  and the normalized vector  $b_{ij}$ :

$$b_{ij} = \frac{a_{ij}}{\sum_{i=1}^n a_{ij}} \quad (i, j = 1, 2, L, n) \quad (1)$$

b: Normalization and vector:

$$w_i = \frac{c_i}{\sum_{i=1}^n c_i} \quad (i, j = 1, 2, L, n), \quad c_i = \sum_{j=1}^n b_{ij} \quad (2)$$

c: The maximum eigenvalue of the computing matrix:  $\lambda_{max} = \frac{1}{n} \sum_{i=1}^n \frac{(Pw)_i}{w_i}$ ,  $(Pw)_i$  expresses the component  $i$  of  $Pw$ .

4) Consistency test

a: The index of deviation conformance of metric judgment matrix is CI:  $CI = \frac{\lambda_{max} - n}{n - 1}$ ,  $\lambda_{max}$  expresses the maximum eigenvalue of matrix  $P$ .

b: For consistency check, the average random consistency index RI is required, and its value is shown as shown in Table 3.

Table 3. The value of RI

Matrix order	1	2	3	4	5	6	7	8	9
The value of RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45

c: Calculating the ratio of random consistency CR:  $CR = \frac{CI}{RI}$ . When the matrix satisfies CR 0.1, it is considered that the judgment matrix  $P$  has a satisfactory consistency, and conversely, the judgment matrix

needs to be adjusted.

(2) Objective weighting method

The advantage of entropy weight method is to define the value and weight of the data completely from the discrete degree of the data itself, and it is relatively objective. The calculation steps of entropy weight method are as follows:

1) Collect the original data and standardize the data, thus the standard index vector is obtained.

$$y_{ij} = \begin{bmatrix} y_{11} & y_{12} & \cdots & y_{1m} \\ y_{21} & y_{22} & \cdots & y_{2m} \\ \cdots & \cdots & \cdots & \cdots \\ y_{n1} & y_{n2} & \cdots & y_{nm} \end{bmatrix} \quad (3)$$

$y_{ij}$  represents the normalized value of the  $i$  index in the  $j$  area.

2) Calculation the uncertainty of the index  $H(Y_i)$ , the formula is as follows:

$$H(y_i) = -\sum_{j=1}^n \left( \frac{1+y_{ij}}{y_i} \ln \frac{1+y_{ij}}{y_i} \right), y_i = \sum_{j=1}^n (1+y_{ij}) \quad (4)$$

3) Calculation the information entropy  $e(y_i)$ , the formula is as follows:

$$e(y_i) = \frac{H(y_i)}{\ln n}, 0 \leq e(y_i) \leq 1 \quad (5)$$

4) Calculation objective weight of the index  $\mu_i$ , the formula is as follows:

$$\mu_i = \frac{1-e(y_i)}{m - \sum_{i=1}^m e(y_i)}, 0 \leq \mu_i \leq 1, \sum_{i=1}^m \mu_i = 1 \quad (6)$$

The single evaluation method is not comprehensive. In order to make the evaluation results more precise, we need to consider the possibility of the comprehensive application of various evaluation methods, that is, the combination of evaluation methods. The method of linear weighted combination is generally adopted in the method of combination empowerment, and the formula is as follows:

$$\theta_i = \alpha \omega_i + (1-\alpha) \mu_i \quad (7)$$

In the form,  $\omega_i$  represents the subjective weight vector,  $\sum \omega_i = 1$ ;

$\mu_i$  represents the objective weight vector,  $\sum \mu_i = 1$ ;

$\theta_i$  represents the combination weight vector,  $\sum \theta_i = 1$ ;

$\alpha$  represents the importance of the subjective empowerment method,  $0 \leq \alpha \leq 1$ .

### 3.2. Evaluation process

(1) Data processing

From multiple angles, we compare the established index system and collate the data of each index. Because the dimension and type of each evaluation index are different, it is difficult to directly compare, and we need to standardize the dimensionless processing of raw data of index.

(2) Calculation weight of index

The weight of each index is calculated by analytic hierarchy process (AHP) and the objective weight of each index is calculated by using the entropy weight method. Finally, the combined weight of index is obtained by linear weighted combination method.

### (3) Evaluation of results

The final score of the index is obtained by multiplying the standardized data of each index and its corresponding comprehensive weight. And add the final score of each index of the evaluation object, get the comprehensive score of different sales providers, compare and evaluate them, and use histogram to show the evaluation results intuitively.

## 4. Example Analyses

Six power sellers are selected as the evaluation objects of the case analysis, and the relevant data of the business are collected and standardized. The results are shown in Table 4.

Table 4. Standardized treatment results

Standardized data		Power seller A	Power seller B	Power seller C	Power seller D	Power seller E	Power seller F
Internal evaluation index	Qualification rationality	17.09	17.48	14.95	16.50	16.12	17.86
	Credit level	17.24	16.28	15.33	17.62	18.01	15.52
	Voltage level	16.18	17.93	19.30	15.98	15.20	15.40
	Available electricity	15.82	17.27	16.36	17.09	16.91	16.55
	User scale	17.12	16.54	15.38	16.54	17.31	17.12
External evaluation index	Enterprise assets	17.28	17.09	17.86	15.53	16.50	15.73
	Customer categories	18.50	18.13	15.75	16.73	17.72	14.17
	The output value of the region	15.41	16.96	15.80	17.73	17.34	16.76
	Electricity supply in the area	18.13	15.27	16.90	16.29	18.13	15.27
	The reliability of the power grid in the area	16.13	16.33	17.14	18.15	15.12	17.14
Power generation cleanliness in the area		17.06	16.20	17.28	16.85	17.28	15.33

According to the weight calculation method and the actual data, the results of the subjective weight, the objective weight and the results of the comprehensive weight are obtained and shown in Table 5.

Table 5. Weight calculation results

Standardized data		Subjective weight	Objective weight	Comprehensive weight
Internal evaluation index	Qualification rationality	0.050	0.085	0.068
	Credit level	0.060	0.097	0.078
	Voltage level	0.060	0.194	0.127
	Available electricity	0.125	0.022	0.073
	User scale	0.105	0.039	0.072
External evaluation index	Enterprise assets	0.100	0.064	0.082
	Customer categories	0.055	0.182	0.119
	The output value of the region	0.110	0.061	0.086
	Electricity supply in the area	0.125	0.127	0.126
	The reliability of the power grid in the area	0.150	0.083	0.116
Power generation cleanliness in the area		0.060	0.045	0.053

Thus, the final evaluation results of each seller can be calculated, and the results of the evaluation and the ranking of the retailers are shown in Table 6 and Fig. 2.

Table 6. Evaluation results and sorting

Standardized data		Power seller A	Power seller B	Power seller C	Power seller D	Power seller E	Power seller F
Internal evaluation index	Qualification rationality	1.16	1.18	1.01	1.12	1.09	1.21
	Credit level	1.35	1.28	1.20	1.38	1.41	1.22
	Voltage level	2.06	2.28	2.45	2.03	1.93	1.96
	Available electricity	1.16	1.27	1.20	1.26	1.24	1.22
	User scale	1.23	1.19	1.10	1.19	1.24	1.23
External evaluation index	Enterprise assets	1.42	1.40	1.46	1.27	1.35	1.29
	Customer categories	2.20	2.03	1.87	1.99	2.10	1.68
	The output value of the region	1.32	1.45	1.35	1.52	1.49	1.44
	Electricity supply in the area	2.28	1.93	2.13	2.05	2.28	1.93
	The reliability of the power grid in the area	1.88	1.90	2.00	2.11	1.76	2.00
Power generation cleanliness in the area		0.90	0.85	0.91	0.89	0.91	0.81

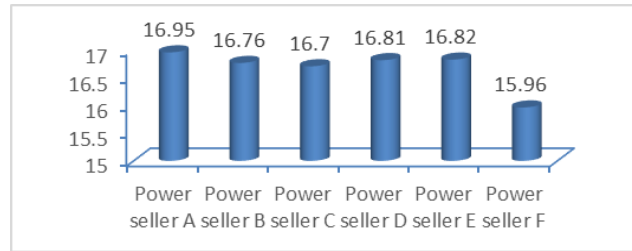


Fig. 2. Comprehensive evaluation results

According to the evaluation results, the final evaluation results for six power sellers: power seller A > power seller E > power seller D > power seller B > power seller C > power seller F. And then combined with the actual situation of the electricity market, considering the number of electricity suppliers that the market can accommodate, we select the power seller which has better results to enter the electricity market.

## 5. Conclusion

First, according to the entry rules of main bodies under the electricity liberalization policy, the evaluation index system of access market for power seller is established from two aspects: internal indicators and external indicators. On this basis, subjective and objective combination method is used to weight the evaluation indexes in the index system. The subjective weighting method is analytic hierarchy process, and the objective weight rule is entropy weight method. Then, through the dimensionless collected data, the comprehensive evaluation model is used to evaluate and sort the power seller. According to the evaluation results, considering the actual situation of electricity market, considering that the market can accommodate the number of the main bodies, it is preferable to choose the appropriate power sellers to participate in the electricity market of the selling side market.

## Conflict of Interest

The authors declare no conflict of interest.

## Author Contributions

W H Weng and Y Zhao determined the topic of the paper. C Y Chen and Y R Meng completed data analysis of the paper. M Liu and D N Liu proofread the paper. All authors had approved the final version.

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