Spatial Load Forecasting of Urban Power Grid Based on Regulatory Detailed Planning

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Abstract. Spatial load forecasting is a basic work in urban power grid planning. Spatial load forecasting should not only forecast the future load, and the spatial distribution of future load should be provided. Only based on the urban controlled detailed planning, determine the future load of each plot, so as to determine the location and capacity of the substation, model and path of line, the installation of switchgear and its input time and other decision variables, to plan.

1. Introduction
Spatial load forecasting, also known as district load forecasting, is the basis of urban power grid planning. Its concept was first proposed by H.L. Willis of the United States in the 1980s[1-2]. Total load forecasting is used as total control in spatial load forecasting. In regional development, various industries and departments coordinate and promote each other, and there is a relatively fixed proportion relationship internally. In the process of load distribution, spatial load forecasting should not only ensure that the total load of all cells is equal to the result of total load forecasting, but also maintain a certain proportion among all kinds of loads.

At present, the most commonly used spatial load forecasting method at home and abroad is the land use simulation method based on the urban regulatory detailed planning[3]. The land use simulation method is a top-down spatial load forecasting method. Based on the total load forecasting results, the total load forecasting is distributed to the community from top to bottom, so as to predict the load distribution of the distribution network in the future.

In order to provide location information for load forecasting, spatial load forecasting usually needs to divide the power supply area into many cells, and then predict the load of each cell separately. Users can be divided into several categories according to the characteristics of land use and electricity consumption, which are called land use types. Industry and residents are not only different in load characteristics, but also in land requirements. The power consumption characteristics of each land use type can be given by typical load density curve, and the change of typical load density curve can be predicted by terminal load forecasting method. Therefore, the spatial load forecasting can be transformed into land distribution forecasting. According to the urban regulatory detailed planning, as long as the spatial distribution of land use types is predicted, the spatial distribution of load can be calculated. The process of solving the spatial distribution of land use is called the process of land use simulation.
Spatial load forecasting includes four modules: (1) data preparation module; (2) total forecast module; (3) land use simulation module; (4) land load conversion module.

2. Plot division and land use classification

Cell division and land use classification are two steps of spatial load forecasting that have a global impact on the forecasting process. Once the cell and land type are determined, the subsequent data collection and processing are carried out around them. Generally speaking, both the purpose and requirement of planning and the situation of data collection should be considered in the division of residential area and power consumption classification. In addition, land classification should integrate the characteristics of users' land use and electricity use. Table 1 lists the commonly used land classification.

| Major categories | Number | Subclass                  |
|------------------|--------|---------------------------|
|                  | 1      | Small industry            |
|                  | 2      | Warehousing               |
| Major categories | 3      | Medium sized industry     |
|                  | 4      | Large industry            |
|                  | 5      | Municipal facilities      |
| Business         | 6      | Retail and entertainment  |
|                  | 7      | Office and hotel          |
|                  | 8      | High rise building        |
| Resident         | 9      | Rural users               |
|                  | 10     | Residential building      |
|                  | 11     | Villa                     |
| Municipal        | 12     | Municipal office          |
| administration   | 13     | Research institutions     |
| School           | 14     | Primary and secondary schools |
|                  | 15     | University                |
| Open space       | 16     | Constrained by the environmen |
|                  | 17     | Bound by the government   |
|                  | 18     | Bound by the public       |
|                  | 19     | Private or unit owned     |
|                  | 20     | Flood area                |
|                  | 21     | Developable but expensive |
|                  | 22     | Exploitable               |

3. Plot division and land use classification

Spatial data collection is divided into three parts: the community's own attributes, distance factors and environmental factors. Table 2 lists common spatial data collection items.

| Category                     | Number | Attribute               |
|------------------------------|--------|-------------------------|
| The property of the community itself | 1      | Sloping fields          |
|                              | 2      | Limit fields            |
4 There are trees
5 Municipal planning constraints

6 Nearest distance to railway
7 The nearest distance to the expressway
8 The shortest distance from the highway
9 The nearest distance to the subway
10 The nearest distance to school
11 The nearest distance to large factories
12 The nearest distance to water source
13 The nearest distance to the shopping mall
14 The nearest distance to the city center
15 The nearest distance to the center of the zone
16 The nearest distance to the industrial center
17 The nearest distance to the commercial center
18 Residential area within 0.5km
19 Residential area within 3 km
20 Commercial area within 3km
21 High rise buildings within 0.5 km
22 Sloping fields

The attribute data of the community itself can be obtained from the planning department based on
the urban regulatory detailed planning, including terrain, landform, municipal planning constraints, etc.
These data are the main way to consider the urban development planning in the land use prediction
process. The distance factor reflects the geographical location, traffic conditions and the distribution of
factories, schools and municipal facilities nearby. The environmental factors reflect the commercial
development degree and market potential around the residential area. For a certain community, the
"residential area within 0.5km around" reflects the community conditions of the community. If there is
no one living near the community, there are few people living in the community. "Residential area
within 3km around" reflects the potential of the community to develop business, schools and
municipal facilities. The large number of people living within 3km around the community indicates
that the market potential is great and it is very likely to construct schools and municipal facilities in the
community. The "commercial area within 3km around" reflects the degree of commercial development
in the neighborhood. If the commerce is already well developed, it is unlikely to develop new
commerce in the community.

4. Total, terminal and classified load forecasting
Total load forecasting is system load forecasting, which is used as total load control in spatial load
forecasting. The function of terminal load forecasting is to forecast the typical load curve of land use
type. In the process of load distribution, spatial load forecasting should not only ensure that the total
load of all cells is equal to the result of total load forecasting, but also maintain a certain proportion
among all kinds of loads. In the development of the city, various industries and departments are
coordinated and promoted each other, and there is a relatively fixed proportion relationship internally.
The classification land forecast is to use this proportion relation to deduce the future land growth of
this land type from the total amount forecast. The proportional relationship can be obtained from
statistical data, and can also be directly used by the current proportional relationship. Classified land
forecast can also be obtained from the land planning department, but the rationality of the data should be verified, especially consistent with the system load forecast.

5. Land use simulation process

Land use simulation is essentially a land use prediction process, which aims to predict the future development of the community. The process of land use simulation includes three steps: the establishment of fuzzy knowledge base of land use requirements, the evaluation of community fitness and the optimal allocation of land use.

6. Example analysis

Taking the residential load forecasting in a certain urban area as an example, the application analysis and result verification of the method proposed in this paper are carried out. This plan takes 2019 as the current year to forecast the load of a certain urban area in 2050[4-7].

There are 189 residential areas in the urban area in the current year, and the residential land area is about 6.65km², and the load density is 18MW/km². Among them, 31 communities only know the operation period, and 44 communities have known the historical load value of 5 years or more. According to the future urban municipal master plan, the total residential land area in this area will reach 17.88km² by 2050. It has been determined that in 2020, the area of new residential quarters added by vacant land will be 1.85km², divided into 28 districts, and another 72 districts will be put into operation in the planning period, but the specific operation time is unknown. Table 3 lists the historical load data of residents in the city.

| Particular year | Load/(MW) |
|-----------------|-----------|
| 2010            | 56.5      |
| 2011            | 62.1      |
| 2012            | 68.2      |
| 2013            | 75.0      |
| 2014            | 81.5      |
| 2015            | 88.6      |
| 2016            | 96.3      |
| 2017            | 103.5     |
| 2018            | 111.3     |
| 2019            | 119.7     |

By using the trend extrapolation method, by 2050, the residential load will be 357.6MW and the load density will be 20MW/km². According to the regulatory detailed planning, the spatial load distribution of each district in 2050 can be obtained.

7. Conclusion

The forecast of long-term annual load is very important for urban power grid planning. In this paper, combined with the regulatory detailed planning of a certain urban area, the residential load of each residential area in the long-term year is predicted. The results provide necessary reference for future power grid planning and promote the coordinated development of power grid planning and social economy.

References

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