The Operating State Assessment of Wind Turbine Based on SCADA System

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Abstract. Based on SCADA system, this paper evaluates the performance and operation status of wind turbines using improved fuzzy neutralization evaluation theory. In this study, the second rolling average method is used to analyze the characteristics of wind power fluctuation from the differential time scale and fan capacity. It provides a theoretical basis for the normal operation of wind turbines.

1. Introduction
In recent years, due to the continuous expansion of wind power Grid-connected scale, the key to ensure the safe operation of the grid is the reliability and operation and maintenance indicators of wind turbines[1]. Professionals in the industry generally attach importance to the evaluation of the operation status of wind turbines. Fuzzy algorithm and grey theory are mostly used in wind power plant unit evaluation[2-3]. Combining the above methods, this paper puts an improved idea for wind farm unit operation evaluation, and establishes an improved evaluation model.

2. Performance evaluation of grid-connected wind turbines based on SCADA system

2.1 Define the appropriate membership function of the evaluation index
SCADA monitoring data can reflect the performance status of wind turbines to a certain extent, and explain the variable process of wind turbines from normal operation state to shutdown state[4]. In this paper, the concept of relative deterioration degree is introduced. Values represent the deterioration degree of the evaluation index. The range of values is [0, 1]. Formula 1 is the calculation formula of the smaller the better index.

\[ g(x) = \begin{cases} 
0, & x < \alpha \\
\frac{x-\alpha}{\beta-\alpha}, & \alpha \leq x \leq \beta \\
1, & x > \beta 
\end{cases} \]

(1)

Formula:
\( g(x) \) denotes the deterioration degree of the evaluation index, \( x \) denotes the measured value of the evaluation index, \( \alpha \) denotes the good value of the index, \( \beta \) denotes the limit value of the index.

Compared with other complex membership functions, it is found that the shape of the distribution functions of semi-trapezoidal and triangle is not complicated, and the results obtained are not very different. Based on the membership functions of different state levels, this paper establishes various indicators. As shown in Figure 1, the membership degree of each deterioration degree is established.
The grey system theory carries on the statistical analysis to the inquiry target. It has the wider analysis object, the target object does not need to obey the arbitrary distribution[5-6]. Firstly, the optimal value of each index is determined to construct the optimal index set. Secondly, the correlation coefficient (k) is calculated. Finally, the weight of each index is calculated.

$$\omega_k = \frac{\bar{\omega}_k}{\sum_{k=1}^{n} \bar{\omega}_k}$$ (2)

2.2 Power fluctuation characteristics of grid-connected wind power in SCADA system

The variation rate of wind power is expressed by the fluctuation of the difference between adjacent sampling points. The variation of the magnitude of the correlation coefficient in time scale can be sampled and compared because of the fluctuation of the correlation coefficient. According to the numerical comparison of the correlation, this paper combines the three indicators of power fluctuation, fluctuation rate and variation rate of generating units to analyze. the formula can be defined as:

1) Unit power fluctuation:

$$\Delta P_{nt} = \sum_{t=1}^{N} P_{nt} - \sum_{t=1}^{N} P_{(n-1)t}$$ (3)

2) Unit power fluctuation rate:

$$V_{np} = \frac{\Delta P_n}{P_N} \times 100\%$$ (4)

3) The unit power change rate:

$$V_{nt} = \frac{\Delta P_n}{\Delta t}$$ (5)

In the above formulas, NTP is power fluctuation, npV is power fluctuation, ntV is power variation, nP represents rated capacity of unit, n is sampling point, t is interval time.

In order to reduce the system error when the average method is used to separate data, this paper adopts the second rolling average method, that is moving the average again on the basis of the first average. It is usually 15 minutes for rolling average period length N, and for large load wind farms it should be 30 minutes. If the selected length is too small, the fluctuation characteristics of wind power will be displayed in the persistent component; if the selected length is too long, the variation trend of wind power will be displayed in the min component. However, for the min component, it is no longer a random variable, and it has certain distribution characteristics. The fluctuation characteristics of wind power are shown in the following figure.
The continuous component curve obtained by the quadratic rolling average method is closer to the measured data curve, which reduces the error caused by data processing and improves the accuracy of analysis.

3. Establishment of wind power evaluation model for SCADA system
This paper takes a 1.5MW unit of a wind farm as an example and combines it with SCADA. The real-time on-line monitoring data are used as the basis for evaluation and analysis, and the on-line monitoring data for the wind farm unit system are implemented according to the relevant calculation methods of the abandoned wind power model. The data are from June 10, 2016 to August 15, 2017.
There are 33 wind turbines in this wind farm. Because of the huge amount of data, only two of them are selected when calculating the abandoned wind volume.

According to the method of wind farm abandoned wind power evaluation model, the wind speed is corrected by programming with MATLAB software, pretreatment and screening of collected data. Figure 3 (a) is the revised power curve of unit A, and figure 3 (b) is the revised power curve of unit B.

![Corrected power curve of unit A](image)

![Corrected power curve of unit B](image)

(a) Corrected power curve of unit A

(b) Corrected power curve of unit B

Fig. 3 Modified power curve

4. Conclusion

Based on SCADA system, this paper evaluates the performance and operation status of wind turbines by using improved fuzzy neutralization evaluation theory. The second rolling average method is used
to analyze the characteristics of wind power fluctuation from differential time scale and fan capacity. The research shows that this method is closer to the real operation status.

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