Load Forecasting of Urban Power Grid under the Condition of Saturation

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Abstract. Urban distribution network is an important part of the power system, as one of the city's important infrastructure; it is closely related to the city's socio-economic development. The goal of urban distribution network planning is to improve the power supply ability and electricity quality constantly of the city network through scientific planning and constructing network-strong, structure-applicable, safe, reliable, running-flexible, energy-saving and efficient distribution network, and consequently the distribution network will meet the requirements of urban economic growth and society development. This study takes a county in eastern Jiangxi as an example; this paper chooses a variety of load forecasting methods to carry on the recent load forecasting calculation to central urban area. At the same time, this paper uses load density index method to predict the Long-term load forecasting of electric saturation load of central urban area lasted until 2030. And further study shows the general distribution of the urban saturation load in space.

1. Introduction
Urban electricity saturation load is a new concept put forward by power load forecasting and power network planning in recent years. Power load forecasting is one of the important works of the power sector. Accurate load forecasting can reasonably arrange the start and stop of the generator set inside the grid, keep the safety and stability of the grid operation, reduce the unnecessary reserve capacity and arrange the unit maintenance Plan to protect the normal production and life of society, effectively reduce power generation costs, improve economic efficiency and social benefits. The power load density is closely related to per capita GDP, population density, land use nature and regional economic planning layout. The trend of power load density increases with the growth of social and economic indicators. But load density cannot grow indefinitely; regional electricity demand will become saturated after full development.

2. Urban electricity demand forecast

| Table 2.1. Data on per capita electricity consumption for a city from 2005 to 2014 |
|------------------------------------------|------|------|------|------|------|------|
| Years                                   | 2005 | 2010 | 2011 | 2012 | 2013 | 2014 |
| Population(ten thousand)                | 153.51| 158.75| 159.94| 161  | 161.95| 162.98|
| Per capita electricity consumption(kWh/year) | 1007 | 1965 | 2156 | 2235 | 2401 | 2506 |
| total electricity consumption (billion kWh) | 15.46| 31.19| 34.48| 35.99| 38.89| 40.84 |
Based on the contents of "Urban Master Plan of This City (2012-2030)", the plan forecast the population is expected to reach 1.65 million, 1.75 million and 2 million in 2015, 2020 and 2030 respectively.

As can be seen from the above table, the city's per capita electricity consumption per capita in 2014 was 2506 kWh/year, it rising rapidly for several years in a row. The reason for this is that industrial development in the park is fast and large industrial users increase their electricity consumption rapidly after they are put into operation. Based on the comprehensive historical per capita electricity consumption data, the per capita electricity consumption and large industrial electricity consumption overlay method, the electricity consumption reached 2650 kWh/year. From 2010 to 2015, the average per capita electricity consumption data shows that the average per capita electricity consumption increased by 137 kWh/year during the "12th Five-Year Plan" period. Therefore, it is estimated that the average per capita electricity consumption by 2020 Power by 3500 kWh/year access. From 2020 to 2030, the per capita electricity consumption per capita will gradually slow down as the city matures. It is estimated that by 2030, the average per capita electricity consumption will be 4.500 kWh/year.

Combined with the per capita electricity consumption indicators and relative indicators of the developed countries or regions in the "city electric power planning norms", therefore, we can conclude that a long-term planning in the long-term integrated use of electricity by 4500kWh/year

To sum up, the predicted annual electricity consumption of this city in the whole year is as follows:

**Table 2.2.** Comprehensive electricity consumption per capita forecast result table for the whole society of a city.

| Years | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2030 |
|-------|------|------|------|------|------|------|------|------|
| Population(ten thousand) | 162.98 | 165 | 167 | 169 | 171 | 173 | 175 | 200 |
| Per capita electricity consumption(kWh/year) | 2506 | 2650 | 2800 | 2950 | 3100 | 3275 | 3500 | 4500 |
| Total electricity consumption(billion kWh) | 40.84 | 43.73 | 46.76 | 49.86 | 53.01 | 56.66 | 61.25 | 90.00 |

3. Urban power load forecasting

3.1. Trend extrapolation

**Table 3.1.** Unit of forecast for the maximum load of the whole society for the year of a city: 10000 Kw

| Method of prediction | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2030 |
|----------------------|------|------|------|------|------|------|------|------|
| Gray method          | 655.4 | 728.94 | 815.78 | 912.78 | 1021.43 | 1143.00 | 1278.90 | 2356.13 |
| Regression method    | 655.4 | 727.63 | 806.10 | 893.20 | 989.67 | 1096.64 | 1215.06 | 2176.06 |
| Growth rate method   | 655.4 | 724.61 | 795.85 | 874.30 | 960.43 | 1055.02 | 1158.88 | 1998.43 |
| Elastic coefficient method | 655.4 | 721.99 | 784.73 | 852.92 | 927.20 | 1007.79 | 1095.51 | 1801.64 |
| Per capita consumption method | 655.4 | 717.93 | 772.31 | 831.09 | 894.30 | 962.29 | 1035.36 | 1639.00 |
3.2. **Maximum load using hourly method**
Due to the rapid growth of the industries such as ceramics, aviation and automobiles in a certain city in recent years, the maximum load utilization hours in a city increased year by year from 2005 to 2012. Due to the economic impact, a certain city tends to be stable at about 6200 hours from 2012 to 2014. It is estimated that industrial development will stabilize in the next two to three years. The maximum load utilization hours from 2015 to 2017 are 6,200 hours, 6,100 hours in 2018, 6,200 hours in 2019, 6,100 hours in 2020 and 5,600 hours in 2030. Based on this, we can predict the annual maximum load results based on the annual forecast of electricity consumption of the whole society as follows.

| Years | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2030 |
|-------|------|------|------|------|------|------|------|------|
| Total electricity consumption | 40.84 | 44.49 | 48.74 | 52.90 | 57.94 | 62.31 | 66.80 | 119.00 |
| Maximum load utilization hours | 6231 | 6200 | 6200 | 6200 | 6300 | 6200 | 6100 | 5600 |
| The maximum load of the whole society | 655.4 | 717.63 | 786.10 | 853.20 | 919.67 | 1005.00 | 1095.00 | 2125.00 |

### 4. Analysis of Load Forecasting Results

#### 4.1. Comparative analysis

| Load forecasting method | Year2015 | Year2020 | Year2030 |
|-------------------------|----------|----------|----------|
| 1. Trend extrapolation   | 724.22   | 1156.74  | 1994.25  |
| 2. Per capita energy consumption method and maximum load use hour method | 717.63 | 1095 | 2125 |

As can be seen from the table, the recent data is reasonable by using the trend extrapolation, the revised forecasts for the results of the program. And the long term data forecasted by load density method and average capacity prediction result is more reasonable.
4.2. Growth rate

Table 4.2. Annual average growth in different stages.

| Years          | The 11th Five-Year | The 12th Five-Year | 2015     | The 13th Five-Year | 2020 | 2020~2030 | 2030 |
|----------------|--------------------|--------------------|----------|--------------------|------|-----------|------|
| Maximum load(MW) | --                 | --                 | 708.7    | 1085.85            | --   | 2187.85   |      |
| Annual average growth rate (%) | 13.42 | 6.1 | -- | 8.91 | -- | 7.26 |      |

Analysis shows that, within the past five years, a city will be in the middle speed development stage under the influence of the international environment and national policies. In the 2020~2030 years, the economic and social development will be gentle. In general, after a period of rapid growth, the load has entered a slow and slow growth stage. The load growth in a city is in line with this rule.

5. Summary

Through calculation and analysis, it is determined that the maximum load of the city in 2015 is 708.7MW, the maximum load of electricity is 1085.85MW in 2020, and the maximum load in 2030 is 2187.85MW. Combined with the results and process of the load forecasting in this study, it can be found that the growth rate method, the gray system method and the regression analysis method in the load forecasting method have the advantages of accurately reflecting the overall level of the urban electricity load, but the disadvantage of these methods is that it can not reflect the spatial distribution of the load. In the construction of power grids, in order to more accurately promote the grid substation distribution and power grid construction, the total load and load growth position is the amount that we must know.

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