Design of users’ electricity purchase packages for electricity sales companies in the electricity market

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Abstract: As the rapid development of the power industry, the analysis and forecasting of large power companies in the power market is very important. It not only makes the distribution and operation of power more reasonable, but also greatly enhances the rationality of customer power consumption. Predictive analysis with power customers is critical. Based on the service side, the electricity consumption of enterprises in Guangdong Province was selected as the training sample, and the BP neural network-based prediction algorithm was selected to study and construct the enterprise electricity package model. The effective data of 695 enterprise electricity consumption was used for training and verification. Achieve accurate package design for enterprises with different power consumption.

1. Introduction

With the rapid development of the electric power industry, as well as some opinions of the State Department on further deepening the reform of the electric power system [1-2], in order to build a unified, open, competitive and orderly electricity market system [3-4], as an important part of electric power customers, it is necessary for enterprises in this field to be provided reasonable services in order to form strong competition. There are the following problems in the service of power supply for enterprises by the power grid company: although the high quality power supply service has made progress, there is still a big gap compared with the actual customer service, and the service suitable for the customer enterprise is not satisfactory. Most of the electricity packages are based on sensibility and lack of Scientific and reasonable analysis, so that enterprises cannot get more suitable for the enterprise's electricity package.

For the existing package prediction research, we can find that there are not many related research papers at present. In view of this phenomenon and the demand for the current customer market, this paper uses neural network to predict the research, because neural network, as an important neural
artificial intelligence technology, can get the effect which cannot be achieved in time series and power analysis, aiming at the neural network. Only the more common BP neural network can achieve better results.

In this paper, the package design model based on BP neural network is used to analyze the electricity consumption and package from 695 enterprises, and finally a set of recommended model based on enterprise electricity package design is formed. It is of great significance to select electricity package for enterprises according to their own actual situation, realize the idea of energy saving and improves the efficiency of service operation, and enhance the competitive strength of enterprises.

2. Design of electric enterprise package [5-6]

2.1. Ideas on the Model of Electric Enterprise package

Based on the monthly electricity consumption and package of 695 power enterprises in 2017, a certain number of training samples and test samples are selected for model construction and verification, and a prediction model training sample database is formed. Through the model training and prediction of the attribute feature data of the sample data, the idea of constructing the design model of the electric enterprise package is shown in figure 1 below.

![Figure 1. Power enterprise package model ideas](image)

3. Construction of package design model based on BP neural network

3.1. Preparation of data

3.1.1. Sample data sort. In this paper, various power enterprises in Guangdong Province are taken as the research subjects. Based on the integrity and effectiveness principle of the basic data of electricity consumption in power enterprises, a total of 695 valid samples of enterprise data are selected. The following is the monthly electricity consumption of 10 companies we randomly selected from January to June 2017 in kWh), as shown in table 1.
3.1.2. Data characterization. The monthly electricity consumption of each company from January to June 2017 is analyzed by spss to ensure the correct prediction of the model and the accurate package scheme of different enterprises, and the monthly electricity consumption characteristic values of 695 companies from January to June 2017 are analyzed, such as harmonic average, average standard error, geometric average, standard deviation. The monthly electricity consumption characteristic value is shown in table 2.

| Table 1. Monthly electricity consumption meter from January to June 2017 |
|-------------------------------------------------------------|
| **Customer number** | **2017.1** | **2017.2** | **2017.3** | **2017.4** | **2017.5** | **2017.6** | **Package** |
| 1 | 8535 | 6842 | 8521 | 9595 | 14930 | 17988 | 1 |
| 2 | 36984 | 29648 | 36926 | 41579 | 64696 | 77949 | 5 |
| 3 | 682788 | 547344 | 681708 | 767604 | 1194396 | 1439064 | 3 |
| 4 | 17070 | 13684 | 17043 | 19190 | 29860 | 35977 | 2 |
| 5 | 739687 | 592956 | 738517 | 831571 | 1293929 | 1558986 | 2 |
| 6 | 341394 | 273672 | 340854 | 383802 | 597198 | 719532 | 5 |
| 7 | 568990 | 456120 | 568090 | 639670 | 995330 | 1199220 | 5 |
| 8 | 205974 | 165115 | 205649 | 231561 | 360309 | 434118 | 3 |
| 9 | 11380 | 9122 | 11362 | 12793 | 19907 | 23984 | 3 |
| 10 | 26174 | 20982 | 26132 | 29425 | 45785 | 55164 | 3 |

In fact, there are many packages, but there are only four or five high-frequency packages. For the same package, it is possible to design many kinds of prices, but the range of price fluctuations is not large. The price fluctuations are based on the monthly market clearing price in the last month of the previous year, floating within a range of price differentials (-10% to -25%). Therefore, in order to simplify the model, we assume that the price value of each package is fixed between the user and the power seller. We have designed ten kinds of electricity sales contract packages with prices, and the price and settlement formulas are shown in table 3 below.

| Table 2. Monthly electricity consumption characteristic value table |
|-------------------------------------------------------------|
| **10 sets of data characteristic values.** | **Harmonic average** | **Average standard error** | **Geometric average** | **Standard deviation** |
| January | 6514 | 1724 | 10318 | 5971 |
| February | 28225 | 7469 | 44711 | 25874 |
| March | 521082 | 137895 | 825435 | 477681 |
| April | 13027 | 3447 | 20636 | 11942 |
| May | 564505 | 149386 | 894221 | 517488 |
| June | 260541 | 68947 | 412718 | 238840 |

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| Package number | Package clause | Formula for calculating user income | Formula for calculating the income of Power sales Company |
|----------------|----------------|--------------------------------------|----------------------------------------------------------|
| 1              | -35 PCT / kWh  | Income = electricity / kilowatt-hours × 35 PCT / kWh | Income = electricity / kilowatt-hour (catalogue electricity price-clearing price-35) PCW / kWh |
| 2              | 7/3 points     | Income = electricity / kilowatt-hour × (catalogue electricity price-clearance price) × 70% | Income = electricity / kilowatt-hour × (catalogue electricity price-clearance price) × 30% |
| 3              | 75 / 25 points | Income = electricity / kilowatt-hour × (catalogue electricity price-clearance price) × 75% | Income = electricity / kilowatt-hour × (catalogue electricity price-clearance price) × 25% |
| 4              | 8 / 2 points   | Income = electricity / kilowatt-hour × (catalogue electricity price-clearance price) × 80% | Income = electricity / kilowatt-hour × (catalogue electricity price-clearance price) × 20% |
| 5              | -30 PCH / kWh, superimposed by 6 / 4 | Income = electricity × 30 PCT × (catalogue electricity price-clearance price-30) × 60% | Income = electricity quantity × (catalogue electricity price-clearance price-30) × 40% |
| 9              | -30 PCH / kWh, superimposed by 8 / 2 | Income = electricity × 30 PCT × (catalogue electricity price-clearance price-30) × 80% | Income = electricity quantity × (catalogue electricity price-clearance price-30) × 20% |
| 7              | -40PCH / kWh, superimposed by 9 / 1 | Income = electricity × 40 PCT × (catalogue electricity price-clearance price-40) × 90% | Income = electricity quantity × (catalogue electricity price-clearance price-40) × 10% |
| 8              | -50 PCT / kWh or 9 / 1 points | Revenue 1 = electricity × 50 PCT |
|                |                | Income 2 = electricity quantity × (catalogue electricity price-clearance price) × 90% |
|                |                | Income = max {income 1, income 2} |
| 10             | 50% fixed electricity:-35 PCT / kWh, 50% floating electricity: 8 / 2 | Income = electricity × 50% × 35 PCT × 50% × (catalogue electricity price-clearing price-35)% × 80% | Income = electricity × 50% × (catalogue electricity price-clearing price-35) × 50% × (catalogue electricity price-clearing price-35) × 50% × (catalogue electricity price-clearing price-50) PCT × 50% × (catalogue electricity price-clearing price-50) × 10% |
|                |                | Income = min {income 1, income 2} |
According to electricity market terminology, the following explanations are made:

1) XXPCW / kilowatt, indicating that the amount of electricity that the user participates in the electricity market transaction through the sales company agent floats XXPCW / kWh (including tax) as the user's income on the basis of the catalogue sales price of the market.

2) X / X share, indicating the combined tariff differential income (long-term market income plus monthly bidding market income) obtained by the user through the electricity sales company agent participating in the electricity market transaction electricity price difference income (long-term market income plus monthly bidding market income), the electricity bill comprehensive price difference income (long-term market income plus monthly bidding market income), the user and the selling company share according to the X / X ratio.

3) The other packages come from a combination of these two basic situations.

4. Model training

4.1. Settings of datasets
The verification and test data sets are set to 15% of the raw data (the power consumption of 695 enterprises), respectively. With these settings, the input vector and the target vector are randomly divided into three groups,

1) 70% is spent on training.
2) 5% is used to verify the generalization of the network and stop training before overfitting.
3) The last 15% is used as a completely independent test for network generalization.

4.2. Settings of two-layer network function
The standard network for pattern recognition is a two-layer feed forward network with tansig transfer function in hidden layer [7-8] and sigmoid transfer function in output layer. The default number of hidden neurons is set to 10. If the performance of the network is not as good as expected, you need to return and increase this number. The number of output neurons is set to 9, equal to the number of elements in the target vector (number of categories).

4.3. The results of model prediction
Ten sets of data are selected for verification, and the results of the verification are shown in table 4 below.
Table 4. Schematic diagram of prediction results

| Customer number | Harmonic average | Average standard error | Geometric average | Standard deviation | Actual package | Forecast package |
|-----------------|------------------|------------------------|-------------------|-------------------|----------------|------------------|
| 105             | 6667             | 3185                   | 919               | 3474              | 3              | 3                |
| 215             | 416667           | 199034                 | 57456             | 217117            | 5              | 5                |
| 255             | 50000000         | 2388405                | 689473            | 2605410           | 9              | 2                |
| 258             | 250000           | 11942                  | 3447              | 13027             | 3              | 1                |
| 307             | 125000           | 59710                  | 17237             | 65135             | 1              | 1                |
| 325             | 33333            | 15923                  | 4596              | 17369             | 5              | 5                |
| 369             | 83333            | 39807                  | 11491             | 43423             | 5              | 9                |
| 435             | 333333           | 159227                 | 45965             | 173694            | 3              | 3                |
| 445             | 41667            | 19903                  | 5746              | 21712             | 1              | 1                |
| 586             | 16667            | 7961                   | 2298              | 8685              | 5              | 2                |

4.4. Evaluation of accuracy of package Design results

According to the verification results, we can see that after testing the 10 groups of data, we can see that 6 groups are correct, 60% of the correct classification rate can be obtained, 7 groups are very close to the results, and 70% of the top2 correct classification rate, which proves that the method is effective.

At the same time, we also find that the companies with high annual electricity consumption (large users) and the companies with small annual electricity consumption (ordinary users) are different in the package. The price difference of large users is larger, and the price difference of ordinary users is very small. The company with better development of the industry makes the profit bigger, the company with the worse market makes the profit smaller; Companies with robust investments prefer fixed prices, while companies with risky investments prefer to split and float. The verification results are in line with the actual situation, and the prediction results show the effectiveness of the method. Thus, the prediction method can be used to customize a special package for customers.

5. Conclusion

In this paper, the package design model is used to analyze the electricity consumption and package from 695 enterprises, and the prediction method based on BP neural network is adopted to analyze the service form of training samples. Finally, a set of recommendation model based on enterprise electricity package design is formed, which can better select electricity package for enterprises according to their own actual situation, which realizes the idea of energy saving and improves the efficiency of service operation. It is of great significance to enhance the competitive strength of enterprises.

The package design model constructed in this paper is helpful for Guangdong electric power to meet the individualization of different power enterprises, differentiate the demand of power supply service, and realize the balance between supply and service demand, and help the power grid to optimize the resource allocation of power supply service. Improving the operation efficiency of enterprises and increasing the core competitiveness of enterprises are at the forefront of electric power reform.

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