Operation Risk Assessment of Large-scale Wind Power Grid Connected Power System Based on Value at Risk

Jun WANG Zongrui Shi

State Grid Shandong Electric Power Company Tancheng County Power Supply Company,Tancheng , Shandong, China

sdtcwj@163.com

Keywords: Risk assessment, Large-scale wind power grid connected power system, Value at risk

Abstract: The power system needs various support and guarantee, but power system components, voltage, lines and so on will produce risks under certain conditions, which is not conducive to the operation of the power system. In view of this, this paper expounds the operation risk assessment theory, operation risk assessment index and calculation of wind power grid connected power system, hoping to provide valuable reference for ensuring the smooth operation of large-scale wind power grid connected power system.

1. Introduction

The reason why large-scale wind power integration will produce power system operation risk is mainly large scale, followed by the instability of wind. In this case, if the risk situation of power grid is not evaluated, it will lead to power grid operation risk, resulting in irreparable consequences. Therefore, according to the characteristics of wind power grid, the risk assessment of voltage, line, load and other aspects is carried out, and the risk assessment is carried out through budget error, budget original damage probability, so as to avoid the risk of power grid operation and ensure the stable operation of power system.

2. Overview of Operation Risk Assessment Theory of Wind Power Grid Connected Power System

In the operation process of the power system, in order to ensure the smooth operation of the power system and reduce the occurrence of risks, the risk assessment of the power system is carried out. The factors that threaten the stability of the power system are taken into account, and the risk assessment is realized through a certain calculation method. The most commonly used risk assessment is achieved by mathematical calculation. Our country started the research of power system very early to avoid the operation risk, bring the risk research into the research system, so as to control the risk factors and ensure the smooth operation of the power system. In order to determine the anti-interference of the uncertain factors and the impact on the system, the comprehensive and in-depth identification of the uncertain factors is carried out. For large-scale wind power grid connected power system, due to its complex structure, there will be various problems in operation, which will lead to different risks. The main risks are as follows. First, the operation of power system includes multiple links, which will produce voltage, load and other consumption in the process of operation. Whether it can provide guarantee for power system operation after consumption, and whether it will produce the risk caused by energy shortage, which will seriously hinder the smooth operation of power system. Second, the loss of the power system, such as loss of load and voltage, causes risks. If the elements of power system operation lose, what kind of situation will appear. Third, the operation of the power system covers multiple components. Therefore, in the risk assessment, the risk situation of each component under different conditions is assessed, and the severity of risks is assessed through calculation.

  DOI: 10.25236/icited.2021.117

3. Operation Risk Assessment Index of Large-scale Wind Power Grid Connected Power System Based on Value at Risk

3.1. Risk Assessment Index of Voltage Overrun

Voltage is the precondition to ensure the operation of large-scale wind power grid connected power system, especially for the complex wind power grid connected operation system, whether the voltage is stable and within the specified range plays an important guiding role in ensuring the normal operation of the system. The calculation of risk index is the precondition for the objective risk assessment, usually for the risk assessment of voltage at the critical point. On the one hand, setting a specific operating environment, and then testing the voltage in this environment can find out whether the voltage is more likely to rise or fall in this case, and assess the risk of the voltage in the rising or falling state, and calculate the risk value in the process of assessment, and then determine the risk level, through which the risk of power system operation in a certain situation can be judged. As a result, in the daily system maintenance, the change of voltage is focused on to ensure the smooth operation of the system. In addition, this study is aimed at the large-scale wind power grid connected power system. It can be seen that the system has the characteristics of large scale and complex system, so there will be the risk of voltage collapse when it is running. Therefore, the risk assessment also involves the assessment of voltage collapse risk. In order to avoid the phenomenon of power collapse in the operation of power system, the risk value of voltage collapse in a certain operation condition is calculated to avoid the risk.

3.2. Risk Assessment Index of Cutting Load

The operation of large-scale wind power grid connected power system has the characteristics of high load, high voltage, complex system, etc., so in the long-term operation process, it will produce the risk caused by the high load intensity. If the risk can be predicted in time, we can actively take measures to control. For example, once the power system load exceeds the critical value, or is close to the critical value, the load can be cut off to maintain the stable operation of the power system, so the risk assessment is very important. However, in the specific assessment, due to the greater impact of operation time, the assessment of risk should consider the time factor, consider how long the power system operation will generate load, whether the load can cause risk, and the probability of causing risk, then define the safety value through the determination of risk value, that is, in which period the power system operation is safe. Of course, the control of time lacks rationality, because many practical factors need to be considered comprehensively. In short, after the load risk assessment index prediction, according to the risk index, the power system can be maintained and managed. After the risk value exceeds the safety critical value and the value continues to increase, the load needs to be cut off actively, so as to reduce the operating load pressure and ensure the smooth operation of large-scale system. Moreover, for the operation of large-scale wind power grid connected power system, the purpose of load risk assessment is to reduce the risk, but in order to ensure the operation of the power system, we should pay attention to the construction of load-related support, so as to reduce the risk caused by excessive load.

3.3. Line Voltage and Comprehensive Risk Assessment Index

Generally, the line operation risk of power system is low. As long as the quality and power of the line are guaranteed, the normal operation of the line can be guaranteed. However, there are many uncertain factors in the operation of large-scale wind power grid connected power system. In addition, the operation system is complex and the line load is large, so it is very easy to cause line risk. Therefore, the line voltage is included in the evaluation index of power system. Generally, the risk assessment of transmission line is mainly realized through the calculation of transmission line power. Under certain conditions, in the process of line operation of power system, according to the maximum power value that the line can carry, the risk level of different power values is divided, so as to avoid the line risk problems in the operation of power system. In addition, due to the complex structure of large-scale wind power grid connected power system operation, it is impossible to face only one kind of risk in operation, but a variety of risks, such as load risk, line risk, voltage risk, etc.

Therefore, after a single risk assessment, we should pay attention to the comprehensive assessment of a variety of risks, so as to more objectively carry out risk monitoring and reduce the operation risk of large-scale power grid. In addition, the measurement of comprehensive risk is based on the overall operation of the power grid, which is more comprehensive than a single risk assessment. Therefore, comprehensive risk assessment should be used as an important risk reference for power grid operation.

4. Operation Calculation of Large-scale Wind Power Grid Connected Power System Based on Value at Risk

4.1. Wind Power Probability Calculation

In the risk assessment of wind power grid connected power system, the risks are predicted, and the prediction is uncertain and subjective, so it will produce errors. In order to ensure that the calculation is closer to the objective facts, the prediction error is introduced in the calculation, which is expressed by ε, the predicted power is expressed by p''w, and the wind power rate is expressed in Pw. The calculation of wind power is the sum of prediction error and prediction power. Prediction error is an evaluation index to ensure the objectivity of risk assessment. When calculating, it is generally predicted under the guidance of the probability of a certain event change. The interception of this probability is not clearly defined in the calculation, so it is also called prediction error. Therefore, it is very important to evaluate and extract probability events. In general, it is more objective to use Logistic distribution and TLS distribution for error prediction, which are also the main methods used in daily error prediction. In addition, wind power error is also affected by wind speed, and the power displayed under different wind speed is also different. Generally, there are several cases of cut-in wind speed and the conversion from cut-in wind speed to rated wind speed. In order to ensure the objectivity of the prediction error, according to the consideration of the actual situation, it is specified in the range of 3-12 m/s.

4.2. Load Probability Calculation

From the above analysis, it can be seen that large load is easy to appear in the operation of large-scale wind power grid connected power system. To ensure that the load value is within a reasonable range, it is necessary to predict the load under a certain operation condition and evaluate the prediction error, so that the calculation of load probability is closer to the objective facts. In the calculation, the prediction error is taken as ξ, the prediction load is expressed as p''l, and the node load is expressed as PD. The node load is equal to the sum of the two. As the calculation method of prediction error of wind power probability, several probability points can be selected for error budget. Both load probability prediction error and load prediction are calculated under specific conditions. In order to ensure that the load value is more objective, the calculation of prediction error is very important. How to choose and what kind of probability have a great impact on the calculation results of node load value.

4.3. Real-time State Probability Calculation of Wind Turbine

The real-time state of wind turbine in wind power grid connected power system is an important reference for risk assessment. Both lines and power need to be within the safe value to ensure the smooth operation of wind power grid connected power system. In the calculation, pwt is regarded as the real-time state probability, which includes all the states of wind turbine operation. In order to ensure the objectivity of risk monitoring of wind power grid connected power system, the components that participate in the operation are treated as broken software for better risk assessment. λ w is the probability of motor failure, h is used to represent the stopped wind turbine, and h' is used to represent the running wind turbine. Risk assessment is carried out according to the probability under different conditions.

5. Conclusion

Large-scale wind power grid connected power system has the characteristics of large scale and high operation load, so it is prone to operation risk in a certain period of time. At present, the risk assessment indexes of large-scale wind power grid connected power system mainly include voltage overrun risk assessment, cutting load risk assessment, line risk assessment and comprehensive risk assessment, etc. Based on these assessment indexes, the risk assessment calculation mainly includes load probability calculation, wind power probability calculation and wind power real-time probability calculation. The risks are assessed through budget to ensure the stable operation of power system.

References

[1] Shang Haoyu, Liu Tianqi, Bu Tao, He Chuan, Yin Yue, Ding Lijie. Operation Risk Assessment of Power System Considering Wind Power and Photovoltaic Grid Connection. Modern Power, vol.37, no.04, pp.358-367, 2020.

[2] Dong Jianhua. Operation Risk Assessment of Power System Considering Wind Power and Photovoltaic Grid Connection. Industrial Science and Technology Innovation, vol.2, no.06, pp.96-97, 2020.

[3] Li Jinghua, Zuo Junjun, Wang Sai. Operation Risk Assessment and Analysis of Large-scale Wind Power Integrating into Electrical System. Power System Technology, vol.40, no.11, pp.3503-3513, 2016.