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**Evaluation Method of Grid-integration Characteristics for
Electrochemical Energy Storage Station**

电化学储能电站并网性能评价方法

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Evaluation Method of Grid-integration Characteristics for Electrochemical Energy Storage Station

1 Scope

This document specifies the overall requirements for the evaluation of grid-integration characteristics of electrochemical energy storage station (hereinafter referred to as “energy storage station”), as well as the evaluation items and contents, and the technical requirements for evaluation conclusions. It also describes the evaluation method for the performance of grid-integration equipment, the functions and grid-integration characteristics of the energy storage station.

This document is applicable to the operation, dispatch, management and evaluation of energy storage stations connected to the power grid with a voltage level of 10 kV and above. Other types of energy storage stations may refer to it for implementation.

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 12326 Power Quality - Voltage Fluctuation and Flicker

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

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

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

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

GB/T 36548 Test Specification for Electrochemical Energy Storage System Connected to Power Grid

GB/T 36549 Operation Performance Index and Evaluation of Electrochemical Energy Storage Station

GB/T 40595 Guide for Technology and Test on Primary Frequency Control of Grid-connected Power Resource

months of grid-integrated operation, and the evaluation period should be 12 months.

4.3 When the replacement of key equipment, such as: energy storage battery, battery management system and energy storage converter, and the update or replacement of software version affects the grid-integration characteristics of the energy storage station, an evaluation shall be re-conducted within 6 months after the replacement or update is completed.

4.4 The evaluation of grid-integration characteristics of the energy storage station shall be carried out through the steps of information and data collection, on-site inspection and testing, data analysis and processing, etc., so as to form evaluation conclusions and complete evaluation reports. The grid-integration characteristics evaluation procedures are shown in Appendix A.

4.5 The evaluation of grid-integration characteristics of the energy storage station shall be based on the basic information and operating data of the power station. The basic information collected is shown in Appendix B. In the absence of historical data of the items to be evaluated, on-site testing can be adopted; the test method shall comply with the requirements of GB/T 36548. When the on-site testing involves the jurisdiction of power dispatching, a dispatching permit shall be applied for.

4.6 The evaluation of grid-integration characteristics of the energy storage station shall be conducted through the modes of information review, on-site verification and on-site testing, including quantitative analysis and qualitative analysis.

4.7 The conclusions of the evaluation of grid-integration characteristics of the energy storage station shall be judged based on compliance. For non-compliant items, improvement measures or suggestions shall be provided.

5 Evaluation Items and Contents

5.1 Evaluation of Grid-integration Equipment

5.1.1 The evaluation of grid-integration equipment of the energy storage station includes evaluation of the information completeness and compliance of grid-integration equipment, and evaluation of the grid-integration equipment status.

5.1.2 For the evaluation of the information completeness of grid-integration equipment, the information completeness of the key equipment, such as: energy storage battery, battery management system and energy storage converter, etc., the information completeness of auxiliary equipment, such as: relay protection and safety automatic device, firefighting system, heating, ventilation and air conditioning system, and other primary and secondary equipment, as well as the compliance of actual operating equipment information and submission to the dispatching institution for filing shall be evaluated.

5.1.3 For the evaluation of the grid-integration equipment status, the effectiveness of the equipment's start-stop, switch and circuit breaker breaking functions, protection functions, remote and local control functions, and functions of receiving and uploading dispatch

information shall be evaluated.

5.2 Evaluation of Functions and Basic Performance

5.2.1 The evaluation of functions and basic performance of the energy storage station includes power station function evaluation, charging and discharging capacity evaluation, energy efficiency evaluation and operating status evaluation.

5.2.2 For the evaluation of functions of the energy storage station, the actual functional requirements for the energy storage station shall be evaluated.

5.2.3 For the evaluation of charging and discharging capacity, the indicators, such as: actual chargeable and dischargeable power, actual chargeable and dischargeable energy and energy retention rate of the energy storage station shall be evaluated.

5.2.4 For the evaluation of energy efficiency of the energy storage station, the indicators, such as: comprehensive efficiency, energy storage loss rate and station power consumption rate of the energy storage station shall be evaluated.

5.2.5 For the evaluation of equipment operating status, the indicators, such as: success rate of power grid dispatching response, equivalent operating hours, unplanned outage factor and availability factor of the energy storage station shall be evaluated.

5.3 Evaluation of Grid-integration Characteristics

5.3.1 The evaluation of grid-integration characteristics of the energy storage station includes active power control evaluation, reactive power control evaluation, primary frequency modulation capability evaluation, inertia response capability evaluation, grid adaptability evaluation, grid-integrated operation power quality evaluation and grid-integrated and off-grid switching capability evaluation.

5.3.2 The active power control evaluation shall include the following contents:

- a) Steady-state control evaluation: evaluate the relative active power deviation between the measured active power value at grid-integration point and the setting value of power dispatch after the energy storage station completes active power adjustment;
- b) Dynamic response characteristics evaluation: evaluate active power dynamic response indicators, such as: response time, adjustment time, switching time and power change rate, etc. during the execution of active power commands by the energy storage station;
- c) Automatic generation control (AGC) response characteristics evaluation: evaluate the indicators, such as: adjustment rate and adjustment accuracy of the energy storage station when participating in the AGC of the power system.

5.3.3 The reactive power control evaluation shall include the following contents:

dispatching institution;

- b) Check on-site the information completeness of the installation, commissioning, overhaul and operation tests of the grid-integrated key equipment of the energy storage station;
- c) Check on-site the compliance between the actual installation and operation of the auxiliary facilities, relay protection and automatic safety devices of the energy storage power station with the submitted information;
- d) Check on-site the functions and commissioning status of equipment start-stop, switch and circuit breaker breaking, emergency shutdown protection, remote and local control of the energy storage station;
- e) Check on-site the correctness of the dispatch information received and uploaded by the energy storage station;
- f) If the actual operation of the key equipment and auxiliary facilities of the energy storage station is consistent with the equipment information, it shall be determined as qualified; if one of them fails, then, it shall be determined as disqualified. If the energy storage station equipment can normally start, stop or shut down, and normally alarm and perform corresponding protective actions when an abnormality occurs, it shall be determined as qualified; if one of them fails, then, it shall be determined as disqualified.

7 Evaluation of Functions and Basic Performance

7.1 Evaluation of Station Functions

The evaluation of functions of the energy storage station is carried out in accordance with the following method:

- a) Check on-site the historical data of the energy storage station operating in accordance with the designed functions during the evaluation period; mark one continuous operation in accordance with the designed function as a functional event; select no less than 3 functional events; record the start and end time of each functional event, and the status of the energy storage station;
- b) When there are no valid functional events in the historical data, carry out no less than 3 continuous functional cycle tests on site in accordance with the requirements of the designed functions, and record the status of the energy storage station during each functional event;
- c) The actual functions of the energy storage station shall comply with the design documents or relevant contract provisions, otherwise, the energy storage station shall be determined as disqualified.

7.2 Evaluation of Charging and Discharging Capacity

The evaluation of charging and discharging capacity of the energy storage station is carried out in accordance with the following method:

- a) Check on-site the historical data of charging and discharging of the energy storage station in accordance with the rated power during the evaluation period; mark the continuous charging and discharging operation time in accordance with the rated power not less than the nominal time as a charging and discharging event; select no less than 3 charging and discharging events; record the maximum charging and discharging power value and charging and discharging energy value of each charge and discharge event in continuous operation;
- b) When there are no valid charge and discharge events in the historical data, carry out no less than 3 continuous charge and discharge cycle tests on-site at the maximum power, until reaching the charge and discharge cut-off conditions; record the charge and discharge time, and charge and discharge energy of each charge and discharge event; calculate the energy retention rate each time;
- c) The actual chargeable and dischargeable power, actual chargeable and dischargeable energy and energy retention rate of the energy storage station shall comply with the stipulations of GB/T 36549. If one of them fails, then, the energy storage station shall be determined as disqualified.

7.3 Evaluation of Energy Efficiency

The evaluation of energy efficiency of the energy storage station is carried out in accordance with the following method:

- a) Check the historical data, such as: daily, monthly and yearly on-grid and off-grid power, total power loss and station power consumption of the energy storage station during the evaluation period; calculate in accordance with the stipulations of GB/T 36549;
- b) The energy storage loss rate and station power consumption rate of the energy storage station shall comply with the stipulations of GB/T 36549. If one of them fails, then, the energy storage station shall be determined as disqualified.

7.4 Evaluation of Operating Status

The evaluation of operating status of the energy storage station is carried out in accordance with the following method:

- a) Check the historical data, such as: the number of times the dispatching institution issued commands to the energy storage station, the number of times the energy storage station successfully responded to the dispatching institution's commands, the charged quantity, discharged quantity, planned outage time, unplanned outage time and

shall be carried out on site in accordance with the method specified in GB/T 36548;

- c) The charge / discharge response time, charge / discharge adjustment time, charge-to-discharge switching time, and discharge-to-charge switching time of power control of the energy storage station shall comply with the stipulations of GB/T 36547. If one item fails, then, the energy storage station shall be determined as disqualified.

8.1.3 The evaluation of AGC response characteristics is carried out in accordance with the following method:

- a) Randomly check no less than 3 response AGC command events during the evaluation period; record the indicators, such as: operating range, adjustment rate and adjustment accuracy of each AGC command event;
- b) The AGC input capacity range of the energy storage station shall be consistent with the data reported to the dispatching institution. The adjustment rate and adjustment accuracy shall comply with the provisions of the dispatch agreement. If one item fails, then, the energy storage station shall be determined as disqualified.

8.2 Reactive Power Control

8.2.1 The evaluation of reactive power steady-state control is carried out in accordance with the following method:

- a) Check the reactive power issued value and grid-integration point reactive power measured value during the evaluation period; mark the energy storage station completing reactive power adjustment and maintaining stable power output for no less than 15 min as a power adjustment event. When the deviation of the reactive power issued value from the value issued at the previous moment exceeds 10% of the rated reactive power, record it as a valid reactive power adjustment event; randomly select no less than 5 valid reactive power adjustment events. The reactive power adjustment event shall include inductive reactive power and capacitive reactive power adjustment events;
- b) When there are no valid power adjustment events in the historical data, the test shall be carried out on-site in accordance with the method specified in GB/T 36548;
- c) The reactive power deviation of the energy storage station shall comply with the stipulations of GB/T 36547, otherwise, the energy storage station shall be determined as disqualified.

8.2.2 The evaluation of reactive power dynamic response characteristics is carried out in accordance with the following method:

- a) Check the reactive power response events of the energy storage station of the voltage fault ride-through period during the evaluation period. Randomly select no less than 5 valid reactive power dynamic response events; record the indicators, such as:

response time, voltage control deviation and power control deviation of each valid reactive power dynamic response event. The reactive power adjustment event shall include inductive reactive power and capacitive reactive power adjustment events;

- b) When there are no valid reactive power dynamic events in the historical data, the test shall be carried out on-site in accordance with the method specified in GB/T 36548;
- c) The reactive power response time of the energy storage station shall satisfy the requirements during voltage fault ride-through, otherwise, the energy storage station shall be determined as disqualified.

8.2.3 The evaluation of AVC response characteristics is carried out in accordance with the following method:

- a) Randomly check no less than 3 AVC command response events of the energy storage station during the evaluation period. Record the indicators, such as: adjustment range, adjustment rate and adjustment accuracy of each AVC response event;
- b) The AVC input capacity range of the energy storage station shall be consistent with the data reported to the dispatching institution. The indicators, such as: adjustment rate and power control deviation shall comply with the provisions of the dispatch agreement. If one item fails, then, the energy storage station shall be determined as disqualified.

8.2.4 The evaluation of power factor control is carried out in accordance with the following method:

- a) In accordance with the stipulations of GB/T 36548, operate on-site in the power factor control mode, and record the continuously adjustable range of power factor;
- b) The continuously adjustable range of power factor of the energy storage station shall comply with the stipulations of GB/T 36547, otherwise, the energy storage station shall be determined as disqualified.

8.3 Primary Frequency Modulation

The evaluation of primary frequency modulation of the energy storage station is carried out in accordance with the following method:

- a) Randomly check no less than 3 primary frequency modulation events, in which, the energy storage station participates, during the evaluation period. Record the power change amplitude, lag time, rise time, adjustment time and reactive power adjustment deviation of each participation in the primary frequency modulation event;
- b) Carry out on-site query of the dead zone setting range and error adjustment rate of primary frequency modulation of the energy storage station;
- c) When there are no valid primary frequency modulation event in the historical data,

- a) Check the operating data, protective actions and grid-integration point power operating status change records of the energy storage station during the evaluation period;
- b) Within the normal operating range of voltage, the energy storage station does not trigger protective actions, and the grid-integration point power operating status does not automatically switch. Under abnormal voltage operation, the energy storage station shall perform fault ride-through. The technical parameters during the fault ride-through shall comply with the stipulations of GB/T 36547, otherwise, the energy storage station shall be determined as disqualified.

8.6 Power Quality of Grid-integrated Operation

The evaluation of power quality of grid-integrated operation is carried out in accordance with the following method:

- a) Check the historical data of online power quality monitoring device of the energy storage station during grid-integrated operation;
- b) If the energy storage station is not equipped with the online power quality monitoring device, the test shall be carried out on-site in accordance with the method specified in GB/T 36548, and recorded;
- c) The harmonics of the energy storage station shall comply with the stipulations of GB/T 14549; the inter-harmonics shall comply with the stipulations of GB/T 24337; the three-phase voltage unbalance shall comply with the stipulations of GB/T 15543; the voltage fluctuations and flickers shall comply with the stipulations of GB/T 12326. If one item fails, then, the energy storage station shall be determined as disqualified.

8.7 Grid-integrated and Off-grid Switching

The evaluation of the energy storage station equipped with the function of grid-integrated and off-grid switching is carried out in accordance with the following method:

- a) Check the operating data of the energy storage station during the evaluation period. Record the relay protection action records, voltage and frequency signals during the planned grid-integrated to off-grid switching operation and off-grid to grid-integrated switching operation process of the energy storage station;
- b) When there are no valid grid-integrated and off-grid switching events in the historical data, the test of grid-integrated to off-grid switching test shall be carried out on-site, and the indicators, such as: voltage, frequency and power shall be recorded;
- c) During the planned grid-integrated to off-grid and off-grid to grid-integrated switching process of the energy storage station, if the energy storage station satisfies the requirements that no relay protection action is triggered and no unplanned load outage occurs, and the voltage during the switching process shall comply with the

Appendix B

(informative)

Information Collection Contents of Energy Storage Station Grid-integration Characteristics Evaluation

B.1 Basic Information

The basic information of the energy storage station includes the following contents:

- a) Name and geographical location of the proprietor or construction party; name and functional orientation of power station;
- b) Rated power and rated energy of energy storage station;
- c) Primary electrical wiring topology, grid-integrated voltage level and grid-integrated location;
- d) Feasibility study report, power station construction drawings and preliminary design documents;
- e) Specifications and parameters, type test report, exit-factory test report and sampling inspection report of equipment, such as: energy storage battery, battery management system, energy storage converter and monitoring system, etc.;
- f) Specifications and parameters, type test report and exit-factory test report of equipment, such as: fire-fighting system, heating ventilation and air-conditioning system, and booster station (switching station), etc.;
- g) Debugging report, safety assessment report (if present) and grid-integration testing report;
- h) Power station registration documents, grid-integration dispatch agreement, electricity purchase and sale contract, fire-fighting registration or approval documents, etc.

B.2 Evaluation Information

The information of grid-integration characteristics evaluation of the energy storage station includes the following contents:

- a) Protection value setting for primary and secondary equipment of the energy storage station;
- b) Electrical, electric quantity and event sequential records of power station operation, and historical data of online power quality monitoring;

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