Research on vulnerability assessment technology of power consumption based on data analysis

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Abstract. In this paper, an evaluation model for the vulnerability of power consumption in enterprises is proposed. Firstly, we establish the customer electricity vulnerability index system, which includes the organizational structure, hidden trouble and optimized power consumption. Then, we calculate the index weight and assignment based on the analytic hierarchy process (AHP). And the comprehensive index method is employed to get the customer electricity vulnerability. At last, an example is employed to show our results clearly.

1. Introduction

The development of modern industrial enterprises is quite dependent on the support of safe and stable power system\textsuperscript{1}. The power supply system composed of generator, power transformer, cable and other major electrical equipment provides reliable power guarantee for the normal operation of electrical equipment. With the deregulation of the power sales side, in order to improve their competitiveness and customer satisfaction, in 2018, State Grid Corporation of China formally determined comprehensive energy services as the main business, and the role orientation has changed qualitatively\textsuperscript{2}. How to give full play to the company's brand, technology, customer resources, services and other advantages, and promote the company's transformation from a single power supply service to a comprehensive energy service, from the original passive service to active service. After years of operation, the grid has accumulated a large number of customer data. How to use big data technology to mine valuable customers and achieve accurate marketing is an urgent problem\textsuperscript{3}.

This paper takes the electric power custody project as an example, uses the data analysis method to diagnose the energy custody demand of the enterprise, establishes the vulnerability assessment model of the enterprise's electricity consumption, realizes the precise marketing of the comprehensive energy service, and improves the marketing efficiency.

2. Establishment of customer electricity vulnerability index system

Through market research, the main factors affecting the risk of electricity consumption are screened, and an indicator system for the vulnerability of customers' electricity consumption is established, which is divided into primary indicators and secondary indicators, as shown in the fig. 1.
From Fig 1, we know that the vulnerability of enterprise power consumption mainly includes the vulnerability of organization, the vulnerability of hidden trouble and the vulnerability of optimized power consumption. Among them, the frequency of electrician certificate indicates how many enterprises the electrician certificate of the electricity consuming enterprise is affiliated to at the same time; the frequency of prevention test indicates the number of emergency power failure drills of the enterprise; the scale of electricity consumption indicates the scale of the enterprise applying for the power station, and these three indicators represent the vulnerability of the enterprise's organizational structure.

3. Calculation of index weight and assignment based on AHP

3.1 Determination of index weight

(1) Construct the judgment matrix

Through expert scoring, we can determine which of the two factors is more important, how much is important and how much is important. The first level evaluation indexes of electric power emergency capability evaluation are 4. According to the scores of experts, the matrix is made up of numbers 1 to 9 and their reciprocal as the importance scale. Among them, 1 indicates that two elements are equally important; 3, 5, 7 and 9 indicate that one element is slightly important, obviously important, strongly important and absolutely important than the other; 2, 4, 6 and 8 indicate the median of two adjacent odd scales. Here, we conduct a questionnaire survey to power experts, and then get two judgment matrices through data processing:

\[
A = \begin{bmatrix}
1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 & 9 \\
1/2 & 1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 \\
1/3 & 1/2 & 1 & 2 & 3 & 4 & 5 & 6 & 7 \\
1/4 & 1/3 & 1/2 & 1 & 2 & 3 & 4 & 5 & 6 \\
1/5 & 1/4 & 1/3 & 1/2 & 1 & 2 & 3 & 4 & 5 \\
1/6 & 1/5 & 1/4 & 1/3 & 1/2 & 1 & 2 & 3 & 4 \\
1/7 & 1/6 & 1/5 & 1/4 & 1/3 & 1/2 & 1 & 2 & 3 \\
1/8 & 1/7 & 1/6 & 1/5 & 1/4 & 1/3 & 1/2 & 1 & 2 \\
1/9 & 1/8 & 1/7 & 1/6 & 1/5 & 1/4 & 1/3 & 1/2 & 1
\end{bmatrix}
\]

(2) Calculate the weight of indicators

The square root method is used to calculate the maximum eigenvalue and eigenvector of the judgment matrix. The calculation steps are divided into three steps:
Step 1: Calculate n-th root of the product of elements in each row of the standard judgment matrix, denoted by $\bar{W}_i = \sqrt[n]{\prod_{j=1}^{n} a_{ij}}$

Step 2: Normalize the vector $W_i = \bar{W}_i / \sum_{j=1}^{n} \bar{W}_j$, and the calculated value is the weight vector of the evaluation index.

Step 3: Calculate the maximum eigenvalue of the judgment matrix, $\lambda_{max} = \frac{1}{n} \sum_{i=1}^{n} (AW)_{ii}$.

From this, we can get the weight of each index, see the following Table.

| Index                          | Weight |
|-------------------------------|--------|
| Frequency of use of electrician certificate | 0.3070 |
| Number of preventive tests    | 0.2182 |
| Power consumption scale       | 0.1543 |
| 95598 work order times        | 0.1089 |
| Pms2.0 fault information      | 0.0764 |
| Power failure alarm times     | 0.0533 |
| Power factor                  | 0.0370 |
| Load rate                     | 0.0259 |
| Cusp ratio                    | 0.0189 |

3.2 Index Assignment

In the electric power system of our country's enterprises, we first obtain the index value from the marketing system and the electric power collection information system. For the specific indexes such as the frequency of use of electricians, we can first determine the upper and lower bounds of each specific index, and then calculate each index accordingly, normalize each index, so that the final value of each specific index is between 0 and 1, the closer it is 0, it is proved that the lower the vulnerability is, the safer the power system is, and the closer it is to 1, it indicates that the vulnerability is higher and the power system is not firm. For example:

Frequency of using electrician certificate: 10 times is the maximum allowable range, so the calculation formula of assignment can be given as

$$\begin{cases} 
\frac{x}{10} : 0 \leq x < 10 \\
1 : x \geq 10
\end{cases}$$

Number of preventive tests: the index should be more than twice a year, so the calculation formula of this index can be given as

$$\begin{cases} 
1 - \frac{x}{2} : 0 \leq x < 2 \\
0 : x \geq 2
\end{cases}$$

4. Calculation of customer electricity vulnerability based on comprehensive index method

The comprehensive index method is to transform the indexes of different grades into a unified grade through normalization, and compare them. Specifically, the comprehensive index method will multiply and add the values and weights of all the indexes to get the final comprehensive evaluation index (a specific value):
\[ V = \sum_{i=1}^{n} W_i I_i \]

Here, the greater the weight \( W_i \) is, the greater the impact of the indicator on the results is. The greater the value is, the worse the indicator is. According to the calculated vulnerability results, we can see the difference between the vulnerability of power enterprises and the industry average level. At the same time, according to the calculation formula, we can also calculate the contribution of each indicator to the overall vulnerability, and its size determines the vulnerability of the indicator in the system. The larger the value is, the weaker the index is, which indicates that this index is the weak segment in the power stability of enterprises, so it should be dealt with preferentially.

5. Application

In order to apply the model to practice, we should first obtain the access right of marketing system database. By using Python software to write the corresponding query statements and visiting the marketing system database, we can obtain the information of all special transformer users within the monitoring scope, and the extracted field information includes: power supply unit (including prefecture, County, District, and power supply station), user number, user name, power address, industry code, and contract capacity. Volume, operation capacity, multiple rate, implementation price, user classification, power consumption category, hidden danger type, electrician remarks, legal person information, electrical contact information, etc. detailed list is exported. These field data are online data, which can be automatically taken.

Taking an enterprise in Ningbo as an example, we crawl relevant data of the enterprise in 2018 from the marketing system. The obtained model can be used to calculate the power vulnerability of the enterprise, as shown in the following table:

| Index                                             | Weight | Assignment | Influence       |
|---------------------------------------------------|--------|------------|-----------------|
| Frequency of use of electrician certificate        | 0.3070 | 0.5        | 0.153476        |
| Number of preventive tests                        | 0.2182 | 0          | 0               |
| Power consumption scale                            | 0.1543 | 0.8        | 0.123458        |
| 95598 work order times                            | 0.1089 | 0.4        | 0.043553        |
| Pms2.0 fault information                          | 0.0764 | 1          | 0.076442        |
| Power failure alarm times                         | 0.0533 | 1          | 0.053309        |
| Power factor                                      | 0.0370 | 0.6        | 0.022217        |
| Load rate                                         | 0.0259 | 0.7        | 0.018162        |
| Cusp ratio                                        | 0.0189 | 0.4        | 0.007566        |

Vulnerability Value 0.4982

From the table, we can see the vulnerability value of the enterprise is 0.4982. On the one hand, it can be seen from the influence coefficient that the vulnerability risk of the enterprise is mainly caused by the large scale of power consumption, and the enterprise can adjust for the large index to reduce the power risk of the enterprise; on the other hand, for the power company, the power vulnerability of the enterprise can be obtained from the model, and the higher the vulnerability of the enterprise, the greater the demand for energy custody. Therefore, this model can be used to select enterprises with high vulnerability for marketing of energy custody business.

Through this model, all enterprises registered in the system can be assessed for vulnerability, and the recommendation of power custody business can be made according to the vulnerability from high to low.
6. Conclusion

In this paper, firstly, the index classification of enterprise brittleness evaluation is established, and the weight of the index is obtained by using analytic hierarchy process (AHP). Secondly, the index data is obtained from the marketing system, and the index is assigned; Finally, the vulnerability value of the enterprise is calculated by using the comprehensive index method, and the higher the ranking is, the higher the user's demand for equipment trusteeship is, the real-time monitoring system can be established to produce the urgent demand measurement. Turn the market and submit to the professional department as the support of power supply service.

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