Original Research Article

Analysis of the impact of distributed generation on power system scheduling

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Abstract: Against the backdrop of energy transformation, the rapid progress of distributed energy technology has led to an increasing proportion of its application in the power network, which has had a profound impact on the traditional power grid dispatch mode. This article provides a brief introduction to the basic concepts and characteristics of distributed energy, and explores the various impacts of distributed energy on power grid flow distribution, voltage stability, system security, and scheduling decisions. Measures have been proposed to optimize the power flow calculation model, implement comprehensive optimization and control of voltage, enhance system stability, and introduce intelligent scheduling methods. These measures aim to effectively address the challenges brought by distributed energy, enhance the flexibility and operational efficiency of power grid scheduling, and promote the deep integration of distributed energy and the power grid.

Keywords: Distributed power generation; Power system dispatch; Trend calculation

1. Introduction

The popularization of distributed generation is not only beneficial for helping some special users meet their electricity requirements, but also for promoting the development of power generation and distribution networks to a high-tech level. While helping the normal operation of the distribution system and the gradual development of distributed generation technology, it is necessary to maintain the normal operation of the distribution network and carry out relay protection. In order to better carry out the arrangement of distributed power generation, it is necessary to first understand the different types of distributed power generation, comprehensively consider the application of distributed power generation at multiple levels such as user experience, environmental impact, and technological development, and analyze and summarize better development strategies for distributed power generation while protecting the normal operation of the distribution network. The article will start by interpreting the basic concepts and unique properties of distributed generation, carefully analyzing its impact on the power dispatch system, and exploring targeted solutions, aiming to provide practical reference for the actual operation of power dispatch.

2. Overview of distributed power generation

2.1. Definition of distributed generation

Distributed generation (DG), as an innovative means of energy supply, is gradually disrupting the traditional power network architecture. This mode involves small, modular power generation around users or directly at power consumption sites. Most of these power generation units are directly connected to the distribution grid. The main purpose is to supply the power demand of surrounding users. At the same time, it has the potential to output energy to the power grid in farther regions. Unlike traditional large-scale centralized power plants, decentralized power supply is closer to the user end. Although the individual scale is not large, it has a wide coverage area and can adapt more flexibly to fluctuations in electricity demand, thereby enhancing the stability and efficiency of power supply.

2.2. Characteristics of distributed generation

The significant characteristics of distributed energy are variability and adaptability. In terms of energy types, distributed energy systems can integrate various green energy sources such as sunlight, wind power, biomass, and small-scale hydropower. This diversification not only promotes the richness of energy composition, but also reduces reliance on conventional fossil fuels, effectively reducing greenhouse gas emissions and playing a positive role in environmental protection. In terms of spatial layout, distributed energy stations are often located around users, which reduces the losses and costs of long-distance transmission and improves the stability and security of power supply. Distributed energy systems can also quickly adapt to fluctuations in regional loads, which is of great significance for regulating the supply-demand balance of the power grid and improving the overall performance of the power system.

3. The impact of distributed generation on power system scheduling

3.1. Impact on power system flow

With the widespread integration of decentralized energy, the traditional pattern of grid current flow has undergone significant changes. In the past power grid architecture, the flow of current was mainly unidirectional from large power generation bases to the user end. With the large-scale integration of decentralized energy, the flow of current has become more diverse, and even reverse flow may occur. This is mainly because decentralized energy sources are usually installed around users and can directly provide electricity to local users, sometimes even supplying power in reverse to the main grid. The bidirectional flow characteristics of this current pose higher requirements for the planning and operation of the power grid. More accurate current calculation methods and control measures should be adopted to ensure the stability and reliability of the power grid. The integration of decentralized energy sources may also lead to overload issues in local power grids. The power generation of decentralized energy sources is susceptible to interference from climate and environmental factors, and their power generation characteristics are unstable and intermittent. When the decentralized energy generation is large, it may cause local grid loads to exceed their designed capacity, leading to overloaded operation of the grid. This not only threatens the safety and stability of the power grid, but may also have adverse effects on users' power supply.

3.2. Impact on voltage stability

The integration of distributed power sources has brought significant changes to the voltage stability of the power grid. This type of power supply can provide voltage support and optimize the voltage quality of the power grid. When the grid voltage is at a low level, distributed power sources can increase the output of reactive power, thereby increasing the grid voltage and improving the voltage stability of the grid. The connection of distributed power sources may also cause issues such as voltage fluctuations and flicker. This is mainly because the output of distributed power sources is affected by numerous factors, and the changes may be frequent and drastic, which can have an impact on the grid voltage. The integration of distributed power sources may also have an impact on the power factor of the power grid. Due to the fact that distributed power sources are typically connected to the grid through power electronic devices such as inverters, these devices may generate harmonics and reactive power, reducing the power factor of the grid.

3.3. Impact on system reliability

The introduction of distributed energy has both positive and negative effects on the stability performance of the power grid. The integration of distributed energy enhances the stability of the power grid. Given that distributed energy devices are often deployed around users, once the main power grid fails, distributed energy can quickly transform into emergency power supply, providing emergency power to users, effectively shortening the duration and scope of power outages, and thereby improving the stability of the power grid. The integration of distributed energy sources may also pose a threat to the stability of the power grid. If the connection between distributed energy and the power grid is unstable, power grid failures may cause the separation of distributed energy and the power grid, thereby affecting the stability and reliability of the power grid. The power generation of distributed energy is constrained by various factors, and its volatility is significant. When the distributed energy generation is insufficient or excessive, it may disrupt the supply-demand balance of the power grid, thereby affecting the stability of the power grid.

4. Scheduling strategies for dealing with the impact of distributed generation

4.1. Improved trend calculation method

The integration of distributed energy has brought about a transformation in the existing power grid flow patterns, making the flow paths more complex and even potentially leading to backflow phenomena. Conventional power flow analysis techniques may be difficult to accurately depict the impact of distributed energy on grid power flow. In the face of such challenges, optimize trend analysis methods to match the access needs of distributed energy. This can be achieved by incorporating a simulation model of distributed energy in power flow analysis, while considering its generation characteristics and the specific location of grid connection points on the distribution of power flow in the grid. By accurately simulating the power generation of distributed energy sources, it is possible to predict the power flow direction of the power grid more accurately, providing a solid basis for power dispatch decisions. The introduction of distributed power flow analysis technology divides the vast power network into several small regions and conducts separate power flow analysis for each region. This strategy not only improves the efficiency of power flow analysis, but also more finely reflects the impact of distributed energy on local power grid power flow.

4.2. Implementing global optimization control of voltage

The connection of distributed power sources has brought significant fluctuations to the voltage balance of the power grid. In order to achieve overall voltage regulation optimization, a comprehensive voltage monitoring network is constructed to track the voltage status of each node in the power grid in real time. With the help of voltage monitoring, irregular changes in voltage can be quickly identified, providing accurate information foundation for voltage management. Utilizing cutting-edge voltage management technologies such as reactive power optimization and automatic voltage regulation (AVC). These technologies can automatically adjust the operation of reactive power compensation devices based on the specific conditions of the power grid, ensuring the balance of power grid voltage. The reactive power output characteristics of distributed power sources should also be considered as a supplementary measure for voltage management. Strengthen the construction of reactive power compensation facilities in the power grid and improve the level of reactive power reserve in the power grid. By adding reactive power compensation equipment, the voltage of the power grid can be more effectively adjusted and the stability of the voltage can be enhanced. Reactive power compensation devices can also be installed around the location of the distributed power supply to reduce the impact of the distributed power supply on the grid voltage.

4.3. Improving system reliability

The integration of distributed energy has brought both positive and negative effects on the stability of the power grid. In order to enhance the stability of the power grid, strengthen the connection between distributed energy and the power grid, and ensure its stable operation even in the event of power grid problems. This can be achieved by improving the connection mode of distributed energy and enhancing the stability of connected devices, thereby improving the firmness of the connection between distributed energy and the power grid. Fault isolation facilities can be installed near the location of distributed energy access to avoid grid faults affecting distributed energy. Build a sound distributed energy management system to achieve real-time monitoring and regulation of energy. Through this system, the operation status and output capability of distributed energy can be grasped in real time, providing accurate data foundation for scheduling decisions. Based on the real-time status of the power grid, dynamically adjust the output of distributed energy to ensure the balance and stability of power grid supply and demand. Energy storage technologies such as electrochemical energy storage and water pump energy storage can also be introduced to reduce fluctuations in distributed energy output and improve the stability of the power grid. Energy storage technology can release energy when distributed energy output is insufficient, store energy when output is excessive, and maintain the smooth operation of the power grid.

5. Conclusion

The distributed energy revolution is quietly reshaping the face of the power industry, gradually eroding and overturning the old power network structure and operation mode with a new posture. This article deeply analyzes the impact of distributed energy on power grid scheduling, revealing challenges at multiple levels such as power flow distribution, voltage stability, system security, and scheduling decisions. Further exploration was conducted on scheduling strategies to address these challenges, such as optimizing power flow calculation techniques, implementing comprehensive voltage optimization management, enhancing system stability, and introducing intelligent scheduling methods. The adoption of these strategies not only helps ensure the safety, stability, and economic operation of the power system, but also promotes the deep integration and harmonious coexistence of distributed energy and existing power networks. With the continuous innovation of technology and the continuous support of policies, the position of distributed energy in the power industry will become increasingly important, contributing an indispensable force to building a green, intelligent, and efficient modern energy system.

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