Electricity market liberalization under the power of customer value evaluation and service model

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Abstract: After the power reform No. 9 was released in March 2015, the state officially released the Opinions on the Implementation of the Reform on the Power Sales Side. From this document, we can see that the openness of sales of social capital to the electricity business, the sales side of the market competition through multiple ways to train the main competitors, the result is more users have the right to choose, sales service quality and user energy levels will significantly improve. With the gradual promotion of the electricity sales market, the national electricity sales companies have been established one after another. In addition to power grid outside the power generation companies, energy-saving service companies and distributed power companies may become the main selling power, while industrial parks, commercial complex, large residential area, industrial and commercial users, large industrial users in the new electricity demand appearing The new changes, some power customers have also self-built distributed power supply, installation of energy storage devices or equipment to participate in the transformation of the electricity market. The main body of the electricity sales market has gradually evolved from the traditional electricity generation main body to the multi-unit main body and emerged new value points. Therefore, the electricity sales companies need to establish a power customer value evaluation method and service mode to adapt to the new electricity reform, Provide supportive decision support.

1 Introduction

Nowadays, the theories and methods of power customer value both at home and abroad are mainly focused on the definition of customer value, the index system of customer value evaluation, the model and method of customer value evaluation, and the classification of customer value. When defining customer value, customer value is generally evaluated in two ways: one is the value that the business provides to the customer and the other is the value of the customer to the business. In the power customer value evaluation model and method, a comparatively complete matrix model is formed both at home and abroad. The matrix model is compiled on the basis of a more complete data. This method is applied to segment the customer so that a better service In the high-quality customers. The classification of customer value is generally based on the evaluation results after the completion of the customer value rating based on the level of value, and finally divided into important customers, general customers and low value customers, different types of customers to adopt different marketing strategies.

When the electricity sales market is liberalized, the trading activities of both the main power suppliers and the main power suppliers will change. The services required by the customers are not limited to the power supply services with small differences in the past. The service demands of different customers on the power sales agents Not the same, at the same time liberalization of customer power options, you can choose to serve more high-quality electricity sales of the main. Therefore, the main power sales should pay more attention to customer needs, and strive to improve customer satisfaction in order to achieve a win-win situation. The customer value evaluation index system constructed in this paper integrates the value-added value of customers after the liberalization of the electricity sales market, designs two indexes of customer demand side value and energy management consulting service value, and the weight design of the index system adopts fuzzy analytic hierarchy process Entropy method of subjective and objective combination of methods, the use of TOPSIS evaluation method for comprehensive evaluation of customer value. In the service mode, the design of the customer stickiness index is considered considering the customer power option. The customer characteristics are analyzed according to the customer value rating result to better provide the decision support for the differentiated service of the power company.

2 Electricity customer value evaluation index systems

This article builds the customer value evaluation system
as shown in Figure 1 below. The demand-side peak clipping potential depends mainly on the customer's load characteristics, which mainly reflects the customer's peak clipping potential during peak load periods, so as to provide reference for the selling company to implement the interruptible load service. The calculation method is as follows:

If the customer's load value at peak time \( t_1, t_2, t_3, \ldots, t_Z \) is \( l_1, l_2, l_3, \ldots, l_Z \), the potential demand response potential of the customer is:

\[
f = \left( \frac{l_1^1 + l_2^2 + l_3^3 + \ldots + l_Z^Z}{Z} \right) \lambda
\]

Where \( \lambda \) is the average load drop rate under the customer's demand response measure and the other is the ratio of the average load reduction to the maximum load when the demand response is implemented.

The value of energy management consulting services mainly includes customer's electricity management costs, distributed power supply commissioning and maintenance wishes, energy-saving solutions, commissioning of electricity engineering projects and purchase of electricity. Customer's energy management consulting commissioned demand reflects the added value of customers, the higher the commission will, the higher the value. Due to the different types of customers of the sales company, different types of customers are not the same in terms of characteristics, and evaluation of various types of customer value can’t be made using a unified value evaluation index.

### Table.1. The index system of power customer value evaluation

| Electricity customer value | A1 Sales economic contribution | A11 Annual sales of electricity |
|---------------------------|--------------------------------|--------------------------------|
|                           | A12 Average annual selling price |
|                           | A13 Annual electricity growth   |
| A2 Customer credit conditions | A21 The number of default electricity |
|                           | A22 Electricity pay timely rate  |
|                           | A23 Contract compliance rate     |
|                           | A24 Annual contract deviation of electricity |
| A3 Customer management    | A31 Assets and liabilities       |
|                           | A32 Liquidity turnover           |
|                           | A33 Total asset turnover         |
|                           | A34 ol                          |
|                           | A35 Industry market share        |
| A4 Electricity management level | A41 Equipment reliability and operating conditions |
|                           | A42 Electricity safety management level |
|                           | A43 Work with the situation      |
| A5 Customer demand side value | A51 Demand side clipping potential |
|                           | A52 Energy storage capacity      |
|                           | A53 Charging pile number         |
|                           | A54 Controllable micro-source installed capacity |
|                           | A55 Electricity demand elasticity |
| A5 Energy Management Consulting Services | A61 Customer electricity management costs |
|                           | A62 Distributed power consignment operation and maintenance wishes |
|                           | A63 Energy-saving solution needs |
|                           | A64 Electrical Engineering Commission situation |
|                           | A65 Purchase electricity willingness to consult |

### 3 Customer stickiness index

Considering that customers have the right to choose in the electricity sales market, this paper designs the customer stickiness index, which reflects the satisfaction of different customers to the sales company and on the other hand, can reflect the persistence of customer value. Customer satisfaction is determined by two factors, namely, the customer's expectation and the customer's perception. The lower the customer's expectation, the
easier it is to satisfy. The worse the actual perceived customer is, the more difficult it is to satisfy. It can be deduced that customer satisfaction is inversely proportional to expectation, and customer satisfaction is proportional to perceived. The evaluation criteria of customer satisfaction can be described by a simple function as follows:

\[ c = \frac{b}{a} \]  

Where, A represents customer satisfaction; B represents the customer's perceived value; C represents the customer's expectations. In evaluating the customer stickiness index, the sales company should take the initiative to understand the core needs of customers, whether their own products and service water products meet customer expectations, and the evaluation process is based on the judgment of the sales company itself and the customer questionnaire. The core requirements are different for different types of customers. This article lists only some of the indicators used to reflect customer stickiness (Figure 2). In practice, sales companies should strengthen customer interaction and understand the real core needs of customers.

![Customer stickiness index](image)

**Figure 1. Customer stickiness index system**

### 4 Electricity customer value evaluation model

In this paper, the design of customer value index weight is based on the combination of fuzzy analytic hierarchy process and entropy method, subjective fuzzy analytic hierarchy process for the second-level indicators, objective entropy method for the third-level indicators, subjective and objective A comprehensive weight, with some scientific rationality.

Design index weight steps are as follows:

#### 4.1. Design two indicators of weight

Establish a fuzzy consistency judgment matrix, \( U \) is a set of elements \( A_i \) (secondary indicators), that is \( U = \{ A_1, A_2, \ldots, A_i \} \), \( i = 1 \sim n \), its fuzzy relation matrix expressed as

\[
R = \begin{bmatrix}
    r_{11} & r_{12} & L & r_{1n} \\
    r_{21} & r_{22} & L & r_{2n} \\
    M & M & O & M \\
    r_{n1} & r_{n2} & L & r_{nn}
\end{bmatrix}
\]  

\( r_{ij} \) indicates the importance of \( A_i \) relative to \( A_j \). If \( r_{ij} > 0.5 \), then \( A_i \) is more important than \( A_j \); if \( r_{ij} < 0.5 \), then \( A_j \) is more important than \( A_i \). If there is consistency in the process of determining the degree of membership of an element that is more important than the other element, then when \( r_{ij} > 0.5 \), \( \forall k (k = 1 \sim n), \; r_{ik} > r_{jk} \), then \( r_{ij} = r_{ik} - r_{jk} + 0.5 \).

From the literature [3] that the two indicators weight:

\[
w_{ij} = \frac{1}{n^2-n} \left( 2 \sum_{k=1}^{n} r_{jk} - 1 \right), \; i, j = 1 \sim n
\]  

#### 4.2. Design three indicators of weight
Select \( n \) power customers, \( m \) three under the two indicators, \( x_{ij} \) is the \( i \) th customer \( j \) index value (\( i = 1 \sim n, j = 1 \sim m \)). Which can be quantified using the actual data of electricity customers, non-quantifiable values scored by experts, this article uses the percentage system.

1) The normalization of indicators
Because they can’t unify the units of measurement of each indicator, they should be standardized before they can be used to calculate the comprehensive indicator. Processing calculation is as follows:

For the benefit index:
\[
x_i^+ = \frac{x_i - \min \{x_{1i}, x_{2i}, \ldots, x_{ni}\}}{\max \{x_{1i}, x_{2i}, \ldots, x_{ni}\} - \min \{x_{1i}, x_{2i}, \ldots, x_{ni}\}} \times 100 \tag{5}
\]

For cost indicators:
\[
x_i^- = \frac{\max \{x_{1i}, x_{2i}, \ldots, x_{ni}\} - x_i}{\max \{x_{1i}, x_{2i}, \ldots, x_{ni}\} - \min \{x_{1i}, x_{2i}, \ldots, x_{ni}\}} \times 100 \tag{6}
\]

2) Calculate the i-th customer's j-th indicator of the proportion of the indicator
\[
p_{ij} = \frac{x_{ij}}{\sum x_{ij}}, (i = 1, 2, \ldots, n, j = 1, 2, \ldots, m) \tag{7}
\]

3) Calculate the entropy of the j-th indicator:
\[
e_j = -k \sum_{j=1}^{n} p_{ij} \ln(p_{ij}) \tag{8}
\]

Where, \( k = 1/\ln(n) > 0 \), satisfy \( e_j \geq 0 \);

4) Calculate the information entropy redundancy of the j-th indicator:
\[
d_j = 1 - e_j \tag{9}
\]

\( 0 \leq d_j \leq 1 \) for the j-th index, the greater the redundancy of information entropy, the greater the effect on the evaluation program, the greater the entropy.

5) Calculate the weight of each indicator:
\[
w_j = \frac{d_j}{\sum_{j=1}^{m} d_j}, \quad j = 1, 2, \ldots, m \tag{10}
\]

4.3. Comprehensive evaluation method based on TOPSIS method

1) Construct the matrix of weighted norms
By formula (4) and formula (5) respectively, the weight of the second-level index and the third-level index are obtained. The final weight of the third-level index can be obtained by multiplying
\[
w'_j = w'_i w_j \tag{11}
\]

We construct a weighting rule matrix \( Y = (y_{ij})_{n \times m} \):
\[
y_{ij} = w'_i x_{ij}, (i = 1, 2, \ldots, n, j = 1, 2, \ldots, m) \tag{12}
\]

2) Determine the positive and negative ideal solution
The positive and negative ideal solutions are respectively the combination of the optimal value and the worst value of each solution.

Positive ideal solution:
\[
x_j^+ = \max_i x_j^i \tag{13}
\]

Negative ideal solution:
\[
x_j^- = \min_i x_j^i \tag{14}
\]

3) Calculate the Euclidean distance between the solutions and the positive and negative ideal solutions
Distance to the ideal solution:
\[
d_i^+ = \sqrt{\sum_{j=1}^{n} w_j (x_j^i - x_j^+)^2} \tag{15}
\]

Distance to negative ideal solution:
\[
d_i^- = \sqrt{\sum_{j=1}^{n} w_j (x_j^i - x_j^-)^2} \tag{16}
\]

4) Calculate the relative closeness between the index value and the ideal solution of each evaluation object
\[
c_i = d_i^- / (d_i^- + d_i^+) \tag{17}
\]

According to the relative close evaluation of the various programs (that is, each customer) the pros and cons, the closer the greater the greater the customer value, and vice versa lower.

5 Case Analyses
In this paper, we choose five large industrial customers for empirical analysis, the statistics of the customer value data can be quantified after normalization of indicators, non-quantifiable data based on objective and reasonable experts scoring obtained by the formula (5) and (6) After processing the data shown in Table 2:

| Evaluation index            | A    | B    | C    | D    | E    |
|-----------------------------|------|------|------|------|------|
| Sales                      | 92   | 68   | 40   | 68   | 98   |
| economic contribution      | 80   | 93   | 50   | 70   | 50   |
| Annual sales of electricity| 45   | 61   | 30   | 20   | 57   |
| Average annual selling price| 95   | 47   | 30   | 90   | 70   |
| Electricity growth rate    | 96   | 60   | 34   | 98   | 80   |
| Credit conditions          | 92   | 70   | 36   | 99   | 78   |
| The number of default electricity| 90   | 80   | 57   | 98   | 80   |
TOPSIS method

In the evaluation program, the greater the entropy, the greater the redundancy of information entropy, the greater the effect.

The proportion of the indicator can be used to calculate the comprehensive index. Using the actual data of electricity customers, for the benefit index:

1) The normalization of indicators

2) Calculate the weight of each indicator:

3) Calculate the entropy of the

4) Calculate the relative closeness between the index

The negative ideal solution:

The final weight of the third-level indicator:

R_{nov} = \begin{bmatrix}
0.5 & 0.7 & 0.8 & 0.9 & 0.6 & 0.7 \\
0.3 & 0.5 & 0.6 & 0.7 & 0.4 & 0.5 \\
0.2 & 0.4 & 0.5 & 0.6 & 0.2 & 0.3 \\
0.1 & 0.3 & 0.4 & 0.5 & 0.1 & 0.3 \\
0.4 & 0.6 & 0.8 & 0.9 & 0.5 & 0.6 \\
0.3 & 0.5 & 0.7 & 0.7 & 0.4 & 0.5 
\end{bmatrix}

Using formula (4) calculate the weight of two indicators are 0.167, 0.087, 0.207, 0.167. Use formula (7-10) to calculate the weight of the third-level indicator. Enter the formula (11) and obtain the comprehensive weight of the indicator. As shown in table 3:

| Secondary indicators | Secondary indicator weight | Three indicators | Three-level indicator weight | Comprehensive weight |
|----------------------|---------------------------|-----------------|-----------------------------|----------------------|
| Sales economic contribu| 0.247 | Annual sales of electricity 0.431 | 0.106 |
| Credit conditions | 0.167 | Average annual selling price 0.416 | 0.103 |
| Operating conditions | 0.127 | Electricity growth rate 0.154 | 0.038 |
| Electricity | 0.087 | The number of default electricity 0.146 | 0.024 |

For the second-level index element $[A_1, A_2, A_3, A_4, A_5]$, by contrasting the importance of each two, the experts form a fuzzy judgment matrix after empowerment, as follows:

$$R = \begin{bmatrix}
0.5 & 0.7 & 0.8 & 0.9 & 0.6 & 0.7 \\
0.3 & 0.5 & 0.6 & 0.7 & 0.4 & 0.5 \\
0.2 & 0.4 & 0.5 & 0.6 & 0.2 & 0.3 \\
0.1 & 0.3 & 0.4 & 0.5 & 0.1 & 0.3 \\
0.4 & 0.6 & 0.8 & 0.9 & 0.5 & 0.6 \\
0.3 & 0.5 & 0.7 & 0.7 & 0.4 & 0.5 
\end{bmatrix}$$

Using the consistency condition $r_{ij} = r_{ik} - r_{jk} + 0.5$, adjust the fuzzy matrix to form $R_{nov}$. The number of default electricity 0.146 | 0.024 |
| Electricity pay timely rate 0.272 | 0.045 |
| Contract compliance rate 0.253 | 0.042 |
| Contract deviation power 0.330 | 0.055 |
| Assets and liabilities 0.181 | 0.023 |
| Liquidity turnover 0.240 | 0.030 |
| Total assets growth rate 0.264 | 0.033 |
| Industry market share 0.125 | 0.016 |
| Equipment reliability and operating | 0.303 | 0.026 |
Use formula (12-17) to determine the positive and negative ideal solutions, and calculate the Euclidean distance of each customer, and finally get the relative closeness of each customer, as shown in Table 4 below.

**Table 4.** The weight of customer value indexes

| Electricity customers | Proximity | The relative post progress |
|-----------------------|-----------|----------------------------|
| client1               | 2.611     | 9.150                      | 0.778                      |
| client2               | 5.071     | 6.691                      | 0.569                      |
| client3               | 11.124    | 0.638                      | 0.054                      |
| client4               | 4.949     | 6.813                      | 0.579                      |
| client5               | 3.794     | 7.968                      | 0.677                      |

Through the relative closeness of the size of the customer value can be drawn as A> E> D> B> C. Close to the value of more than 0.6 for the high value customers, 0.4 to 0.6 for the value of the customer, 0.4 following the low value customers, according to grading standards A ~ E customers were high value, medium value, low value, medium value, high value. As all five electric power customers are large industrial users, the core customer needs are as follows: (1) in the research, we use the satisfaction of low-cost agent purchase as the index to evaluate the customer's viscosity. According to the sensitivity of 5 electric power customers to the price, The customer's viscosity is high viscosity, medium viscosity, medium viscosity, high viscosity, low viscosity. The resulting two-dimensional customer evaluation chart 5, as shown in Figure 2

For customers with high value and high viscosity, such customers are the best customers of the sales company and achieve a win-win result. The service company of the sales company should maintain a good relationship with the customers and provide high quality VIP service. For high-value low-viscosity power customers, sales companies should continue to improve their product and service quality, as much as possible to improve customer satisfaction and achieve win-win results. For low-value but highly-viscous customers, the main strategy of a sales company is to increase customer value by tapping customer value added. For the low-value and low-viscosity customers, the sales company needs to analyze the reasons that cause its low value while providing the basic services, and in what ways can help the enterprise improve its own value, meanwhile, it should pay attention to prevent the operation risk.
6 Conclusion

With the liberalization and gradual maturation of the electricity sales market, sales companies are increasingly important to customer relationship management. This paper mainly constructs the power customer value evaluation method. This method mainly adapts to the current electricity market environment, and puts forward the customer evaluation method of customer value and customer stickiness. It not only evaluates the customer value from the perspective of the enterprise, but also from the perspective of the customer. Analysis of customer satisfaction, more specific reflection of the characteristics of customers, for the sale of electricity companies to provide more comprehensive management information. After the market is further matured, the sales and after-sales service company can realize the accurate positioning and marketing of customers by observing the customers in more dimensions from customer value evaluation, customer demand identification, customer stickiness identification, customer transaction monitoring, etc., and realize customer-centric, The ultimate power company and customers achieve a win-win situation.

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