

## Saturated Load Forecasting Based on Per Capita Electricity Load

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**Abstract:** Aiming at the difficulty of evaluating the peak load utilization hours in traditional saturated load forecasting, a saturated prediction method based on per capita electricity load is proposed. The method uses unidimensional Logistic model to predict the per capita electricity load and the population saturation value, and the saturation load is effectively obtained by the product of the two. The example in the paper shows that the method is feasible.

**Keywords:** Saturated Load; Per Capita Electricity Load; Population Saturation Value

### 1. Introduction

Power load forecasting is one of the basic links in the construction of smart grid. Precise and timely load forecasting is the basis for smart grid to achieve energy saving, meticulous dispatching management and the foundation of power grid's early warning<sup>[1-2]</sup>. As the load scale of power demanding saturation stage in power grid, the prediction of Saturation load's level helps to determine the final size of the power grid, which is extremely significant to ensure the sustainable development and planning of power grid. The saturated load has two aspects: first, the scale of the whole social electricity consumption in the region into the stage of saturated growth; two, the scale of the annual maximum load in the region into the stage of saturation growth. This paper mainly uses the method of per capita electricity consumption to predict the saturation scale and saturation time of the whole social electricity consumption in a city in East China.

### 2. Prediction method Based On Per Capita Electricity

According to the overall planning and all kinds of special planning, studying the maximum size of the population adapt to the environment and resources first, and referring to foreign major developed countries per capita consumption, and determining per capita consumption of saturated city, on this basis, the scale of the city saturation load is calculated and the approximate time of the electricity demand in the city store is estimated. The idea of the method of saturated load forecasting based on per capita electricity is as follows: the product of saturated annual population and per capita saturated electricity consumption is the saturated scale of total electricity consumption in the area, as shown in formula (1) and the saturated scale of peak load can be obtained according to the formula (2)<sup>[3-6]</sup>.

$$Q_s = N_s * Q_a \quad (1)$$

$$P_s = Q_s / T_{\max} \quad (2)$$

In the formula (1) and (2)

$Q_s$  : The scale of electricity consumption in the whole society,

$Q_a$  : The Scale of per capita consumption of electricity

$P_s$  : The Scale of peak load

$T_{max}$  : The peak load using hourage

Formula (1) and (2) show the traditional model of the saturation load forecasting based on per capita electricity method. The prediction of total social electricity consumption used in this paper is the same as that in the previous article. Its load forecasting model is :

$$P_s = N_s * Q_a \quad (3)$$

In the formula (3)

$Q_a$  : The scale of per capita electricity load saturation

### 3. Logistic Forecasting Model Based On Per Capita Saturation Load

Because of the size of the population, per capita consumption per capita and the development history of the electric load is the load of such a law, which started slowly, then there is a stage of rapid development, to a certain extent because of resource, environment and demand constraints, the growth rate of the scale of development becomes comparatively slow until the respective tends to be stable. Such a whole process shows the trend in development of a S type curve. The Logistic curve of population size, per capita consumption and per capita S power load development to fit and forecast, according to the predictive value of these factors into the equation (1) and (3), you can get the future electricity with the development trend of power load demand.

The mathematical expressions of Logistic model (4) is

$$y_t = \frac{1}{k + a * e^{bt}} \quad (3)$$

$K > 0, a > 0, b < 0$ . This curve model plays an important role in the market share of new products, the development and change process of biological groups, population growth, urban electricity consumption and the prediction of economic development and change process, and has also been widely adopted. According to the law of load growth, the whole cycle of load growth can be roughly divided into slow growth stage, rapid growth stage, and saturated growth stage, such as Figure 1.

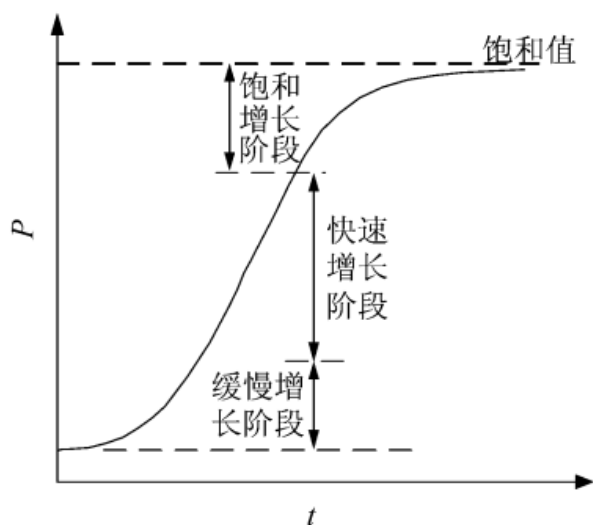


Fig1 The Curve of Logistic Model

#### 4. Case Calculation

The data selected by the case are data from a city in East China, which include electricity consumption, load and population, as shown in Table 1

Table1 Electricity Consumption, Load and Population Data of A City In East China

Year	Electricity Consumption/ $10^8$ kWh	Load/MW	Population/ $10^4$
2000	9.9	182.3	66.8
2001	12.6	224.1	67.2
2002	16.7	303.2	67.6
2003	20.3	362.8	68.0
2004	24.1	419.1	68.8
2005	31.4	552.7	69.7
2006	37.5	680.3	70.7
2007	43.2	799.1	71.6
2008	45.2	829.0	72.4
2009	49.2	963.7	73.0
2010	56.3	1066.3	74.0
2011	63.5	1231.1	74.7
2012	67.7	1321.4	75.3

The idea of saturated load forecasting based on the per capita electricity consumption method is that the total population in saturated year is multiplied by the saturated electricity consumption per capita, that is to say, the saturated electricity consumption of the whole society in this area is saturated. First of all, the number of population in the city is fitted and predicted through the Logistic curve. It is shown that the forecast results are shown in Figure 2. According to the results of the analysis of Figure 2, the population of the city is basically saturated in 2030, and the size of the population is 869 thousand.

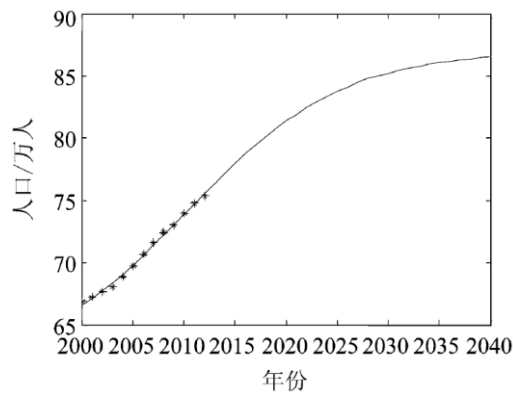


Fig2. The Logistic Fitting Forecast Curve of The City Population

The Logistic fitting forecast curve of the city's per capita electricity consumption development trend is shown in Figure 3. According to Figure 3, the city's per capita electricity consumption is basically saturated in 2030, and its saturation scale is 13340 (kWh) for one person.

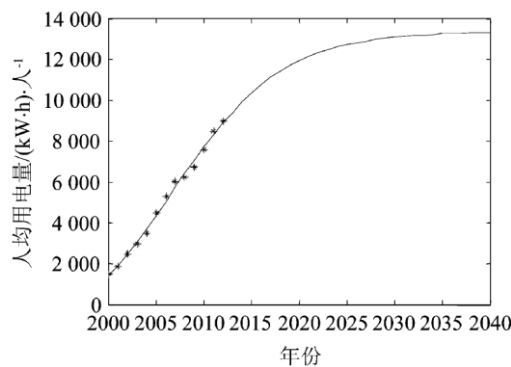


Fig3. The Logistic Fitting Forecast Curve of The City's Per Capita Electricity Consumption

The Logistic curve fitting prediction curve of the city's per capita electricity load development trend is shown in Figure 4. According to figure 4, the city's per capita electricity consumption is basically saturated in 2028, and its saturation scale is 2315W for one person.

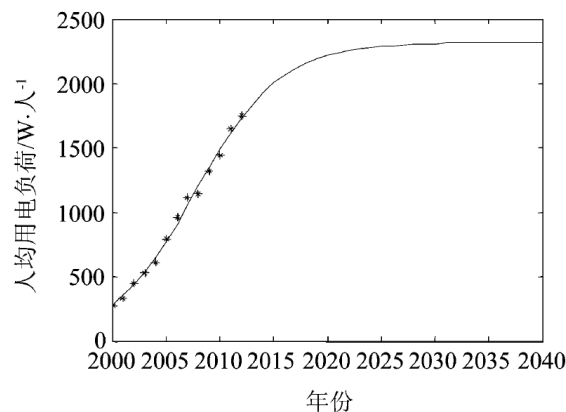


Fig4. The Logistic Fitting Forecast Curve of The City's Per Load

The Logistic curve of the city's population, the per capita consumption and per load conditions for fitting and prediction, the predicted household population, per capita consumption per capita reached saturation load size and year, the saturation of electricity and saturation load are shown in table 2.

表2 该市用电量与最大负荷饱和值预测结果

Table2.The Forecasting results of the Power Consumption and the Peak SaturationLoad ofTheCity

	Electricity Consumption/10 <sup>8</sup> kWh	Load/MW
Saturated year	2030	2028
Saturation Scale	116	2012

## 5. Conclusion

At present, there is a little forecasting model for saturated load, and different models have different emphasis. Because the peak load utilization hours don't have obvious development rules, so it's difficult to get a reasonable saturated load prediction value by directly calculating saturated load values by saturation power consumption. This paper provides a prediction model of saturated load based on per capita electricity consumption method. This method does not need to estimate the maximum load utilization hours, but uses the more obvious electricity consumption per capita and population to predict the load saturation scale. The feasibility of the method is proved by an example in this paper, which is also enlightening to the prediction of saturated load.

## Reference

- [1]. WANG Wei, FANG Ting-ting. The application of per-person electricity consumption method in saturation load forecasting [J]. Power Demand Side Management, 2012, 20 ( 6 ): 34-38
- [2]. CUI Kai, LI Jing-ru, LIU Hai-bo, et al. City's power planning methods at the stage of load saturation and its application in Jinan power grid [J]. Power System Technology, 2007, 31(S2) : 14
- [3]. CUI Kai, ZHANG Li-juan, LI Jing-ru, et al. Analysis and forecast of saturated load for the central city district of Tianjin [J]. Electric Power Technologic Economics, 2008, 20 ( 5 ) : 33-36 .
- [4]. CUI Kai, LI Jing-ru, ZHAO Biao, et al. Research on city saturated load and its forecast methods. Electric Power Technologic Economics, 2008, 20( 6 ) : 34-38.
- [5]. JIA Yu-dong, LI Sheng-hu, TAN Yun, et al. Improved parametric estimation of logistic model for saturated load forecast [C]. Power and Energy Engineering Conference, Shanghai: 2012: 1-4.
- [6]. Papadopoulos S, Karakatsanis I. Short-term electricity load forecasting using time series and ensemble learning methods [C] // Proceedings of the 2015 IEEE Power and Energy Conference at Illinois. Piscataway: IEEE, 2015: 1-6.