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Energy Internet System - Interconnection of Active Distribution Network

能源互联网系统 主动配电网的互联

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Table of Contents

Foreword 3
1 Scope 4
2 Normative References 4
3 Terms and Definitions 5
4 General Requirements 6
5 Physical Interconnection of Active Distribution Network 7
5.1 Grid Structure 7
5.2 Interconnection with Distributed Resources 8
5.3 Interconnection with Microgrid 8
5.4 Interconnection with Electric Vehicle Charging and Battery Swap Infrastructure 9
5.5 Interconnection with Energy Storage 9
5.6 Interconnection with Users 10
6 Information Interconnection of Active Distribution Network 12
6.1 Information Interaction 12
6.2 Communication Mode 15
6.3 Security Protection 15
7 Cyber-Physical Fusion of Active Distribution Network 15
Appendix A (informative) Typical Interconnection Modes of AC and DC Distribution Networks 17
Appendix B (informative) DC Side Grid Structure of Medium-voltage Distribution Network 19
Bibliography 21

Energy Internet System - Interconnection of Active Distribution Network

1 Scope

This document specifies the general requirements for the interconnection of active distribution network, as well as the requirements for the physical interconnection, information interconnection and cyber-physical fusion of active distribution network under the energy internet system.

This document is applicable to the planning, design and operation control of the active distribution network under the energy internet system.

2 Normative References

The contents of the following documents constitute indispensable clauses of this document through the normative references in the text. In terms of references with a specified date, only versions with a specified date are applicable to this document. In terms of references without a specified date, the latest version (including all the modifications) is applicable to this document.

GB/T 12325 Power Quality - Deviation of Supply Voltage

GB/T 14549 Quality of Electric Energy Supply - Harmonics in Public Supply Network

GB/T 15543 Power Quality - Three-phase Voltage Unbalance

GB/T 22239 Information Security Technology - Baseline for Classified Protection of Cybersecurity

GB/T 24337 Power Quality - Interharmonics in Public Supply Network

GB/T 29328 Specific Configuration of Power Supply and Self-emergency Power Supply for Important Power Users

GB/T 33589 Technical Requirements for Connecting Microgrid to Power System

GB/T 33593 Technical Requirements for Grid Connection of Distributed Resources

GB/T 36278 Technical Code for Electric Vehicle Charging / Battery Swap Infrastructure Interconnecting to Distribution Network

GB/T 36547 Technical Rule for Electrochemical Energy Storage System Connected to Power Grid

NOTE: 110 kV ~ 35 kV power grid is a high-voltage distribution network, 10 (20, 6) kV power grid is a medium-voltage distribution network, and 220 / 380 V power grid is a low-voltage distribution network.

3.3 active distribution network

Active distribution network is a distribution network that internally contains distributed power, energy storage and demand response resources, and with the capabilities of flexible topology, active control and operation management.

3.4 distributed resources

Distributed resources are the power supply that is connected to the power grid with a voltage level of 35 kV and below, and located near the user, and mainly consumed locally at a voltage level of 35 kV and below.

NOTE 1: including synchronous generator, asynchronous generator, converter and other types of power supplies.

NOTE 2: including solar energy, natural gas, biomass energy, wind energy, water energy, hydrogen energy, geothermal energy, ocean energy, comprehensive utilization of resources for power generation (including coal-mine gas for power generation) and energy storage, etc.

[source: GB/T 33593-2017, 3.1, modified]

3.5 microgrid

Microgrid is a small-size power supply network composed of distributed power generation, power load, monitoring, protection and automation devices (including energy storage devices when necessary) and can basically achieve internal balance of electric power and energy.

NOTE: microgrid is divided into grid-connected microgrid and independent microgrid.

[source: GB/T 33589-2017, 3.2, modified]

3.6 cyber-physical systems

Cyber-physical systems are systems constructed by integrating advanced perception, computation, communication, control and other information technologies and automatic control technologies, so that humans, machines, objects, the environment, information and other elements are mutually mapping, timely interacting and efficiently collaborating in the physical space and cyberspace.

4 General Requirements

4.1 The active distribution network is an important constituent part of the energy internet system. Its planning, design, operation control and information interaction shall be coordinated with the

architecture of the energy internet, so as to support the interconnection of energy and information.

4.2 The planning and design of the active distribution network shall adhere to the concept of user-oriented power supply reliability, so as to satisfy safe, efficient and flexible power transmission and distribution.

4.3 The active distribution network shall satisfy the convenient and flexible access, and consumption requirements of distributed resources, microgrid, electric vehicles, energy storage and various types of users.

4.4 The active distribution network shall comprehensively utilize various flexible resources on the power source side, the grid side and the load side, so as to implement the active operation and management of the distribution network and enhance the efficiency level of energy allocation.

4.5 The active distribution network shall realize the deep sharing and integration of information with the energy internet system and satisfy the relevant requirements of information security protection.

5 Physical Interconnection of Active Distribution Network

5.1 Grid Structure

5.1.1 The active distribution networks at all levels shall be mutually matching and supportive, robust and well-organized, so as to support the safe and flexible operation of the distribution network and the hierarchical and efficient consumption of distributed resources.

5.1.2 The grid structure of the same type of power supply area in the same region should be unified. The grid structure design shall follow the principle of non-cross power supply, so as to form relatively independent power supply areas. Each power supply area should contain a certain number of distributed resources, energy storage and demand response resources.

5.1.3 The structure of the active distribution network of a high-reliability power supply area shall realize the automatic isolation of faults, with the capability of network reconstruction, and gradually develop the capability of fault self-recovery.

5.1.4 The AC grid and the DC grid can constitute an AC-DC hybrid distribution network through flexible DC technology.

5.1.5 The interconnection of the AC-DC distribution network can adopt AC-DC, DC-AC and AC-DC-AC typical structures and their combinations. The typical interconnection modes of AC and DC distribution networks are shown in Appendix A.

5.1.6 The grid on the AC side shall comply with the stipulations of DL/T 5729, and a grid structure that satisfies the reliability requirements of power supply shall be selected.

5.3.2 The voltage level of the interconnection of the microgrid shall be comprehensively determined after technical and economic comparison based on the exchange capacity.

5.3.3 The power quality of the public connection point of the grid-connected microgrid connected to the AC distribution network shall comply with the stipulations of the relevant standards of GB/T 12325, GB/T 14549, GB/T 15543 and GB/T 24337. The requirements for the power quality of independent microgrids shall be determined through negotiation between the user and the microgrid operator.

5.3.4 The DC microgrid should be connected to the DC or AC distribution network nearby, and the AC microgrid should be connected to the AC distribution network nearby.

5.4 Interconnection with Electric Vehicle Charging and Battery Swap Infrastructure

5.4.1 The interconnection between the active distribution network and the charging and battery swap infrastructure shall comply with the stipulations of GB/T 36278 and GB 50966, etc.

5.4.2 The power supply voltage level of electric vehicle charging and battery swap infrastructure shall be determined after technical and economic comparison based on the total capacity of charging equipment and auxiliary equipment, and with comprehensive consideration of factors such as: demand factor and simultaneous factor, etc.

5.4.3 When the electric vehicle charging and battery swap infrastructure is connected to the AC distribution network, the power quality of the access point shall satisfy the stipulations of GB/T 12325, GB/T 14549, GB/T 15543 and GB/T 24337, etc. The installation location of power quality control equipment shall be reserved at the charging and battery swap infrastructure site.

5.4.4 The user level of the electric vehicle charging and battery swap infrastructure shall comply with the stipulations of GB/T 29328. For electric vehicle charging and battery swap infrastructures with great political, economic and safety significance, or charging and battery swap infrastructure sites whose interruption of power supply will have a relatively great impact on public transportation or affect the normal operation of important organizations can be regarded as secondary important users, and others can be regarded as general users.

5.5 Interconnection with Energy Storage

5.5.1 The interconnection of the active distribution network and energy storage shall comply with the stipulations of relevant standards, for example, GB/T 36547.

5.5.2 The voltage level of energy storage connected to the distribution network shall be determined by comprehensively considering the rated power of the energy storage system and the conditions of the local power grid.

5.5.3 The grounding mode of the neutral point of energy storage shall be consistent with the grounding mode of the connected grid.

5.5.4 When the energy storage is connected to the distribution network, the short-circuit capacity shall be verified, and the power quality connected to the AC distribution network shall satisfy the stipulations of GB/T 12325, GB/T 14549, GB/T 15543 and GB/T 24337, etc.

5.5.5 The energy storage grid-connected point shall be equipped with a grid-connected disconnection device that is easy to operate, can be locked and has an obvious disconnection indication.

5.5.6 When the energy storage is connected to the distribution network, the power control, frequency adaptability and fault ride-through shall comply with the relevant stipulations of GB/T 36547.

5.5.7 When the energy storage connected to the distribution network is used as a power source, control measures, such as: shifting peaks and filling valleys, smoothing power curves, and improving power supply reliability and operating efficiency of the grid, shall be taken to output active power. The energy storage system used as an emergency power supply shall have the capability of isolated island operation and be able to supply power to emergency loads after the upper-level distribution network loses power.

5.5.8 The energy storage interconnected with photovoltaics shall adopt integrated equipment as a technical guide to reduce the space occupied by equipment.

5.6 Interconnection with Users

5.6.1 The interconnection between the active distribution network and the users shall comply with the stipulations of relevant national standards and shall not affect the safe operation and power quality of the power grid.

5.6.2 The voltage level of the user's power supply shall be determined after technical and economic comparison and demonstration based on the conditions of local power grid, the safety requirements and reliability requirements for power supply, the maximum power load and the user's reported installation capacity. The user's access capacity and power supply voltage level are shown in Table 2. For users with a relatively long power supply radius and heavy load, when the power quality does not satisfy the requirements, they shall be interconnected with a network with a higher voltage level.

control layer can be integrated with the existing power distribution master station or separately set up and can also be deployed on the cloud platform of the Internet of Things application architecture.

b) Regional control layer: the regional control layer shall take the regional controller as the core and be mainly responsible for regional power coordination in a short time scale, and should be calculated in seconds. Based on the optimization goals and reference information provided by the optimization of global operation decision-making, the local autonomous optimization of distributed resources within its scope shall be carried out. In addition, through the distributed power management unit devices, different types of distributed resources are controlled. When the global operation decision-making loses its function, independent decision-making is also feasible to complete the autonomous operation control and management of its own region. The regional control layer can be deployed in the distribution substation or in the edge computing nodes in the application architecture of the Internet of Things, so as to realize cloud-edge collaborative control.

c) Local control layer: the local control layer belongs to short-time-scale power control, and the time response should be at the second level or below. The control unit of the distributed resources shall be taken as the core to dispatch the same type of distributed resources on the same power distribution node. It should be used to improve the power tracking speed of distributed resources, and meanwhile, it can realize the distribution coordination of multiple distributed resources.

6.1.4 In the active distribution network, data communication shall be realized between each level of equipment and related equipment, and data, such as: operating conditions of lower equipment and units, active power, reactive power, voltage, current and power factor, shall be collected.

6.1.5 The content of the interaction between the master station and the regional controller shall include the communication link status, operation mode and topology information of the regional controller, as well as the control reference values and control parameters of the regional controller, etc.

6.1.6 The content of the interaction between the regional controller and the local controller shall include distributed power supply / energy storage operation / charging pile / flexible load status, active power and reactive power, etc.

6.1.7 The content of the interaction between the regional controllers shall include the communication link status, operation mode and topology information of the regional controllers, as well as the control reference values and control parameters of the regional controllers, etc.

6.1.8 The control system of the active distribution network can adopt centralized or distributed control mode, and both can act as the backup of each other.

6.1.9 The control system of the active distribution network can exchange data with the master station of dispatching through the mode specified in IEC 61968, so as to ensure the safe

operation of the power grid.

6.2 Communication Mode

6.2.1 The communication system of the active distribution network shall satisfy the access demands of the remote communication channel of the source network load storage terminals, such as: distribution automation, power consumption information collection, distributed power supply, electric vehicle charging and battery swap infrastructure, and energy storage facilities, etc., so as to adapt to the development demands of emerging services and new communication technologies.

6.2.2 For the terminal remote communication, appropriate communication modes, such as: optical fiber, wireless and carrier communication shall be selected in accordance with factors such as: business performance demands, technical and economic benefits, environment and implementation difficulty of the active distribution network. When the medium-voltage distribution communication network adopts technologies such as: Ethernet Passive Optical Network (EPON), Gigabit Passive Optical Network (GPON) or Industrial Ethernet, independent fiber cores shall be used.

6.2.3 Wireless communication includes wireless public network and wireless private network. The wireless public network should adopt the access modes of private line access point name (APN) / virtual private network (VPN), and authentication encryption, etc.; the wireless private network should adopt the access modes of long-distance radio (LoRa) and ZigBee, etc., and security measures, such as: two-way authentication and security activation, etc. shall be adopted.

6.3 Security Protection

6.3.1 The information security protection of the active distribution network shall comply with the stipulations of GB/T 36572 and GB/T 22239, and satisfy the requirements of security partition, dedicated application of network, lateral isolation and vertical authentication.

6.3.2 The terminal equipment with control requirements shall be equipped with a security module. For control commands and parameter setting instructions from the master station system, security authentication and data integrity verification measures shall be taken to prevent posing as the master station to attack on on-site terminals and maliciously operate electrical equipment.

7 Cyber-Physical Fusion of Active Distribution Network

7.1 The application scenarios of cyber-physical fusion of active distribution network can effectively improve the analysis, decision-making and control capabilities of the active distribution network, including but not limited to source network load storage collaborative optimization analysis control and risk assessment scenarios across cyber-physical spaces of the cyber-physical fusion of the active distribution network.

7.2 The active distribution network shall adapt to the development direction of the energy

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