

Load Forecasting of Central Urban Area Power Grid Based on Saturated Load Density Index

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Abstract. In the current society, coordination between urban power grid development and city development has become more and more prominent. Electricity saturated load forecasting plays an important role in the planning and development of power grids. Electricity saturated load forecasting is a new concept put forward by China in recent years in the field of grid planning. Urban saturation load forecast is different from the traditional load forecasting method for specific years, the time span of it often relatively large, and involves a wide range of aspects. 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 work 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 can not grow indefinitely, regional electricity demand will become saturated after full development.

2. Electricity demand forecast

2.1. Common methods of load forecasting

Commonly used power load forecasting methods are broadly divided into two categories: The first method starts from the predicted power and is converted to the electricity load, such as integrated electricity level method, single consumption method, growth rate method and power elastic coefficient method; another type of method predicts the electricity load directly, such as regression analysis, gray system method and load density method.

2.2. The selection of Load forecasting methods



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To forecast electrical load in the Central Urban Area, we mainly use the growth rate method, the regression method, the gray method, the per capita electricity consumption method, the average load method for calculating and Load density method. At the same time, we check with the number of hours of using the maximum load.

3. Load Forecasting

In this study, we selected a county in Jiangxi Province as an example to load forecast, the county is located in the eastern part of Jiangxi Province, it has a good industrial base. In the 12th five-year plan period, the economic and social development achievements of the central urban area are very significant. So it needs to further increase the demand for power network construction. This load forecast is a recent load forecast for the central urban area from the future to 2020, and the long-term load forecast from the future to 2030.

3.1. Recent load forecast

3.1.1. Electricity forecast.

According to central urban area historical load development level, a variety of methods are calculated by programming, we selected five of these methods for analysis. At the same time, we made a horizontal comparison of the development trend of meeting the maximum load utilization hours. The five methods are the growth rate method, the regression method, the gray method, the per capita electricity consumption method and the elastic coefficient method.

Table 3-1 Forecast of Total Electricity Consumption in Central Urban Area Unit: 100 million kWh

method of prediction	Year 2014	Year 2015	Year 2016	Year 2018	Year 2019	Year 2020
Gray method	6.9495	7.3392	8.7514	11.7464	13.6088	15.7665
Regression method	6.9495	7.3392	8.3205	10.0281	13.6088	11.7356
Growth rate method	6.9495	7.3392	8.3344	10.6064	11.8898	13.2749
Elastic coefficient method	6.9495	7.3392	8.253	10.4359	11.7351	13.1961
Per capita consumption method	6.9495	7.3392	8.3554	10.1178	11.0123	11.9374

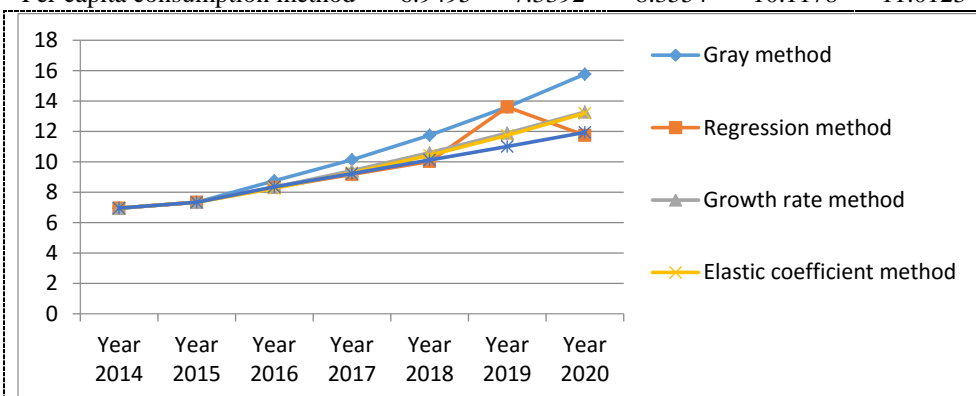


Figure 3-1 Forecast of Total Electricity Consumption in Central Urban Area

Unit: 100 million kWh

We choose high, medium and low three programs as the electricity forecast alternative, and recommend the program as the final plan for this power forecast. We can see from the table below, to 2020, Dongxiang County, the whole society electricity consumption is 13.2789 billion kWh.

Table 3-2 Central Urban Area, the whole society electricity consumption forecast results High and low units: 100 million kWh

Scheme comparison	Year 2014	Year 2015	Year 2016	Year 2018	Year 2019	Year 2020
High program	6.9495	7.3392	8.253	10.0281	10.8819	11.7356
Middle program	6.9495	7.3392	8.3344	10.6064	11.8898	13.2749
Low program	6.9495	7.3392	8.7514	11.7464	13.6088	15.7665

3.1.2. Load Forecasting.

According to load history data, combining with electricity consumption forecast results, we choose the appropriate forecasting method is used to forecast the power load. The five methods are the growth rate method, the gray method, the average load method and the maximum load utilization method. After a comprehensive analysis, we recommend a basic forecasting scheme.

Table 3-3 Highest load forecast for the whole society of Central Urban Area Unit:MW

method of prediction	Year 2014	Year 2015	Year 2016	Year 2017	Year 2018	Year 2019	Year 2020
Gray method	130.9	144.5	162.59	182.1	203.59	228.43	255.85
Growth rate method	130.9	144.5	157.51	168.53	178.64	187.57	195.08
Average load method	130.9	144.5	152.63	174.75	186.75	201.63	215.5
Maximum load utilization hours	130.9	144.5	157.32	186.69	191	207.83	227.09

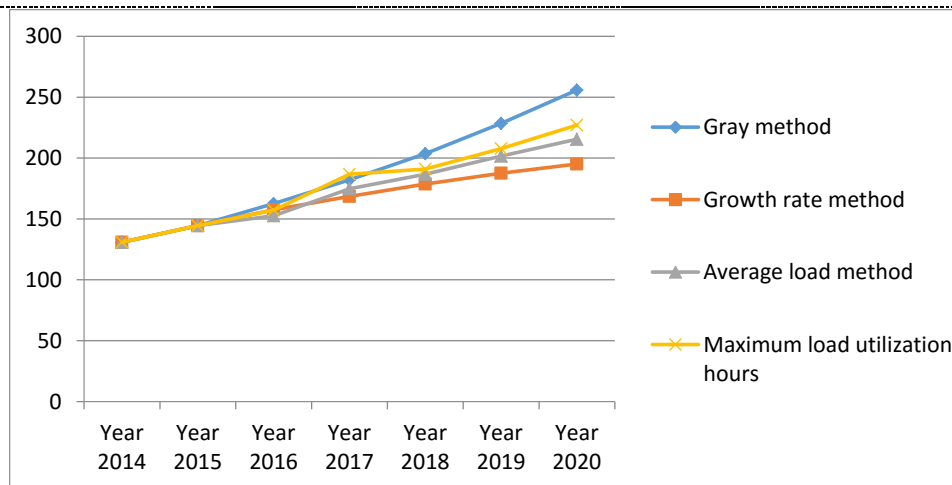


Figure 3-3 Highest load forecast for the whole society of Central Urban Area Unit:MW

We choose high, medium and low three programs as the load forecast alternative, and recommend the program as the final plan for this load forecast, we can see from the table below, to 2020, central urban area, the maximum social load forecast is 227.09MW.

Table 3-4 Central Urban Area, the total social load forecast results of high, medium and low programs Unit: MW

Scheme comparison	Year 2014	Year 2015	Year 2016	Year 2017	Year 2018	Year 2019
High program	130.9	144.5	162.59	186.69	203.59	228.43
Middle program	130.9	144.5	157.51	174.75	191	207.83
Low program	130.9	144.5	152.63	168.53	178.64	187.57

3.1.3. Maximum load utilization hours.

Maximum load typical day of this central urban area appears in the summer, summer temperatures are higher, residents living electricity consumption was affected by temperatures and increased. We combine the maximum load utilization hours in central urban area in recent years. Annual maximum load utilization hours of central urban area as shown in the table below.

Table 3-5 The recent electricity and load forecast results of Central Urban Area

Project	Year2014	Year 2015	Year 2016	Year 2017	Year 2018	Year 2019	Year 2020
The whole society electricity consumption (Billion kWh)	6.9495	7.3392	8.3344	9.4221	10.6064	11.8898	13.2749
The whole society the maximum load (MW)	130.9	144.5	157.51	174.75	191	207.83	227.09
Maximum load utilization hours (h)	5309.015	5079.0311	5291.347	5391.7597	5553.089	5720.926	5845.656

3.2. Forward load forecast

3.2.1. Load density index method.

Load Forecasting in this central urban area determine the load density indicator by investigating the load density of some of the same land properties in the case of saturation, considering plots development timing and strength. We use the cell load density index method to predict, and compare with other regions of the domestic load density and analysis, verify the rationality of the forecast results. According to the basic data collected in this plan, we determine load classification of load distribution prediction take the planning department classification method which according to land properties. Finally, we determine divide planning area load and land properties into eight categories. We divide Public management and public service facilities into administrative office land, cultural facilities land, educational research sites, sports land, medical and health land and so on. According to city planning results, the demand for electricity is different for different land properties, and therefore must be divided into blocks for analysis.

Table 3-6 Central Urban Area center city construction land balance table

Serial number	Land code	Land name	Planning (2030)		
			Area (ha)	proportion(%)	Per capita (m2 / person)
1	R	Residential land	961.3	30.6	32
2	A	Public management and public service facilities	194.1	6.2	6.5
	A1	Administrative office land	40.4	1.3	1.3
	A2	Cultural facilities land	19.5	0.6	0.7
	A3	Education and Research Land	97.5	3.1	3.2
	A4	Sports land	16.5	0.5	0.6
	A5	Medical and health land	20.2	0.6	0.7
3	B	Commercial service facilities	155.8	5	5.2

4	M		Industrial land	840.1	26.7	28
5	W		Logistics warehousing land	89.8	2.9	3
	S		Road and traffic facilities	444.5	14.1	14.8
6	among them	S1	Urban road land	399.6	12.7	13.3
		S3	Transportation hub land	28.8	0.9	1
		S4	Traffic station land	33.6	1.1	1.1
7	U		Public facilities land	65.1	2.1	2.2
	G		Green and square land	394.3	12.5	13.1
8	among them	G1	Park green	288	9.2	9.6
		G2	Protection of green space	85.6	2.7	2.9
		G3	Square land	20.7	0.6	0.6
total			Urban construction land	3145	100	104.8

3.2.2. Selection of Load Density Index

Through the study of load density indicators, referring to a large number of similar types of urban load density indicators, and according to central urban area regional development, finally, we get the central urban area load density indicators of various types of land. As shown in the following table.

Table 3-7 Load density index of Central Urban Area

Land properties		Building Area Indicators (W/m ²)	The required coefficient	Volume rate	Final load density index (W/m ²)
Residential land (R)	Class II residential land	40	0.3-0.5	0.8-1.5	15
	Administrative office land (A1)	40	0.7~0.85	1.2	20
Public management and public service facilities (A)	Cultural facilities land (A2)	30	0.30~0.50	1.25	12
	Education and Research Land (A3)	30	0.4~0.6	1.2	12
	Sports land (A4)	20	0.3~0.5	1	10
	Medical and health land (A5)	35	0.5~0.7	1.2	12
	The land of cultural relics (A7)	10	0.5	0.75	5
	Religious land (A9)	8	0.5	0.7	4
Commercial service facilities (B)	Commercial and financial land	45	0.5~0.9	1.2-1.8	24
Industrial land (M)	Class II industrial land	50	0.4~0.7	0.7-1.2	18
Storage land (W)		10	0.3~0.5	1	5
Road and traffic facilities (S)		5	0.6~0.8	0.75	4.5
Utility land (U)		20	0.3	1.2	8
Green and square land (G)		1	0.2	1	0.2

3.2.3. Spatial load forecasting.

According to the selected results of the load density index for different types of land, combined with the actual situation of planning of planning area land, using the space load density index method, We get the load distribution prediction results of planning area land.

To target year(2030), prediction results of spatial load in central urban area are shown in the following table.

Table 3-8 Statistics of Central Urban Area load forecast results

Land properties	Area (km2)	Load (MW)	
Residential land	9.613	144.195	
Administrative office land (A1)	0.404	8.08	
Cultural facilities land (A2)	0.195	2.34	
Education and Research Land (A3)	0.975	11.7	
Sports land (A4)	0.165	1.65	
Medical and health land (A5)	0.202	2.424	
Commercial service facilities (B)	1.558	37.392	
Industrial land (M)	8.401	151.218	
Storage land (W)	0.898	4.49	
Road and traffic facilities (S)	4.445	20.0025	
Utility land (U)	0.651	5.208	
Green and square land (G)	3.943	0.7886	
Total	31.45	Not consider simultaneous rate	389.4881
		Considering simultaneous rate of 0.85	331.0649

As can be seen from the table above, to target year, central urban area total load is 331.0649MW, the city area is 31.45km², the load density is 10.53 MW / km².

Growth rate method is a more accurate way to predict long-term data, in this maximum load forecast of the whole society, we use the growth rate method.

Table 3-9 Total social load forecast of Central Urban Area in recent years

Years	2011	2012	2013	2014	2015
load	9.88	10.24	11.66	13.09	14.45
Forecast Year	2016	2017	2018	2019	2020
Predict load	15.7505	16.853035	17.864217	18.757428	19.507725

Based on previous data and nearly five years of forecast data, the forecast is 483.4458MW.

According to the previous description, the final load situation in this central urban area is shown in the table below.

Table 3-10 Central Urban Area Load Density Index +The load forecasting result of the household capacity method

Years	The target year
The maximum load of the whole society (MW)	483.4458
County urban area load (MW)	331.0649

From the table can be seen, to the vision of the whole society, the maximum load of 483.4458MW, central urban area load of 331.0649MW. Combined with urban positioning and development planning of this central urban area, the electricity consumption of central urban area is mainly composed with residential electricity and industrial electricity, to the maximum annual use of the number of hours to consider the number of hours 5700h, the total electricity consumption of 27.5564 billion kWh.

3.3. Load forecast results

From the short-term forecast results, we can see that by 2020, the total electricity consumption of Dongxiang County is 1.327 billion kWh, the maximum load of the whole society is 227.09MW, and the

average annual growth rate of the "13th Five-Year Plan" period is 15.17% and 12%. From the long-term forecast calculation results, by 2030, Dongxiang County, the total electricity consumption of 2.756 billion kWh, the whole society, the maximum load of 483.45MW, the average annual growth rate of 18.54% and 16.83%.

4. Conclusion and analysis

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. The load density method is based on the acquired basic data and the predicted path, and it is more accurate than other prediction methods, the load density method satisfies our demand for the total load and the spatial load distribution. Therefore, the load density method is the better algorithm in our research process.

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