Power Planning Algorithm Considering the Operating Strategy of a Power Sales Company under the Background of New Electricity Reform

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Abstract. With the introduction of the open electricity sales side in the new power reform, more and more power sales companies have joined the competition on the power sales side, and various power sales companies have been defined as different names due to different resources used. In view of the problem of power supply planning under the background of new power system reform, this paper firstly models the operation of different types of power sales companies, and designs the power planning algorithm considering the impact of the sales company, and then analyzes its operation for load forecasting and power planning. The impact is finally calculated by simulation to calculate the amount of peak reduction in load forecasting and power planning capacity.

Introduction

With the increasing demand for urban energy in the future, traditional energy allocation methods will be difficult to maintain economic development. Renewable energy and traditional energy complement each other to meet the needs of the times [1-2]. The power market reform has promoted the development of distributed power generation technology, energy Internet technology, energy system supervision technology, and the widespread application of new energy trading methods. As a participant in the power trading market, the power sales company can provide users with various energy services [3] while participating in market competition on behalf of users.

In [4], in order to promote the release of the power-selling side, the qualifications and characteristics of various types of power-selling companies were studied, and the foreign development model was used to propose a business model that was in line with its development; the literature [5] also targeted a new round of domestic development. The power reform, combined with the various operating mechanisms and development trends of the foreign power-selling side, proposes the key to the future construction of China's electricity-selling market and measures to promote marketization; the literature [6] studies the new mode of load aggregators participating in market transactions. It brings flexibility to the market and utilizes market time to integrate resources. The above literature considers the impact of peak-to-valley time-of-use electricity prices and renewable energy consumption on purchase and sale strategies, but few studies have examined the impact of sales company operating strategies on grid power planning.

In view of the power planning problem under the background of the new power market reform, this paper considers the operation strategies of energy service providers and load aggregators separately, and reduces the peak value of load forecasting curve by means of distributing distributed renewable energy and adjusting interruptible load. The purpose of reducing the overall investment in traditional thermal power plant power planning is to save costs.
Sales Company Operating Strategy

With the development of the energy Internet, the sales company can break through a single power operation mode, and transform to a high-level power sales company that takes into account load dispatching and energy aggregation, and gradually expands into a multi-energy operation mode, which has certain energy production and conversion level storage. Able to provide a variety of energy sources to users in a certain area. The specific structure of the electricity sales company is shown in Figure 1.

Energy Service Provider Operation

The main targets of energy service providers include: distributed energy, cogeneration, energy storage and other equipment to meet the needs of end users for diversified energy. Distributed energy (DG) is an integrated energy system close to the user side, using distributed power sources such as photovoltaic power generation and wind power as a means.

Load Aggregator Operation Business

Load aggregator (LA), as an intermediate mechanism between the power grid dispatching center and large-scale users, can greatly improve the peak-filling capacity of the load side by controlling the power equipment in real time and maintaining the balance between supply and demand of the power grid. Its operations mainly include: transferable load and interruptible load.

Power Planning Algorithm Taking into Account the Operating Strategy of the Sales Company

Consider the Power Plan of the Electricity Sales Company

The goal of power planning is to seek the most economical planning results based on load demand forecasts and to ensure operational safety. The calculation formula for the planning of the power capacity considering the total capacity matching is as shown in equation (1):

\[ P_{GF} = P_{GQ} - \sum_{i=1}^{n} P_{ji} \]  

(1)

Among them, \( P_{GF} \) is the capacity of the traditional generator set in the power supply plan; \( P_{GQ} \) is the total capacity of electricity generated for prediction; \( P_{ji} \) is the power generation capacity owned by the ith sales company.

In addition to the matching of the total capacity of the power supply plan, another consideration is the maximum load value of the daily power, and the calculation formula for considering the phase balance of the daily maximum load is as shown in equation (2).

\[ P_{GF} = \max P_{i, high} - \sum_{i=1}^{n} P_{ji} \quad i \in [0.365] \]  

(2)

Among them, \( P_{i, high} \) is the highest load on the day of the first day.
Simulation Study

Grid Load Data and Forecast in a Certain Area

The long-term forecast of load is combined with the indicators of local economic development and energy development planning. Table 1 shows the goals of energy development in the region during the 13th Five-Year Plan period. Figure 2 shows the power operation and predicted values of the region in recent years.

Table 1. Targets for energy development in a region during the “Thirteenth Five-Year Plan” period.

| Classification | index                                | 2015  | 2020  |
|----------------|--------------------------------------|-------|-------|
| Total control  | Total energy consumption of the whole society | 11388 | 12500 |
|                | Whole society electricity consumption/ 100 million kWh | 1406  | 1560  |
| Structural     | Coal share /%                         | 36    | 33    |
| optimization   | Coal share /%                         | 10    | 12    |
|                | Non-fossil energy ratio /%            | 13    | 14    |
|                | Local renewable energy power generation installed capacity /% | 4.7   | 10    |

As can be seen from Figure 2, the area is the receiving power grid, and its power consumption is greater than the power generation in the region. A large part of the power supply comes from the external power grid. This paper only considers the capacity allocation of the power plan in the region, so only consider the power generation in the region. Forecast of equipment capacity growth and forecast of peak load of electricity consumption in the region.

Sales Company Data and Forecasts

Table 2 shows the growth in the number of electricity sales companies in the region. This paper takes energy service providers and load aggregators as research objects. Figure 3 shows the energy-saving effect of an energy service provider's energy business. Figure 4 shows the effect of a load aggregator on peak clipping response in a particular area.

Table 2. Growth in the number of electricity sales companies in the region.

| years | 2016 | 2017 | 2018 |
|-------|------|------|------|
| Number of electricity sales companies | 117  | 761  | 852  |
Simulation Results

This paper divides the power plant power plan into total capacity and peak shaving capacity. The simulation of total capacity is for energy service providers; the simulation of peak capacity is for the impact of load aggregators.

**Total Capacity Matching.** From Figure 2, we can predict the annual growth capacity of power generation equipment. Combined with Table 2 and Figure 3, we can predict the growth of energy service providers and the savings for power consumption in the next five years. Then we can get regular power supply according to formula (1). The planned total capacity requirements, the simulation results are shown in Table 3.

| index                              | 2021 | 2022 | 2023 |
|------------------------------------|------|------|------|
| Forecast total power generation machine / 10,000 kW | 20   | 15   | 150  |
| Forecast energy service provider installed increment / 10,000 kW | 3    | 7    | 13   |
| Power planning total capacity / 10,000 kW | 17   | 8    | 127  |

**Peaking Capacity Matching.** From Figure 2, we can predict the maximum annual load of electricity. Combined with Table 2 and Figure 4, we can predict the growth of load aggregators in the next 5 years and the effect on peak shaving. Then we can get the conventional power plan according to formula (2). The total peaking demand, and then the total amount of power planning, the simulation results are shown in Table 4.
Table 4. Peak matching simulation results.

| index                                                        | 2021 | 2022 | 2023 | 2024 |
|--------------------------------------------------------------|------|------|------|------|
| Predicted power consumption maximum load increment / 10,000 kW | 160  | 130  | 120  | 120  |
| Predictive load aggregator can respond to load / 10,000 kW    | 60   | 80   | 109  | 120  |
| Power planning peaking / 10,000 kW                           | 100  | 50   | 11   | 0    |
| Power planning total capacity / 10,000 kW                     | 77   | 38   | 8.5  | 0    |

Taking the annual planned total capacity that satisfies the total capacity matching and peak shaving matching as the target, the larger value is used as the reference value of the power planning for the year, and the margin of 50,000 kW is retained on the basis, and the final calculation result is obtained. As shown in Figure 5.

It can be concluded from Tables 3 and 4. With the development of the power sales company, it will have a huge impact on the load side management, effectively solving the peak demand of the power grid, which also indicates that the auxiliary services in the future power market are mainly the responsibility of the electricity sales company with lower operating costs. In addition, with the direct consumption of distributed energy at the end, the power planning capacity of traditional thermal power plants is reduced, and the optimization and upgrading of energy structure is promoted.

Summary

This paper discusses the impact of power sales companies on power supply planning in the context of new power reforms. The following conclusions can be drawn from a certain area:

1. With the advancement of new power reforms, more and more power sales companies will participate in the power market. The increase in power sales companies is conducive to the stable operation of the power grid, improving the penetration rate of new energy sources, promoting the efficient use of energy, and considering the impact of new power reforms when formulating power supply plans.

2. Different types of power sales companies are faced with different objects. The load aggregator is mainly responsible for the function of power grid peak shaving. The role of energy service providers is to dissipate distributed energy. The two reduce the capacity of power supply planning from different angles.

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