# Analysis on Competitive Ability of Grid Sales Corporation Based on Fuzzy Comprehensive Evaluation

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## Abstract

A new round of power system reform has triggered fierce competition in the power sales market. As one of the main competitors, how to evaluate the competitiveness of grid Sales Corporation reasonably and effectively has become a problem that needs to be solved. This paper firstly analyzes the current situation of competition in the power sales market, and then uses the analytic hierarchy process to design the competitiveness evaluation index system. Finally, the fuzzy comprehensive evaluation method is applied to estimate and verify the rationality of the evaluation method through an example.

## Keywords

Grid Sales Corporation; competitiveness evaluation; analytic hierarchy process; fuzzy comprehensive evaluation method.

## 1. Introduction

In March 2015, China issued "Several Opinions on Further Deepening the Reform of the Electric Power System" (abbreviated as "No. 9 Document"). This marks the beginning of a new round of reform of the electric power system in China. “No. 9 Document” clearly stated that allowing existing power supply companies, large-scale power generation companies, engineering construction companies, energy-saving service companies, large-scale industrial parks, and conditional social capital set up independent power sales companies to enter the sales side. This indicates that power sales in the future will be a diversified market pattern [1].

Under the background of new mechanisms and multiple market entities, grid sales corporations have entered the fierce market competition with their financial advantages, huge talent advantages, and strong technical platform advantages [2]. However, in the open sales market, they also face the threat from various parties. Therefore, if Grid Sales Corporation wants to adapt to new market changes, they need to make an in-depth evaluation of their competitiveness, find out the space for further development and enhance their competitiveness.

## 2. Evaluation Index System of Competitiveness of Power Grid Corporations

### 2.1 Build a Competitiveness Evaluation Index System

In addition to non-different power sales, electricity bills and other power-selling business, high-quality power supply and quality service are the core of the competition in the power sales market [2]. In this paper, through reference to relevant literature, and based on the principle of objectivity, comprehensiveness, rationality, independence, and operability of the index system construction, the evaluation index system for the competitiveness of power grid corporations is constructed as follows:

(1) Establish target layer

The target level is the competitiveness of power grid corporations. The indicators at all levels point to the overall goal of "the competitiveness of power grid corporations".

(2) Establish criteria layers

According to the different space and contents of power supply enterprises, 3 criteria for business office service, on-site service and telephone service are first determined [3]. Providing qualified and reliable electric energy for customers is the ultimate goal of the power company's service. Therefore, power quality should also be used as a criterion. The last item is other services, including energy-saving services, differentiated services, and value-added services.

(3) Determine specific indicators based on criteria

In summary, criteria level consists of business office service, on-site service, telephone service, power quality and other services. On this basis, combined with the contents of each link, 17 items of 2 indicators are further set up, and the specific index system is shown in table 1.

Table 1. evaluation index system of Grids Sales Corporation

| First-level indicators $A_i$ | Secondary indicators $A_{ij}$ |
|---|---|
| $A_1$ Business Office Service | $A_{11}$ The convenience of business outlets |
| | $A_{12}$ Timeliness of business acceptance |
| | $A_{13}$ Salesperson business level |
| | $A_{14}$ Salesperson service attitude |
| $A_2$ On-site service | $A_{21}$ Completion time |
| | $A_{22}$ Timely and accurate meter reading |
| | $A_{23}$ Timely repair response |
| | $A_{24}$ Timely and accurate issue bills |
| $A_3$ Telephone service | $A_{31}$ Telephone connection |
| | $A_{32}$ Attendant business level |
| | $A_{33}$ Attendant service attitude |
| $A_4$ Power quality | $A_{41}$ Power stability |
| | $A_{42}$ Power reliability |
| | $A_{43}$ Power security |
| $A_5$ Other service | $A_{51}$ Energy-saving Service |
| | $A_{52}$ Differentiated Services |
| | $A_{53}$ Value-added services |

2.2 Calculate Indicator Weights

In this paper, we use analytic hierarchy process to calculate indicator weights. According to the steps of the analytic hierarchy process, the expert group conducts complementarity comparisons to determine the relative importance of each element in the hierarchy. After determining the overall order of importance of each element, the weight vector, characteristic root, and consistency can be calculated. Assume that the weight of the first-level indicator is $\mu_1$, $\mu_2,...\mu_i,...\mu_n$, Secondary indicators is $\mu_{i1},\mu_{i2},...\mu_{ii},...,\mu_{ij},i=1,2,...,m$. The calculation results are shown in Table 2. Since the AHP is a widely used method, the calculation process in this paper is not repeated here.

Table 2. The weight of each indicator

| First-level indicators $A_i$ | weight $\mu_i$ | Secondary indicators $A_{ij}$ | weight $\mu_{ij}$ |
|---|---|---|---|
| $A_1$ Business Office Service | 0.211 | $A_{11}$ The convenience of business outlets | 0.121 |
| | | $A_{12}$ Timeliness of business acceptance | 0.241 |
| | | $A_{13}$ Salesperson business level | 0.315 |
| | | $A_{14}$ Salesperson service attitude | 0.323 |
| $A_2$ On-site service | 0.215 | $A_{21}$ Completion time | 0.304 |
| | | $A_{22}$ Timely and accurate meter reading | 0.191 |
| | | $A_{23}$ Timely repair response | 0.334 |
| | | $A_{24}$ Timely and accurate issue bills | 0.171 |
| $A_3$ Phone service | 0.154 | $A_{31}$ Telephone connection | 0.311 |
| | | $A_{32}$ Attendant business level | 0.333 |
| | | $A_{33}$ Attendant service attitude | 0.356 |
| $A_4$ Power quality | 0.199 | $A_{41}$ Power stability | 0.305 |
| | | $A_{42}$ Power reliability | 0.306 |
| | | $A_{43}$ Power security | 0.389 |
| $A_5$ Other service | 0.221 | $A_{51}$ Energy-saving Service | 0.451 |
| | | $A_{52}$ Differentiated Services | 0.437 |
| | | $A_{53}$ Value-added services | 0.112 |

## 3. Fuzzy Comprehensive Evaluations of Power Grid Corporations

### 3.1 Introduction of Fuzzy Comprehensive Evaluation Method

The fuzzy comprehensive evaluation method is based on fuzzy mathematics, applying the principle of fuzzy relation synthesis, quantifying some factors with unclear boundaries and difficult to quantify, and comprehensively evaluating the status of subordinate levels of evaluated objects from multiple factors. It has the characteristics of clear results and strong system, which has been widely used in the power industry. Therefore, this paper also adopts this method for the evaluation. The basic steps are:

Establish a set of factors. That is, the evaluation index system constructed above.

Create a judgment set. That is, a set of various evaluation results that may be made by the estimator to the evaluation object. Expressed in $V = \{v_1, v_2, ..., v_m\}$.

Build an evaluation matrix.

Determine the factor weight vector W.

Assign a corresponding weight coefficient $W_i$ to each factor X (i=1, 2, ..., m). Then each weight is composed of a weight set, that is, a weight vector W.

When the evaluation matrix R and the weight set W are known, fuzzy transformation can be done for comprehensive evaluation. The fuzzy comprehensive evaluation model is

$$B = W \cdot R = (w_1, w_{2,}..., w_m) \cdot \begin{bmatrix} r_{11} & r_{12} & ... & r_{1n} \\ r_{21} & r_{22} & ... & r_{2n} \\ ... & ... & ... & ... \\ r_{m1} & r_{m2} & ... & r_{mn} \end{bmatrix} = (b_1, b_2, ..., b_m)$$

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### 3.2 Empirical Analysis

This paper takes a grid sales corporation in A province for example. According to the fuzzy comprehensive evaluation procedure, determining the four-level evaluation system Y= (excellent,

good, medium, bad), and then certain the fuzzy comprehensive evaluation matrix. This article selects the evaluation set of each indicator by 30 experts. These people include 5 from Grid Corporation, 8 from power generation companies, 8 from power sales companies, and 9 from research institutions. The selection is shown in table 3.

Table 3. Expert scoring table

| First-level indicators $A_i$ | Secondary indicators $A_{ij}$ | excellent | good | medium | bad |
|---|---|---|---|---|---|
| $A_1$ | $A_{11}$ | 16 | 11 | 2 | 1 |
| | $A_{12}$ | 14 | 9 | 5 | 2 |
| | $A_{13}$ | 17 | 14 | 2 | 3 |
| | $A_{14}$ | 13 | 10 | 4 | 3 |
| $A_2$ | $A_{21}$ | 17 | 9 | 4 | 0 |
| | $A_{22}$ | `16 | 12 | 2 | 0 |
| | $A_{23}$ | 15 | 9 | 4 | 2 |
| | $A_{24}$ | 13 | 9 | 7 | 1 |
| $A_3$ | $A_{31}$ | 19 | 9 | 2 | 0 |
| | $A_{32}$ | 16 | 13 | 1 | 0 |
| | $A_{33}$ | 13 | 9 | 7 | 1 |
| $A_4$ | $A_{41}$ | 12 | 11 | 7 | 0 |
| | $A_{42}$ | 14 | 10 | 6 | 0 |
| | $A_{43}$ | 13 | 12 | 5 | 0 |
| $A_5$ | $A_{51}$ | 7 | 14 | 7 | 2 |
| | $A_{52}$ | 9 | 13 | 6 | 2 |
| | $A_{53}$ | 16 | 11 | 3 | 0 |

According to the choice of experts, we can get a set of fuzzy evaluation matrix of first-level indicators, as shown in table 4.

According to the formula $B_1 = \omega_1 \times A_1$, we can get comprehensive evaluation vector:

$$B_1 = \omega_1 \times A_1 = (0.121 \quad 0.241 \quad 0.315 \quad 0.323) \cdot \begin{pmatrix} 0.533 & 0.367 & 0.067 & 0.033 \\ 0.467 & 0.3 & 0.167 & 0.067 \\ 0.567 & 0.467 & 0.067 & 0.1 \\ 0.433 & 0.333 & 0.133 & 0.1 \end{pmatrix} = (0.496 \quad 0.371 \quad 0.112 \quad 0.084)$$

Therefore, the degree of membership of the business office service is excellent.

Similarly, the fuzzy comprehensive evaluation vector of other first-level indicators can be obtained:

$B_2 = (0.515 \quad 0.319 \quad 0.137 \quad 0.028)$, the degree of membership of on-site service is excellent.

$B_3 = (0.529 \quad 0.344 \quad 0.302 \quad 0.012)$, the degree of membership of telephone service is excellent.

$B_4 = (0.433 \quad 0.369 \quad 0.197 \quad 0)$, the degree of membership of the power quality is excellent.

$B_5 = (0.296 \quad 0.441 \quad 0.204 \quad 0.059)$, the degree of membership of the other service is good.

Therefore, the second-level fuzzy comprehensive evaluation matrix R is

$$R = \begin{pmatrix} 0.496 & 0.371 & 0.112 & 0.084 \\ 0.515 & 0.319 & 0.137 & 0.028 \\ 0.529 & 0.344 & 0.302 & 0.012 \\ 0.433 & 0.369 & 0.197 & 0 \\ 0.296 & 0.441 & 0.204 & 0.059 \end{pmatrix}$$

According to the formula $B = \omega \times R$, we can get comprehensive evaluation vector:

$$B = \omega \times R = (0.211 \quad 0.215 \quad 0.154 \quad 0.199 \quad 0.221) \cdot \begin{pmatrix} 0.496 & 0.371 & 0.112 & 0.084 \\ 0.515 & 0.319 & 0.137 & 0.028 \\ 0.529 & 0.344 & 0.302 & 0.012 \\ 0.433 & 0.369 & 0.197 & 0 \\ 0.296 & 0.441 & 0.204 & 0.059 \end{pmatrix} = (0.448 \quad 0.371 \quad 0.184 \quad 0.039).$$

According to the results of the final comprehensive evaluation vector, among the three degrees of membership, the excellent evaluation is 0.448, the good evaluation is 0.371, the medium evaluation is 0.184, and the bad evaluation is 0.039. Based on the principle of maximum degree of membership, the comprehensive membership value is 0.448, which is evaluated as "excellent". Therefore, in general, Grid Sales Corporation in A province is more competitive in the power sales market.

Judging from the result of the degree of membership of the first-level indicators, Grid Sales Corporation has an excellent level in the business office service, on-site service, telephone service, and power quality. But the capabilities of energy-saving services, differentiated services and value-added services are relatively weak. Therefore, Grid Sales Corporation should further strengthen three capabilities above to enhance market competitiveness.

Table 4. Fuzzy evaluation matrix of first-level indicators

| First-level indicators $A_i$ | Secondary indicators $A_{ij}$ | excellent | good | medium | bad |
|---|---|---|---|---|---|
| $A_1$ | $A_{11}$ | 0.533 | 0.367 | 0.067 | 0.033 |
| | $A_{12}$ | 0.467 | 0.3 | 0.167 | 0.067 |
| | $A_{13}$ | 0.567 | 0.467 | 0.067 | 0.1 |
| | $A_{14}$ | 0.433 | 0.333 | 0.133 | 0.1 |
| $A_2$ | $A_{21}$ | 0.567 | 0.3 | 0.133 | 0 |
| | $A_{22}$ | 0.533 | 0.4 | 0.067 | 0 |
| | $A_{23}$ | 0.5 | 0.3 | 0.133 | 0.067 |
| | $A_{24}$ | 0.433 | 0.3 | 0.233 | 0.033 |
| $A_3$ | $A_{31}$ | 0.633 | 0.3 | 0.667 | 0 |
| | $A_{32}$ | 0.533 | 0.433 | 0.034 | 0 |
| | $A_{33}$ | 0.433 | 0.3 | 0.233 | 0.033 |
| $A_4$ | $A_{41}$ | 0.4 | 0.367 | 0.233 | 0 |
| | $A_{42}$ | 0.467 | 0.333 | 0.2 | 0 |
| | $A_{43}$ | 0.433 | 0.4 | 0.167 | 0 |
| $A_5$ | $A_{51}$ | 0.233 | 0.467 | 0.233 | 0.067 |
| | $A_{52}$ | 0.3 | 0.433 | 0.2 | 0.067 |
| | $A_{53}$ | 0.533 | 0.367 | 0.1 | 0 |

## 4. Conclusions

The liberalization of the power sales market is a key part of this round of power system reform. If power grid corporations want to take the lead in fierce market competition, it is of utmost importance to scientifically evaluate their core competitiveness. This paper uses the analytic hierarchy process to design the evaluation index system, and then uses the fuzzy comprehensive evaluation method to evaluate their competitiveness. Finally, through an example analysis, it verifies the scientificity and effectiveness of the model. It provides a certain theoretical basis and practical reference for the evaluation and promotion of the core competitiveness of power grid corporations.

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