Research on Monthly Unified Scheduling Electricity Consumption Prediction Based on Temperature Gradient Change

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Abstract. With the improvement of residents' living standards, the cooling and heating load are increasing rapidly, and the influence of temperature on the unified scheduling electricity consumption is increasing. Based on the temperature gradient change, the monthly unified scheduling electricity consumption prediction research is carried out to quantify the influence of temperature on the unified scheduling electricity consumption, and the unified scheduling electricity consumption prediction is performed for a provincial power grid. The example further proves the feasibility and effectiveness of the prediction method.

1. Introduction
The unified scheduling electricity consumption is the amount of power used by users connected to the grid. Different from the direct power supply from local small power plants, the unified scheduling electricity consumption is large and involves a wide range of users. It can basically characterize the overall unified scheduling electricity consumption of a region. It is generally issued by the provincial power grid company on a monthly basis. Monthly call power forecasting is the starting point and basis for formulating specific production plans for the next month. It is of great significance for the power dispatching department to organize and arrange power plant output to maintain load balance and grid stability. In order to improve the accuracy of monthly electricity consumption forecasting, the literature [1]-[2] focuses on the economic factors affecting electricity consumption, such as the value added of three industries, industrial added value, and the literature [3]-[5] focuses on the improvement of forecasting methods, such as the introduction of combined forecasting, carry out regression analysis, improve the gray prediction model, and so on.

With the improvement of residents' living standards, the cooling and heating load are increasing rapidly, and the influence of temperature on the unified scheduling electricity consumption is increasing. It is necessary to carry out research on the monthly electricity forecasting method considering temperature factors.
2. Introduction to measurement methods

2.1. Building a gradient temperature electricity model based on historical data

Considering that the temperature changes in the same i-month are similar, the gradient temperature electricity model is constructed based on the data of the first month of the previous year, where the month is the forecast month and the value is. First, the data unit of [daily average temperature, Japanese call power] is formed, and then divided into two types of data groups: working day and holiday. Taking the working day data group as an example, the data units are arranged in ascending order according to the daily average temperature. Using the least squares method, the linearized regression of the sorted data unit sequence is performed to obtain the monthly working day gradient temperature electricity model:

\[ E_{i,w} = k_{i,w} * T_{i,w} + C_{i,w} \]

Among them, \( E_{i,w}, T_{i,w}, C_{i,w} \) respectively represent the daily electricity consumption, daily average temperature, and constant term of the i-month working day of the previous year, \( k_{i,w} \) is the gradient temperature coefficient of the i-month working day of the previous year, and the physical meaning is that the temperature rises by 1 degree Celsius, i month The daily electricity adjustment on the working day increased by \( k_{i,w} \) billion kWh. In the same way, the gradient temperature coefficient \( k_{i,h} \) of the previous year's i-month holiday can be obtained.

2.2. Determine base temperature and base power

Considering that there is no significant change in the expansion of the adjacent monthly industry, the natural growth of the load is small, and the basic temperature and the basic electricity are calculated separately for the working day and the holiday. Taking the working day as an example, the average daily temperature of the working day of the month (I-1) is averaged as the base temperature \( T_{I,W} \) of the working day of the next month (the first month); the amount of electricity is called for the day of the working day of the month. Take the average value as the base electricity \( E_{I,W} \) for the monthly workday. In the same way, the base temperature \( T_{I,H} \) and the basic electricity \( E_{I,H} \) for predicting the holiday of the month can be obtained.

2.3. Prediction of the amount of electricity in the I-month

According to the daily forecast of the first temperature by the meteorological department, the newly added electricity generated by the temperature factor is superimposed on the basic electricity, and the prediction of the first month's total power is completed separately from the working day and the holiday. Taking the working day as an example, the formula for calculating the electricity amount for the first month of work is as follows:

\[ e_{(I,J),W} = E_{I,W} + (t_{(I,J),W} - T_{I,W}) * k_{i,w} \]

Where \( e_{(I,J),W}, t_{(I,J),W} \) respectively represent the J-th working day of the I-th month and the predicted daily average temperature.

Similarly, the I-month of the holiday call power calculation formula is as follows:

\[ e_{(I,J),H} = E_{I,H} + (t_{(I,J),H} - T_{I,H}) * k_{i,h} \]

\( e_{(I,J),H}, t_{(I,J),H} \) respectively represent the J-th working day of the first month and the predicted daily average temperature.

The cumulative predicted power value of the I-th month is obtained by accumulating the daily predicted unified scheduling electricity consumption values of the working days and holidays.
\[ \hat{e}_i = \sum_{j=1}^{m} e_{(i,j),W} + \sum_{j=1}^{n} e_{(i,j),H} \]

3. Case study
In order to verify the feasibility and effectiveness of the prediction method, the unified scheduling electricity consumption of a provincial power grid was predicted in June 2019.

3.1. Building a gradient temperature electricity model
According to the average daily temperature and the corresponding call power in June 2018, the working hours and holiday statistics are sorted in ascending order according to the temperature to form a temperature electric quantity sequence, and a correlation model is constructed to obtain the fluctuation range of the electric quantity caused by the unit temperature rise.

| Working day | Holiday |
|-------------|---------|
| Gradient temperature | Gradient temperature |
| Gradient power | Gradient power |
| 24 | 20 |
| 25 | 22 |
| 26 | 23 |
| 27 | 24 |
| 28 | 25 |
| 29 | 27 |
| 30 | 28 |

A working day gradient temperature electricity model is obtained by linear regression:

\[ E_{i, \text{w}} = 0.40 \times T_{i, \text{w}} - 1.69 \]

In the same way, get the holiday gradient temperature electricity model:

\[ E_{i, \text{h}} = 0.49 \times T_{i, \text{h}} - 4.31 \]

It shows that for every degree of temperature increase, the power of the working day is increased by about 40 million kWh, and the power of the holiday calls is increased by about 4.9 billion kWh.

3.2. In June 2019, the power forecast was called.
The average temperature of May 2019 and the corresponding average daily average electricity consumption are divided into basic temperature and basic electricity. According to the difference between the predicted temperature and the base temperature, combined with the relationship between the gradient temperature and the electric quantity, the daily call power is calculated in June, and the cumulative predicted power value in June 2019 is 28.73 billion kWh.
Table 2. The unified scheduling electricity consumption forecast for the working days and holidays in June 2019 Unit: Celsius, 100 million kWh

| Date    | Working day | Predicted temperature | Base temperature | Basic electricity | Temperature increase | Daily electricity increment | Electricity predictive value |
|---------|-------------|-----------------------|------------------|------------------|----------------------|---------------------------|-----------------------------|
|         |             |                       |                  |                  |                      |                           |                             |
| Working day |             |                       |                  |                  |                      |                           |                             |
| June 3  | Mon.        | 24.68                 | 21.58            | 7.96             | 3.10                 | 1.07                      | 9.03                        |
| June 4  | Tues.       | 25.76                 | 21.58            | 7.96             | 4.18                 | 1.45                      | 9.41                        |
| June 5  | Wed.        | 24.66                 | 21.58            | 7.96             | 3.08                 | 1.07                      | 9.03                        |
| June 6  | Thur.       | 21.38                 | 21.58            | 7.96             | -0.20                | -0.07                     | 7.89                        |
| June 10 | Mon.        | 27.00                 | 21.58            | 7.96             | 5.42                 | 1.87                      | 9.83                        |
| June 11 | Tues.       | 27.42                 | 21.58            | 7.96             | 5.84                 | 2.02                      | 9.98                        |
| June 12 | Wed.        | 27.08                 | 21.58            | 7.96             | 5.50                 | 1.90                      | 9.86                        |
| June 13 | Thur.       | 26.94                 | 21.58            | 7.96             | 5.36                 | 1.86                      | 9.81                        |
| June 14 | Fri.        | 27.78                 | 21.58            | 7.96             | 6.20                 | 2.14                      | 10.10                       |
| June 17 | Mon.        | 29.53                 | 21.58            | 7.96             | 7.95                 | 2.75                      | 10.71                       |
| June 18 | Tues.       | 28.75                 | 21.58            | 7.96             | 7.17                 | 2.48                      | 10.44                       |
| June 19 | Wed.        | 26.78                 | 21.58            | 7.96             | 5.20                 | 1.80                      | 9.76                        |
| June 20 | Thur.       | 25.17                 | 21.58            | 7.96             | 3.59                 | 1.24                      | 9.20                        |
| June 21 | Fri.        | 24.39                 | 21.58            | 7.96             | 2.81                 | 0.97                      | 8.93                        |
| June 24 | Mon.        | 27.64                 | 21.58            | 7.96             | 6.06                 | 2.10                      | 10.06                       |
| June 25 | Tues.       | 26.05                 | 21.58            | 7.96             | 4.47                 | 1.54                      | 9.50                        |
| June 26 | Wed.        | 25.93                 | 21.58            | 7.96             | 4.35                 | 1.50                      | 9.46                        |
| June 27 | Thur.       | 26.42                 | 21.58            | 7.96             | 4.84                 | 1.67                      | 9.63                        |
| June 28 | Fri.        | 27.44                 | 21.58            | 7.96             | 5.86                 | 2.03                      | 9.99                        |
| Holiday |             |                       |                  |                  |                      |                           |                             |
| June 1  | Sat.        | 23.04                 | 22.23            | 7.82             | 0.81                 | 0.40                      | 8.22                        |
| June 2  | Sun.        | 23.74                 | 22.23            | 7.82             | 1.50                 | 0.74                      | 8.56                        |
| June 7  | Fri.        | 22.86                 | 22.23            | 7.82             | 0.63                 | 0.31                      | 8.13                        |
| June 8  | Sat.        | 23.95                 | 22.23            | 7.82             | 1.72                 | 0.85                      | 8.67                        |
| June 9  | Sun.        | 24.95                 | 22.23            | 7.82             | 2.71                 | 1.34                      | 9.16                        |
| June 15 | Sat.        | 30.86                 | 22.23            | 7.82             | 8.63                 | 4.26                      | 12.08                       |
| June 16 | Sun.        | 29.19                 | 22.23            | 7.82             | 6.96                 | 3.44                      | 11.26                       |
| June 22 | Sat.        | 24.94                 | 22.23            | 7.82             | 2.71                 | 1.34                      | 9.16                        |
| June 23 | Sun.        | 25.86                 | 22.23            | 7.82             | 3.63                 | 1.79                      | 9.61                        |
| June 29 | Sat.        | 26.78                 | 22.23            | 7.82             | 4.54                 | 2.24                      | 10.06                       |
| June 30 | Sun.        | 26.25                 | 22.23            | 7.82             | 4.02                 | 1.98                      | 9.81                        |

3.3. Prediction result check
Looking at the statistical report, it can be seen that in June 2019, the actual power of the provincial power grid was 27.63 billion kWh. The predicted value is only 3.98% compared to the actual value. This error has a great relationship with the temperature prediction deviation. Compared with the temperature prediction value of June 2019 and the measured temperature value issued by the meteorological department, the average error rate of the temperature prediction data cited is 7.5%, and the maximum error rate is 18.3%.

4. Analysis Conclusion
The method fully considers the influence of temperature factors on the unified scheduling electricity consumption prediction, especially in the month when the summer temperature changes drastically, which can effectively reduce the prediction error, which is a useful supplement to the short-term electricity forecasting method. The example further proves the feasibility and effectiveness of the
method. The error of the algorithm is mainly caused by the temperature prediction bias. The next step is to study the acquisition method of optimizing the temperature prediction value to further improve the prediction accuracy of the model.

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