Research on Business Expansion and Installation Methods Based on User Feature Analysis

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Abstract. With the changes in policies such as basic electricity bills and the opening up of low-voltage capacity, some regions have gradually seen cases of users reporting their unreasonable installation capacity, and the problem of unreasonable installation for business expansion is becoming increasingly prominent. Unreasonable installation of industrial expansion has caused problems such as waste of supporting investment, uneven distribution of public power grid resources, high pressure on high-quality services, and multiple fire safety hazards. In response to the above impact, this article proposes a business expansion and installation method based on the analysis of user energy demand characteristics from the perspectives of users and the power grid. It can reasonably determine the user's business expansion and installation capacity, select the optimal billing method, reduce user electricity costs, and make the investment of the power grid and users more reasonable, and efficiently utilize power grid resources.

Keywords: electricity demand, analysis, business expansion and installation, methods.

1 Introduction

Business expansion and installation is the starting point for power supply enterprises to establish a power supply and consumption relationship with customers, as well as an important part of customer service perception and satisfaction evaluation [1]. It is one of the core businesses that the country focuses on optimizing the business environment and improving the "electricity acquisition" indicator. Under the current new business environment development situation, it is required to provide customers with more convenient, efficient, intelligent, and cost-effective power supply services.

With the issuance of documents such as the Notice of the General Office of the State Council on Forwarding the Opinions of the National Development and Reform Commission and Other Departments on Cleaning up and Regulating the Charging of Urban Water Supply, Power Supply, Gas Supply and Heating Industry to Promote High quality Development of the Industry, and the Notice of the National Development and Reform Commission on the Provincial Power Grid Transmission and Distribution Elec-

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installation model of the industry has also brought new changes. The funding and construction management entities for external projects have shifted from users to governments and power supply enterprises, with customers no longer focusing on key areas such as access point locations, line open capacity, and access project costs. In some regions, there have been cases of users reporting unreasonable installation capacity.

The main research results on industrial expansion and installation in foreign countries mainly focus on the optimal way to connect to electricity [1-2]. Domestic literature on industrial expansion and installation mainly focuses on power supply companies, and relevant studies focus on improving business processes. Due to extended investment and third regulatory cycle policies, there are no relevant studies on policy-induced phenomena [3-12]. This article proposes a business expansion and installation method based on the analysis of user electricity demand characteristics, which can support power grid marketing personnel to reasonably determine the user's business expansion and installation capacity, help users choose billing methods based on their own situation, and avoid waste.

2 Analysis of the current situation of business expansion and installation

With the changes in policies such as basic electricity bills and the opening up of low-voltage capacity, some regions have gradually seen cases of users improperly reporting their installed capacity. Sampling statistics show the maximum load rate of business expansion users in a two and a half year interval in a certain province. Among them, 71.81% of high-voltage users have not reached the contracted capacity at their maximum load rate since power transmission; 29.98% of high-voltage users have not reached a maximum load rate of 40%, and their capacity accounts for 45.41% of the total installed capacity. There is still a large margin of open capacity, and the phenomenon of unreasonable installed capacity for existing users is quite common. The redundancy of installed capacity is severe, which not only wastes public power grid resources, but also affects the stability of the power grid and the inclusiveness of business expansion and supporting facilities. Some power supply departments still rely on experience and simple analysis to handle the expansion and installation work, which may lead to either excessive approved installation capacity for users or inappropriate recommended installation capacity for users, resulting in insufficient utilization of resources.

3 Research on determining the content of business expansion and installation based on user energy demand characteristics

In general, the higher the user's load rate, the relatively lower the average cost of using system resources. Accurately approving the electricity demand of users and determining the appropriate capacity for business expansion can increase load rates, reduce supporting construction, lower investment costs, reduce electricity expenses, and enhance

economic efficiency. If a reasonable billing method is chosen, the economic efficiency of energy consumption by users can be further improved.

3.1 Electricity demand forecasting methods

The prediction of electricity demand for business expansion users is the key to selecting business expansion capacity. Due to the user's lack of expertise in electricity usage patterns, the installation requirements provided by the power grid company may not be accurate. The installation personnel need to accurately analyze the characteristics of the user's energy consumption needs, and then accurately judge the electricity consumption situation. For the prediction of electricity consumption characteristics for industrial expansion users, electricity consumption can be predicted based on industry or process energy consumption characteristics, combined with daily electricity consumption characteristics, seasonal electricity consumption characteristics, maximum electricity load, peak valley difference, etc. from the sample feature library.

The electricity demand of users has a certain degree of randomness and inherent rules. Based on the electricity consumption characteristics of users in the historical database, users of the same type can be selected, historical data can be retrieved, and analysis and judgment can be carried out. Due to factors such as developed industrial economy and relatively stable industrial structure in most regions, the load curve and load characteristics have not changed significantly year by year. Therefore, based on the method of feature library, the characteristics of future electricity consumption load curve can be analysed.

From an operational perspective, it is necessary to obtain historical business expansion data and classify industries, analyze user behavior and energy consumption characteristics of historical business expansion, and form a basic database.

Basic database establishment: Organize historical business expansion data (including supporting power grid construction, electricity price implementation policies, 96 point electricity load data, etc.), classify by industry, analyze user behavior characteristics, energy consumption characteristics, etc.

User behavior characteristics: For example, industrial users exhibit behaviours such as expanding or reducing production capacity as the production situation changes; Residential users exhibit behaviours of increasing or saving energy consumption due to changes in temperature, weather, and energy prices; Agricultural users can increase or decrease their energy consumption according to the planting and breeding season.

Energy consumption characteristics: There are significant differences in the electricity load curves of different time, space, and users, forming unique energy consumption load curves for each user.

Based on the industry type of expansion users, obtain load data of users in the same industry from the basic database and predict the electricity consumption load of the expansion users; Low frequency data such as monthly electricity consumption of users in the same industry can be obtained from the basic database, as well as high-frequency electricity load data collected every 15 minutes. Based on mixed high and low frequency data, multiple prediction models can be combined to predict the maximum electricity load and consumption of users in the near and medium to long term.

Firstly, it is necessary to obtain the behavioural and energy consumption characteristics data of users in the same industry from the basic database, and predict the future electricity load or consumption of expanded users. Based on the materials provided by the expansion users in this industry, determine the nature of electricity consumption, combine with the historical electricity consumption trends of similar industry users, and analyze the development trend of electricity consumption and load for the expansion users in this industry. Multiple combination prediction analysis methods can be used for specific values. Analyze the regularity of electricity consumption released by users in different industries after expansion.

Then, obtain the behavioural and energy consumption characteristics data of users in the same industry from the basic database, and predict the electricity consumption load of expanded users in the near, medium, and long term in the future.

Finally, predict the electricity consumption characteristics. Based on the energy consumption characteristics of industries or processes, combined with the daily electricity consumption characteristics, seasonal electricity consumption characteristics, maximum electricity load, peak valley difference, etc. of similar industry users, analyze and judge the future electricity load curve.

There are several common prediction methods available for combination use. One is the time series method. Moving average method, exponential smoothing method, seasonal coefficient method, trend extrapolation method, Winters method, etc. are common time series methods. The characteristic of this type of method is that it is easy to predict, but the disadvantage is that the prediction accuracy is not high. The second is the correlation analysis method. This type of method also considers external factors related to load, such as socio-economic development and climate, when analyzing historical load data. By grasping the future socio-economic development dynamics, it achieves the goal of predicting load trends. The third method is regression analysis. When establishing a regression model, it is necessary to fully consider the mutual influence between data, appropriately increase the number of variable parameters in the existing model, improve the degree of freedom of the model, and ultimately improve the prediction accuracy. For some industrial users with high electricity consumption and difficult prediction, it is recommended to use the product consumption analysis method for prediction, which is based on the trend analysis of penetration rate of process electricity technology, to predict the unit output value or unit product electricity consumption; The maximum load should consider the impact of factors such as economy and temperature on load growth. The maximum load should be divided into basic load and air conditioning load, and multi factor regression analysis should be used to predict them separately.

3.2 Determination of business expansion capacity

Based on the predicted maximum electricity load in the near and medium to long term, power factor and load rate in the near and medium to long term, determine the required capacity for business expansion users in the near and medium to long term, and take the maximum value of both as the installed capacity S for business expansion.

$$S = \max(S1, S2) \tag{1}$$

$$S_1 = \frac{P_1}{COS\partial_1 * k_1} \tag{2}$$

$$S_2 = \frac{P_2}{COS\partial_2 * k_2} \tag{3}$$

In formula (1), (2), (3), S1 and S2 are the required capacities for short-term, medium and long-term transformers, and S is the selected transformer capacity;P1 and P2 are the maximum electricity loads in the near, medium, and long term; $COS\partial_1$, $COS\partial_2$ is the power factor in the near, medium, and long term.

Constraint: The determined power supply capacity must ensure the safe and reliable operation of the power grid. That is to say, the maximum power supply capacity of the substation to which the user's address belongs cannot exceed the product of the total rated capacity of the newly installed transformer and the maximum load rate (determined based on empirical values).

For users who are large and have a large number of electrical devices, the issue of simultaneity needs to be considered. For example, the electricity consumption for commercial installation capacity is generally calculated by multiplying the total capacity of the electrical equipment in the mall by the simultaneity rate. The industrial installed capacity is generally calculated by multiplying the total capacity of the factory's electrical equipment by the simultaneous rate. The expression for the reported installation capacity is as follows:

$$S_z = \sum_{i=1}^{n} s_i * L \tag{4}$$

In formula (4), S_z is the overall installed capacity for users, S_i is the capacity of various electrical devices, and L is the simultaneous rate of electrical devices.

After simulating the normal operation of business expansion and installation users obtain the simulated electricity generation and electricity load curve, optimize it to reduce the maximum electricity load, and thus reduce the business expansion and installation capacity. Based on the simulated electricity consumption and load curve, peak and valley time of use electricity prices can be considered to optimize and adjust the electricity consumption mode, thereby optimizing the electricity load curve, reducing the peak valley difference, and lowering the maximum loads P1 and P2, thereby reducing the installed capacity for business expansion.

3.3 Optimize billing methods

According to regulations, users can choose to implement single or two-part electricity prices for capacities between 100 kVA and 315 kVA; For 315 kVA and above, a two part electricity price system will be implemented.

Users who implement the two-part electricity price can choose to pay the capacity demand electricity fee based on transformer capacity, contract maximum demand, or actual maximum demand. Among them, for users who choose to implement the demand electricity price billing method (i.e. billing based on contract maximum demand or actual maximum demand), if their monthly electricity consumption per kilovolt ampere reaches 260 kilowatt hours or more, the monthly demand electricity price shall be executed at 90% of the approved standard.

Basic electricity fee charged based on capacity: Basic electricity fee=Transformer capacity × capacity payment

Basic electricity fee charged based on actual maximum demand: Basic electricity fee=actual maximum demand × Demand electricity price

When the monthly electricity consumption per kilovolt ampere is ≥ 260 kilowatt hours, the demand electricity price in the above formula can be further multiplied by 0.9. Based on simulation data, calculate different billing methods and compare them to determine the optimal billing method. Therefore, for users whose monthly electricity consumption per kilovolt ampere is less than 260 kilowatt hours and users whose monthly electricity consumption per kilovolt ampere is greater than or equal to 260 kilowatt hours, the maximum demand critical ratio is calculated separately, denoted as critical ratio 1 and critical ratio 2, as follows:

$$K_i = \frac{X_i}{R_i} \tag{5}$$

In formula (5), K_i is the critical ratio of maximum demand at voltage level i is 1; X_i is the capacity price at voltage level i; R_i is the price for demand at voltage level i.

$$V_i = K_i / 0.9 \tag{6}$$

In formula (6), V_i is the critical ratio is 2.

There are two critical ratios, one is the critical ratio for users with a monthly electricity consumption of less than 260 kilowatt hours per kilovolt ampere (critical ratio 1), and the other is the critical ratio for users with a monthly electricity consumption of more than 260 kilowatt hours per kilovolt ampere (critical ratio 2). The billing method for selecting the critical ratio is shown in Table 1.

According to the transmission and distribution electricity price standards of Jiangsu Province's power grid, the following are as follows:

- The monthly demand electricity price for 1-10/20 kV is 51.2 yuan/kilowatt, and the capacity pricing is 32 yuan/kilovolt ampere.
- The demand electricity price for 35 kV is 48 yuan/kilowatt, and the capacity pricing is 30 yuan/kilovolt ampere.
- The demand electricity price for 110 kV is 44.8 yuan/kilowatt, and the capacity pricing is 28 yuan/kilovolt ampere.
- The demand electricity price for 220 kV and above is 41.6 yuan/kilowatt, and the capacity pricing is 26 yuan/kilovolt ampere. Actual data can be used to calculate the critical ratio and assist users in selecting billing methods.

Table 1. Critical values for billing method comparison

Voltage level	Critical value 1	Critical value 2	Comparison conclusion
1-10/20 kV	32/51.2=0.625	0.625/0.9=0.694	When the monthly electricity consumption per kilovolt ampere is less than 260 kilowatt hours, and the actual maximum monthly demand is less than 0.625 of the operating capacity, choose the demand electricity price. When the monthly electricity consumption per kilovolt ampere is greater than or equal to 260 kilowatt hours, and the actual maximum monthly demand is less than 0.6944 of the operating capacity, choose the demand electricity price.
35 kV	30/48=0.625	0.625/0.9=0.694	
110 kV	28/44.8=0.625	0.625/0.9=0.694	
220 kV and above	26/41.6=0.625	0.625/0.9=0.694	

In contrast to optimized billing, the business expansion and installation process is shown in Figure 1.

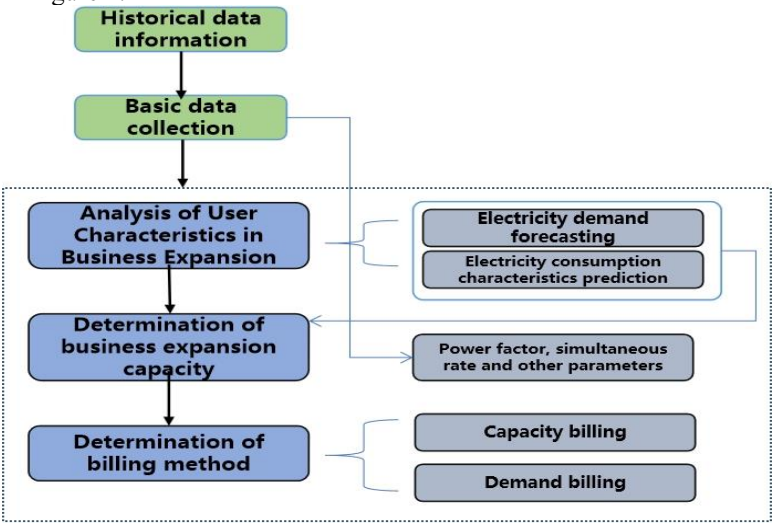

Fig. 1. Schematic diagram of optimizing industry expansion and installation process

4 Conclusion

At present, some regions have seen cases of users reporting unreasonable capacitance usage. To effectively solve the problem, this article provides a business expansion reporting method based on user characteristic analysis. Firstly, obtain historical expansion data and classify industries to form a basic database. Then, based on the industry types of expansion users, obtain load data for users in the same industry from the basic database and predict the electricity consumption load of the expansion users. Next, based on the predicted electricity load, the value of the installed capacity for business expansion will be determined. Finally, different billing methods will be compared based on the critical ratio of maximum demand under different voltage levels to determine the billing method for business expansion users. Together with the final business

expansion installed capacity, a business expansion installation optimization decision plan will be formed.

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