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Analysis of Output Characteristics of Typical Distributed Wind Power

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Abstract. With the development of smart power distribution technology in the future, a large range of power supply load (such as distributed wind power generation) will appear on the power receiving end. When distributed wind power is connected to the power grid on a large scale, it will have a certain impact on the safe and stable operation of the power grid. However, if the wind power output characteristics can be analyzed and the wind power output is properly regulated, the one-way flow of power from the distribution network to the user side will be broken, so that the future "network-load" has dual interaction characteristics based on response and substantial power exchange.

1 Introduction

With the implementation of energy saving and emission reduction policies and the improvement of people's awareness of environmental protection, the use of clean energy such as wind power to generate electricity has become a trend. However, wind power generation is unstable and intermittent, which will bring potential safety hazards to the operation and optimization planning of power system. Therefore, it is of great significance to study and analyze the output characteristics of wind power[1].

In recent years, the scale of wind power installed in China has grown rapidly. By the end of 2017, the installed capacity of wind power connected to the grid in China was 160 million kW. At the same time, domestic scholars have made more and more in-depth research on wind power, such as the output characteristics of wind power bases in Jiuquan[2-3], Fujian[4], Yunnan[5], etc, and analyzed the characteristics of wind power output and its impact on and demand for power grid. Based on wind power output and grid load, the output characteristics of Shanxi wind power are analyzed[6]. Taking Heilongjiang as a typical area, based on mathematical statistics method, wind power output is analyzed according to load characteristics such as simultaneous rate and climbing rate, in order to provide reference for future wind power development and development in Heilongjiang[7].

Based on the wind power output data of 8760h in a certain area in 2017 and the wind power model, this paper analyses the wind power output in a year by means of output characteristic curve and output characteristic index, and then provides the basis for wind power development.

2 Distributed wind power generation model

Due to the influence of wind speed, the distributed wind power output shows more obvious randomness. To build a distributed wind power model, it is necessary to study the transformation of regional wind speed. There are many probability distribution models used to describe the distribution of wind resources in the region, including Weibull distribution and Rayleigh distribution. The two-parameter Weibull distribution is widely used in wind resource fitting. If the wind speed sequence of a wind farm obtained by the wind gauge obeys the two-parameter Weibull distribution, the probability density function is as shown in equation (1):

$$f(v)=\left(\frac{k}{c}\right)\times\left(\frac{v}{c}\right)^{k-1}e^{\left[-\left(\frac{v}{c}\right)^{k}\right]} \tag{1}$$

Where c is the scale parameter of the Weibull distribution, reflecting the average wind speed of the wind farm; k is the shape parameter of the Weibull distribution; v is the given wind speed.

In the actual wind turbine power generation, it is determined that the wind speed can use a large number of actual data to characterize the quantitative relationship between the input power of the fan and the wind speed. According to the existing research results, the input power of wind turbine is proportional to the third power of wind speed at that time, and the specific quantitative model of wind turbine output power is as follows (2):

$$P_o=C_p\times\frac{\rho\times\pi\times R^2}{2}\times v_{wind}^3 \tag{2}$$

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Where, P_o is the output power of wind turbine; C_p is the wind energy conversion coefficient of wind turbine; ρ is the local air density of wind turbine; R is the radius of wind turbine blades; v_{mind} is the wind speed (not greater than the rated wind speed).

3 case analysis

The output of wind power is closely related to the distribution of wind resources and wind direction in the region. The output fluctuation is greater in different periods and seasons. The output of wind power varies greatly in different regions. When studying the characteristics of distributed wind power generation, the specific situation should be analyzed. Taking a certain area as an example, in order to better describe the actual situation of wind power generation, this paper analyzed the output characteristics of distributed wind power generation based on the actual data of wind farms in 2017 in one area. Among them, the total installed capacity of wind power in this area is 1960.91MW.

3.1 Output characteristic curve of typical distributed wind resources

3.1.1 Monthly cumulative output curve of typical distributed wind power resources

The hourly output of the wind farm in one month is queued in descending order, and the cumulative curve of the monthly output of the wind farm is shown in Fig. 1.

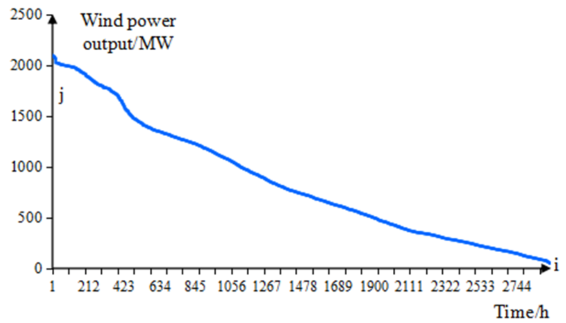

Fig. 1. Cumulative output curve of a wind farm within one month

As can be seen from Figure 1, the highest peak of monthly wind power output reached 2000MW. The abscissa is time and the unit is h; the ordinate is the output of the wind farm, and the unit is MW. A point A_{ij} on the curve, the corresponding abscissa is i, and the ordinate is j, indicating that the wind farm output corresponding to the point is MW, and the time when the wind farm output is greater than or equal to j MW is i hours. The area enclosed by the curve and the horizontal and vertical axes is the amount of electricity generated by the wind farm of the month.

3.1.2 Weekly output curve of typical distributed wind power resources

According to the actual output data of the wind farm, the wind power output curve within one week is plotted, as shown in Fig. 2.

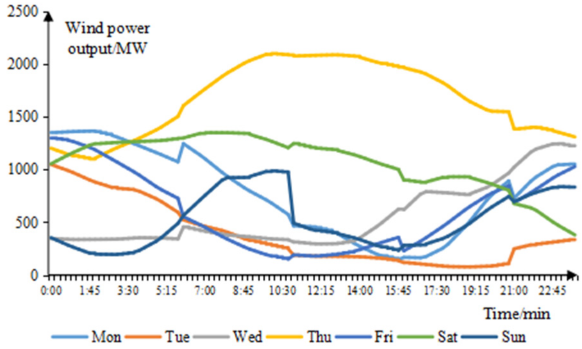

Fig. 2. wind power output curve of a wind farm

It can be seen from Fig. 2 that the wind farm output fluctuates greatly, and the wind power generation has randomness and instability.

In the daytime, the wind farm has a lower output due to the lack of wind; on the contrary, at night, the wind farm has a higher output due to the rich wind. But there are also special circumstances, such as the wind power output on Thursday. The wind power output curve of the day reflects the phenomenon of wind power reverse peaking.

3.2 Analysis of output characteristics index of typical distributed wind resources

3.2.1 Analysis of annual output characteristics of typical distributed wind resources

According to the output data of typical distributed wind resources, the annual maximum output, the generalized annual maximum peak-valley difference, the annual maximum peak-valley difference rate, the generalized annual average daily load rate and the seasonal imbalance coefficient are calculated as shown in Table 1.

Table 1. Output characteristics of typical distributed wind resources

Index	Output Value	Unit
Annual maximum output	1046	MW
Annual maximum peak-to-valley difference	1046	MW
Annual maximum peak-to-valley difference rate	100	%
Generalized annual average daily load rate	74	%
Seasonal imbalance coefficient	92	%

It can be seen from Table 1 that the annual maximum output is 1046MW, and the annual maximum peak-to-valley difference is 1046MW. This is mainly because the wind does not exert force without wind speed, so the minimum output is 0, so the annual maximum rate of peak-to-valley difference is 100%, the generalized annual average daily load rate is 74%, and the seasonal imbalance coefficient is 92%, indicating that the seasonal imbalance is large and there are obvious seasonal differences.

3.2.2 Analysis of daily output characteristics of typical distributed wind resources

Taking the maximum output day of each quarter as the typical day, the typical characteristics of typical distributed wind resources are analyzed. The typical day of spring (March-May) is 2017/3/18, the typical day of summer (June-August) is 2017/8/3, the typical day of autumn (September-November) is 2017/11/27, and the typical day of winter (December-February) is 2017/12/7.

Table 2. Typical daily output characteristics of typical distributed wind resources

Index \ Typical day	2017/3/18	2017/8/3	2017/11/27	2017/12/7
Maximum output /MW	919	1001	1038	1046
Minimum output /MW	289	459	654	548
Mean output /MW	779	870	952	966
Generalized load rate /%	85	89	92	92
Peak-to-valley difference /MW	630	542	384	498
Peak-to-valley difference rate/%	69	54	37	48

From Table 2, it can be seen that the maximum daily output is about 1000MW, the minimum load is higher than 280MW, the peak-valley difference is higher than 380MW, and the peak-valley difference rate is higher than 35%. Among them, the generalized load rate of autumn typical day and winter typical day is the largest, 92%, spring typical day is the smallest, 85%; the peak-to-valley difference rate of spring typical day is the largest, 69%, autumn typical day is the smallest, 37%.

4 Conclusions

Based on the actual wind power output data of one wind farm in a certain region, this paper analyzes distributed wind power output from two aspects of output characteristic curve and output characteristic index, and the following conclusions can be obtained:

(1) Taking 5 minutes as time interval, wind power output data of the wind farm every day in a week were collected to study and analyze the distributed wind power weekly output curve. The results show that the randomness of wind power output in a week is different between night and day, and the wind power output at night is more, while the wind power output during the day is less.

(2) By analyzing the annual output characteristic index and the output characteristic index of each typical day, the wind power output of the wind farm can be more directly reflected, in order to provide reference for the future utilization of wind resources.

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