Summary of Research on Wind Power Participation in Frequency Modulation of Power System

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Abstract: Nowadays, with the increase of wind power input rate, its ratio in the power generation system is also rising, and the stability of the system is also affected. How to make good use of wind power to participate in system frequency adjustment has become a major and difficult issue in research.
Keywords: Wind Power; Frequency Regulation

Introduction

In recent years, people have paid more and more attention to environmental protection and energy conservation. As a kind of clean energy, wind power does not generate greenhouse gases, so the investment income is high. It has developed rapidly in China. But its own problems have also emerged. In the process of grid connection of wind power, the fluctuation of frequency will affect the quality of power and then affect the efficiency of the grid and user experience. Moreover, if large-scale or very large-scale wind turbines are connected to the grid, it will have a major impact on the safe operation of the grid. This poses new problems for the planning, arrangement, and control of the power system.

This article summarizes a small part of the control methods, advantages and disadvantages of wind power participation in system frequency modulation, and prospects for future research. Due to limited capabilities, there are situations in which the principles are not well understood, the problems cannot be viewed comprehensively, and the explanations are inaccurate. Hope the teacher will give guidance.

1. Impact on the power system

1.1 In terms of spare capacity

As wind power is affected by climate and environmental factors, its output power is unstable. In the power system, it is necessary to maintain the balance between power generation and power consumption. Therefore, the power system is equipped with reserve capacity to maintain this balance, while also preventing emergencies from affecting the power system. Due to the intermittent and random nature of wind power generation, the system frequency will be affected. Therefore, this requires the power system to be equipped with a larger reserve capacity to ensure the stability and reliability of the power supply. This increases the investment and at the same time reduces the efficiency of the use of electric energy.

1.2 Power system inertial response and primary frequency modulation ability decrease

In the power system, wind turbines are controlled by inverters. When wind power is connected to the grid on a large scale, the rotors of the wind turbines are decoupled from the system frequency under the control of the inverters and cannot respond to system frequency changes in time. This has a huge impact on maintaining the stability of the system frequency. At the same time, in order to use wind energy more efficiently, the working state of the wind turbine must be at the maximum power point, which makes the system's inertial response and frequency adjustment ability weaker, and frequency-related problems appear more frequently. Especially in some areas with harsh climate or environmental conditions, the impact on the system is more obvious.

2. Wind power participation system frequency modulation control method

2.1 Rotor kinetic energy control

The principle is to add a frequency control link in the control system.Rotor kinetic energy control can be divided into three types, including virtual inertia control, droop control and integrated inertia control. Their advantage is to prevent drastic changes in frequency, to be able to react in time and make adjustments accordingly. In addition, for the problem of wind power generation affected by environmental factors, a variable droop coefficient control method can be adopted. In this way, the frequency of the system in different areas and at different wind speeds can be stabilized, frequency errors can be reduced, and the system can operate more safely and stably. In addition, there is a variable parameter control method for rotor kinetic energy control, which can improve the accuracy of the system's frequency response. Can be expressed as:

$$\Delta P =- K_{df}\frac{df}{dt} - K_{pf}\Delta f$$

Among them, K_{df} represents the virtual inertia control coefficient, and K_{pf} is the droop control coefficient. ΔP is the value of active power change. ΔP is added to the original active power reference value to properly adjust the active output of the wind turbine. The droop control and virtual inertia control jointly adjust the active power, which is more accurate and timely.

2.2 System frequency modulation control with the participation of energy storage

Unlike rotor kinetic energy control, the system frequency will not be unstable due to lack of active support. Energy storage control can quickly respond and release Danone energy when needed, effectively dealing with the volatility of wind power. At the same time, when the frequency is too high or rising, it can adjust the frequency by absorbing energy, and when the frequency is low, it releases energy to stabilize the frequency. Its superior performance also has an ideal effect on the second drop of frequency. But its high energy consumption and high cost make it unrealistic to popularize. In addition, the configuration of energy storage capacity is also a problem, and the problem of effective evaluation and calculation of energy storage capacity will be solved in the future.

3. Limitations of wind power frequency modulation technology and ideas for future research directions

It can be concluded from the above analysis that although all have their advantages, the shortcomings cannot be ignored. Especially in today's situation where the requirements for power quality and power safety are relatively high. Because the current technology is immature, there are obvious problems in many aspects. With the popularization and promotion of wind power, these technical problems need to be solved urgently. For example, although the rotor kinetic energy control can adjust the system frequency to a certain extent, it can maintain the normal and stable operation of the system. However, the virtual inertia control has a short response time, so it is easy to cause a secondary drop in frequency and cannot fully reflect the frequency modulation performance of the wind turbine. The droop control can only intervene and adjust near the lowest point of the frequency, which has limitations. The integrated inertia control expands the range of adjustment, raises the lowest point of frequency drop, and improves stability. However, when the wind speed is in a slow or decelerating state, its control coefficient is difficult to set, and it lacks accurate and fast algorithms, which requires scientific and systematic research. Combining the above three control methods can not provide enough active power support. At the same time, because the control loop is added, it will bring new influences. How to balance many factors to find a better stable system frequency remains to be studied. The system frequency modulation control with the participation of energy storage lacks a set of accurate algorithms to plan the energy storage configuration.

4. Conclusion

Nowadays, wind power is strongly supported by the state. As a clean, pollution-free high-quality energy, its development can greatly alleviate the crisis of energy shortage, but its shortcomings cannot be ignored. It is necessary to find out as soon as possible to fully meet the requirements of wind power participation in system frequency modulation, and to test it in practice. As a result, it is believed that wind power will be widely used. The popularization of wind power development is the general trend.

5. References

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