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Study on power grid characteristics in summer based on Linear regression analysis

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Abstract: The correlation analysis of power load and temperature is the precondition and foundation for accurate load prediction, and a great deal of research has been made. This paper constructed the linear correlation model between temperature and power load, then the correlation of fault maintenance work orders with the power load is researched. Data details of Jiangxi province in 2017 summer such as temperature, power load, fault maintenance work orders were adopted in this paper to develop data analysis and mining. Linear regression models established in this paper will promote electricity load growth forecast, fault repair work order review, distribution network operation weakness analysis and other work to further deepen the refinement.

1. Introduction

Electricity load forecasting is an essential prerequisite and an important foundation for the operation of power grids and the economic security power dispatching. The study of load forecasting model has received a long-lasting and extensive attention. One of the important branches is to explore the establishment of a correlation model between load and temperature. In this respect, there are a lot of available research results. A load forecasting method based on meteorological factors Rough Set Theory was proposed in [1]. An empirical calculation of the relationship between power load and temperature was developed in [2]. A unit temperature load effect of rising section and descending section in summer was established in [3]. The relationship between the air conditioning load with the maximum temperature, the average temperature and human comfort was analyzed in [4].

At present, on the premise of the global warming trend is aggravating, the intensity of sunny and hot weather in many areas during summer increases and the duration increases, which results in the rapid increase of temperature-lowering load and great challenge for reliable supply of electricity and safe operation of power grid. For example, in July 2017, Jiangxi province's power load renewed records for five times and broke through 20 million kilowatts power load for the first time. The main driving factors of power load is temperature-lowering load, which caused by the sustainable and continuous high-temperature weather, especially high-temperature weather above 40°C in local area. The power load caused by temperature rising in the province-wide features significant characteristics, which has provided elaborately detailed data for construction of model in regard to the correlation between temperature and power load, and testified as well as optimized the load-forecasting model. Besides, the sharp rising in power load can be largely attributed to the increase of air conditioner load in the countryside and urban area, which led to more equipment defects due to device over-load, or operation with heavy load in the long run. The dynamic increase of the fault maintenance work orders which due to customer's outage repair demands undertook by customer service center, also provides elaborately detailed data for construction of model in regard to the correlation between the fault maintenance work orders and the power load. Relevant study which was insufficient in the past and almost no desirable fruit that can be taken as reference has been generated.

In this paper, the linear regression equation is used to model the relationship between the power load with the temperature and the fault maintenance work orders. The linear regression models proposed in this paper are used to predict and analyze the power load and the fault maintenance work orders. This analysis provide the mathematical basis for forecasting the growth of power load in high-temperature weather, judging the fault maintenance work orders and analyzing the weak points of distribution operation. The concept of base load level is introduced to make the model more intuitive and reliable in consideration of actual working experience of load forecasting. And the correlation model of power load and fault maintenance work orders provides reference provide reference and research.

2. Correlation analysis of temperature and power load based on linear regression model

All the statistics employed in this chapter are about the highest daily temperature in each part of the province, and daily power load of Jiangxi Electric Power Corporation and each branch companies (the largest load recorded on EMS system). While constructing the model, factors in weak correlation are simplified, which means relevant elements such as the nonlinear correlation between electrical load and temperature, wind-force, and humidity. Finally, a linear regression model established with MATLAB is given by (1), as shown in Fig. 1. L is the value of power load(10MW),T is the value of temperature(℃):

$$L=76.11*(T-30)+1222.3 \qquad (1)$$

The result showed that the maximum power load experienced a linear increase when temperature grew higher— correlation coefficient equaled 0.89 (the value of R)—which revealed a strong linear correlation. The maximum base power load within the province was 12223 MW (the highest temperature was below 30℃), and a rise in temperature by 1℃ should lead to an increase of electrical load by 761.1 MW.

As estimated above, the maximum air-conditioner temperature-lowing load in the province wide would surpass 7600 MW (the temperature is between 30℃ and 40℃.). And a temperature of 40℃ would lead to an exponential increase of power load and a larger index regarding electrical load rise.

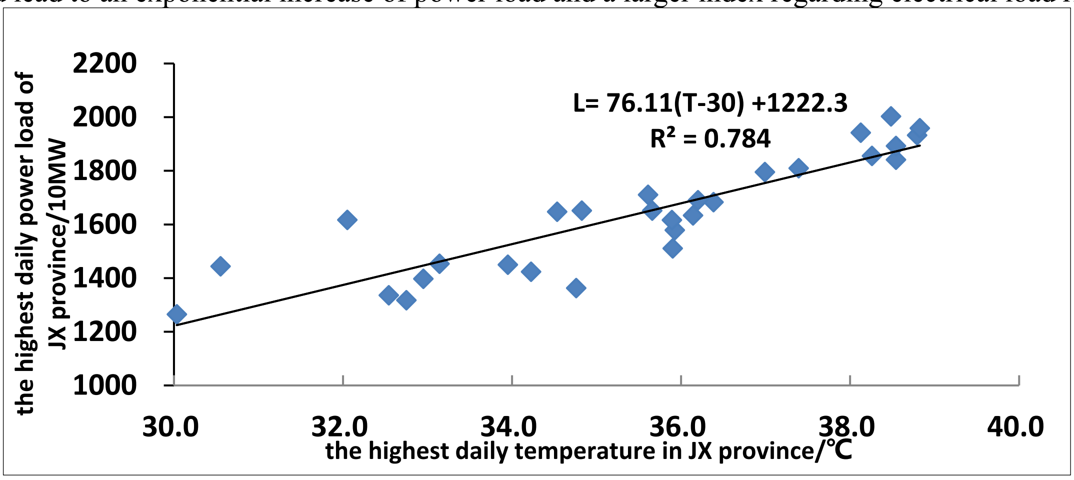

Fig. 1 Correlation of the highest daily power load and the highest daily temperature in JX province

Further, an analysis on the temperature and the maximum electrical load of NC branch company located in the provincial capital was conducted with mathematical model which was given by (2). L is the value of power load(10MW),T is the value of temperature(℃).

$$L=18.68*(T-30)+216.4 \quad (2)$$

As shown in Fig. 2, the maximum base power load of NC Company was 2164 MW, based on which the rise of temperature by 1℃ resulted in that of the maximum power load by 186.8 MW. The coefficient concerning correlation between temperature and load equaled 0.91, which showed a stronger correlation. This analysis proves the higher urbanization level of provincial capital and the centralized of air conditioner temperature-lowing load.

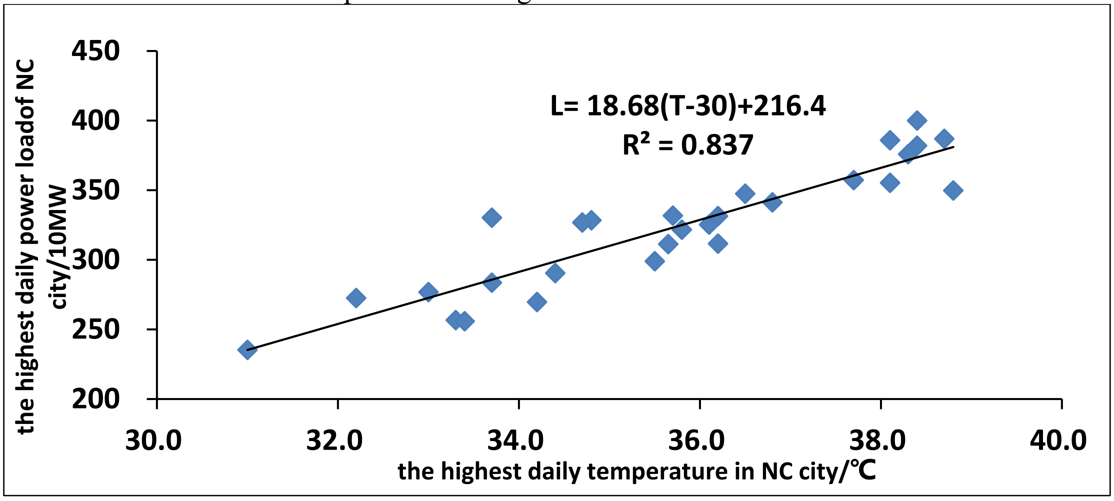

Fig. 2 Correlation of the highest daily power load and the highest daily temperature in NC City

3. Correlation analysis of fault maintenance work orders and power load based on linear regression model

A positive correlation was witnessed between temperature, power load, and fault maintenance work orders, for which a further analysis on the second and third elements has been initiated by linear regression model based on the result generated in the last chapter. Data adopted are about the power load of Jiangxi Electric Power Corporation and each branch companies (the largest load) and the fault maintenance work orders undertook by provincial 95598-service center. In order to construct a more visual and reliable model, the statistics which are below base power load level in the last chapter (12223 MW) were left out. Finally, a linear regression model established with MATLAB is given by (3), as shown in Fig. 3. L is the value of power load(10MW),F is the quantity of fault maintenance work orders(piece):

$$F=1.12*(L-1222.3)+488.6 \quad (3)$$

According to the result, the daily base of fault maintenance work orders in Jiangxi province is 488.6 (corresponding base power load was 12223 MW). An increase in power load by 1000 MW led to that in fault maintenance work orders by 112. And a linear upward trend was witnesses with a comparatively large correlation coefficient of 0.87.

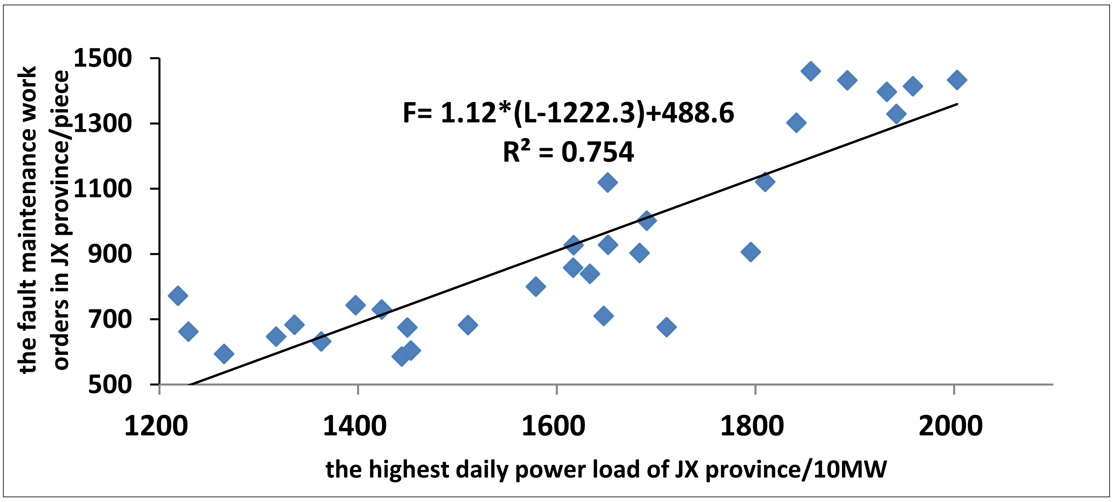

Fig. 3 Correlation of the fault maintenance work orders and the highest daily power load in JX province

Similarly, a linear regression model of NC branch company located in the provincial capital established with MATLAB is given by (4), as shown in Figure 4. L is the value of power load(10MW),F is the quantity of fault maintenance work orders(piece):

$$F=1.13*(L-216.4)+145.5 \quad (4)$$

According to the result, the daily base of fault maintenance work orders in NC is 145.5 (corresponding base power load was 2164 MW). An increase in power load by 1000 MW led to that in fault maintenance work orders by 113, similarly to provincial increse. And a linear upward trend was witnesses with a comparatively large correlation coefficient of 0.73.

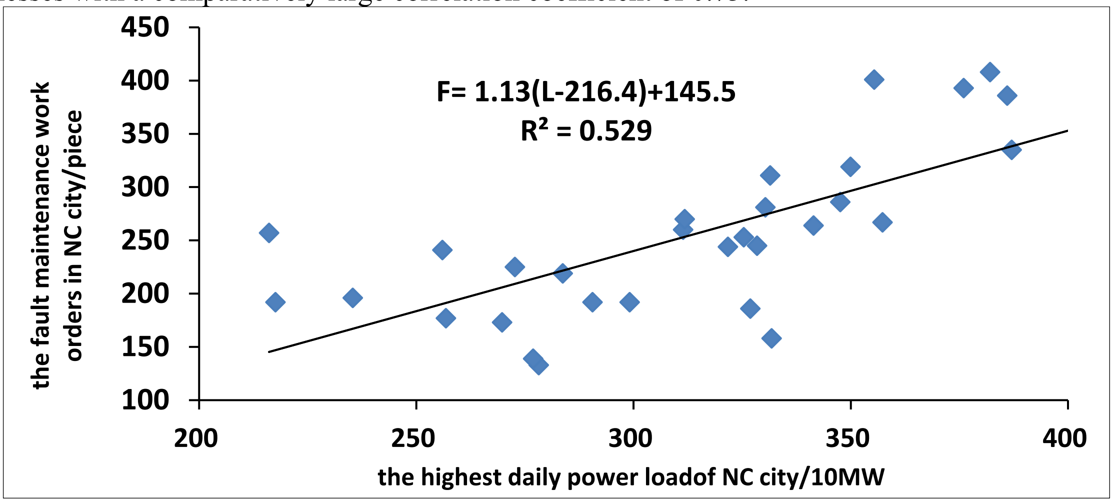

Fig. 4 Correlation of the fault maintenance work orders and the highest daily power load in NC City

4. Conlusion

In combination with the features of temperature and power grid performance in summer when power load appears relatively high, a study on those detail statistics collected from Jiangxi Electric Power Corporation and each branch companies about temperature, power load, and fault maintenance work orders was conducted with linear regression model, which showed a positive and strong correlation between those factors aforementioned.

Although progress has been made in this paper, a further study is still in urgent need so as the electric power system can be better respond to abnormal climate conditions. In summers and winters characteristics of power load of grids are relatively significant, while data on temperature, power load, fault maintenance work orders, and distribution network blackout should also be filed after classification and backed up, hereby to facilitate construction of mathematical models, studying on the law of power load change and fault maintenance work orders distribution, detailed estimation of electrical load, and streamline control over the whole process of fault maintenance work.

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