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Technical Requirements for Connecting Electrochemical Energy Storage Station to Power Grid

电化学储能电站接入电网技术规定

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Technical Requirements for Connecting Electrochemical Energy Storage Station to Power Grid

1 Scope

This document stipulates the overall requirements for connecting electrochemical energy storage stations to the power grid, as well as the technical requirements for power control, primary frequency control, inertia response, fault ride-through, operation adaptability, power quality, relay protection and automatic safety devices, dispatching automation and communication, simulation models, and test and evaluation of connection to the power grid.

This document is applicable to the construction, connection, commissioning, test, inspection, operation, maintenance and overhaul of newly constructed, renovated and expanded electrochemical energy storage stations connected to the public power grid through voltage levels of 10 (6) kV and above.

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 12326 Power Quality - Voltage Fluctuation and Flicker

GB 14050 Types and Safety Technical Requirements of System Earthing

GB/T 14285 Technical Code for Relaying Protection and Security Automatic Equipment

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

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

GB/T 19862 General Requirements for Monitoring Equipment of Power Quality

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

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

GB/T 26399 Technical Guide for Electric Power System Security and Stability Control

time required for the actual output active power change of the electrochemical energy storage station to reach 90% of the difference between the target value and the initial value of active power.

[source: GB/T 40595-2021, 3.11, modified]

3.4 settling time of PFC

From when the power system frequency exceeds the primary frequency control dead zone, the shortest time that the absolute value of the difference between the actual output active power and the target value of active power of the electrochemical energy storage station never exceeds the allowable deviation.

[source: GB/T 40595-2021, 3.12, modified]

3.5 inertia response

When the power system frequency rapidly changes, the control function of the electrochemical energy storage station to regulate the active power in response to the power system frequency change rate.

[source: DL/T 2246.7-2021, 3.1, modified]

4 Overall Requirements

4.1 The electrochemical energy storage station shall have the capability of participating in peak regulation, frequency control and voltage regulation, etc. of the power system, and its safe and stable operation shall comply with the provisions of GB 38755 and GB/T 31464.

4.2 The electrochemical energy storage station shall have four-quadrant power control function and the capability of receiving and executing control instructions issued by the power grid dispatching institution.

4.3 The voltage level of the electrochemical energy storage station’s connection to the power grid shall be determined after comprehensive technical and economic comparison based on conditions, such as: the installed capacity of the energy storage station and the grid structure, etc.

4.4 The network security protection of the electrochemical energy storage station shall comply with the provisions of GB/T 36572.

4.5 The grounding mode of the electrochemical energy storage station shall be compatible with the grounding mode of the power grid, to which, it is connected. Lightning protection and grounding shall comply with the technical regulations of GB 14050, GB 50057 and GB/T 50065.

4.6 The electrochemical energy storage station connected to the power grid shall establish electromagnetic transient, electromechanical transient and medium and long-term dynamic

simulation models in accordance with the requirements of GB/T 42716.

4.7 The electrochemical energy storage station shall have a clarified electric energy measurement point. The electric energy measurement point shall be located at the grid connection point, equipped with a two-way electric energy measurement device, and have the function of remote transmission of electric energy measurement information. The technical requirements shall comply with the provisions of GB/T 50063 and DL/T 448.

4.8 The charge energy and discharge energy of the electrochemical energy storage station shall not be lower than the rated charge energy and rated discharge energy.

4.9 Before the electrochemical energy storage station is connected to the power grid for operation, the performance test of connection to the power grid shall be tested. The test method shall comply with the method specified in GB/T 36548.

5 Power Control

5.1 Active Power Control

5.1.1 The electrochemical energy storage station shall have the capability of controlling active power and shall be able to accept local and remote active power control instructions to achieve continuous regulation of active power.

5.1.2 When the electrochemical energy storage station responds to local active power control instructions, the charge / discharge response time shall not be greater than 500 ms, the charge / discharge regulation time shall not be greater than 2 seconds, the charge-to-discharge transition time, and the discharge-to-charge transition time shall not be greater than 500 ms, and the active power control deviation shall not exceed ± 1% of the rated power.

5.1.3 The electrochemical energy storage station shall be able to respond to automatic generation control (AGC) instructions, and the regulation rate and control accuracy shall satisfy the requirements of the power grid dispatching institution.

5.1.4 The electrochemical energy storage station shall have the capability of emergency power support and shall reach the maximum dischargeable or rechargeable power within 200 ms.

5.2 Reactive Power Control

5.2.1 The electrochemical energy storage station shall have the capabilities of reactive power regulation and voltage control and shall be able to accept local and remote control instructions to achieve continuous regulation of reactive power / voltage.

5.2.2 The electrochemical energy storage station shall have the control modes for power factor, reactive power and voltage control, and have the function of online switching control modes.

5.2.3 The power factor of the grid connection point of the electrochemical energy storage station shall be continuously adjustable within the range of 0.9 (lead) ~ 0.9 (lag).

electrochemical energy storage station shall increase the active power for discharging or reduce the active power for charging in accordance with the primary frequency control curve.

6.5 When the power system frequency rises and exceeds the frequency control dead zone, the electrochemical energy storage station shall reduce the active power for discharging or increase the active power for charging in accordance with the primary frequency control curve.

6.6 The primary frequency control power change amplitude of the electrochemical energy storage station should not be limited. If necessary, the amplitude limit shall not be less than 20% of the rated power.

6.7 The error adjustment rate of primary frequency control of the electrochemical energy storage station shall be 0.5% ~ 3%.

6.8 The delay time of PFC shall not be greater than 1 second, the rise time of PFC shall not be greater than 3 seconds, and the settling time of PFC shall not be greater than 4 seconds. When reaching stability, the active power control deviation shall not exceed ± 1% of the rated power.

7 Inertia Response

7.1 The electrochemical energy storage station shall have the function of inertia response, which can be turned on or off through local or remote control in accordance with the demands of the power system.

7.2 The electrochemical energy storage station shall upload the turn-on-off signals and action status signals of inertia response to the power grid dispatching institution.

7.3 The frequency change dead zone of inertia response of the electrochemical energy storage station should be determined in accordance with the actual situation of the power system, and should be set to ± (0.03 ~ 0.05) Hz. The time window for calculating frequency changes should be 100 ms ~ 200 ms. When the frequency change of the power system is greater than the dead zone range, the electrochemical energy storage station shall provide the capability of inertia response under the condition of satisfying Formula (2), and in accordance with the frequency change rate, change the active power output.

$$\Delta f \times \frac{df}{dt} > 0 \qquad \cdots\cdots (2)$$

Where,

Δf---the frequency deviation of the grid connection point of the electrochemical energy storage station, expressed in (Hz);

f---the frequency of the grid connection point of the electrochemical energy storage station, expressed in (Hz);

t---time, expressed in (s).

7.4 During inertia response, the active power change of the electrochemical energy storage station shall satisfy the requirements of Formula (3).

$$\Delta P_{\mathrm{I}} = -\frac{T_{\mathrm{J}}}{f_{\mathrm{N}}}\frac{df}{dt}P_{\mathrm{N}} \qquad \cdots\cdots(3)$$

Where,

ΔP_{I}---the active power change of the electrochemical energy storage station, expressed in (kW) or (MW);

T_{J}---the equivalent inertia time constant of the electrochemical energy storage station, expressed in (s), which should be set to 4 s ~ 14 s;

f_{N}---the rated frequency of the power system, expressed in (Hz);

P_{N}---the rated active power of the electrochemical energy storage station, expressed in (kW) or (MW).

7.5 The inertia response time of the electrochemical energy storage station shall not be greater than 1 second, and the control deviation of active power shall not exceed ± 1% of the rated power.

8 Fault Ride-through

8.1 Low-voltage Ride-through

8.1.1 When the voltage at the grid connection point drops, the electrochemical energy storage station shall have the capability of low-voltage ride-through. Within the shaded range shown in Figure 1, it shall continuously operate without being disconnected from the power grid. See the specific requirements below.

a) When the voltage at the grid connection point of the electrochemical energy storage station drops to zero, it shall continuously operate for no less than 150 ms without being disconnected from the power grid.

b) When the voltage at the grid connection point of the electrochemical energy storage station drops to 20% of the nominal voltage, it shall continuously operate for no less than 625 ms without being disconnected from the power grid.

c) When the voltage at the grid connection point of the electrochemical energy storage station drops to 90% of the nominal voltage, it shall continuously operate for no less than 2 s without being disconnected from the power grid.

d) When the voltage at the grid connection point of the electrochemical energy storage station drops within the shaded range and the area above the voltage contour in Figure 1, the electrochemical energy storage station shall continuously operate without being

K_1---the dynamic reactive current proportional coefficient of the electrochemical energy storage station;

U_t---the voltage per-unit value at the grid connection point of the electrochemical energy storage station;

I_N---the rated current of the AC side of the electrochemical energy storage station, expressed in (A).

b) The dynamic reactive current proportional coefficient K_1 of the electrochemical energy storage station can be determined in accordance with the actual situation of the power system, and the value range should be 1.5 ~ 3.

c) During the voltage drop at the grid connection point, the maximum output capacity of reactive current of the electrochemical energy storage station shall not be less than 1.05 times the rated current I_N of the AC side of the energy storage station.

d) From the moment when the voltage at the grid connection point drops, the response time of dynamic reactive current of the electrochemical energy storage station shall not be greater than 30 ms. From the moment when the voltage at the grid connection point returns to above 90% of the nominal voltage, the electrochemical energy storage station shall exit the dynamic reactive current increment within 30 ms.

8.1.3 When a three-phase asymmetric short-circuit fault occurs in the power system, causing the voltage at the grid connection point of the electrochemical energy storage station to drop, the electrochemical energy storage station shall have the capability of dynamic reactive support. See the specific requirements below.

a) When the positive-sequence component of the voltage at the grid connection point of the electrochemical energy storage station is 60% ~ 90% of the nominal voltage, the positive-sequence reactive current injected by the electrochemical energy storage station into the power grid shall be the sum of the positive-sequence reactive current output value I_0^+ during normal operation before the voltage drop and the dynamic positive-sequence reactive current increment ΔI_t^+. The negative-sequence reactive current absorbed from the power grid shall be the difference between the negative-sequence reactive current output value I_0^- during normal operation before the voltage drop and the dynamic negative-sequence reactive current increment ΔI_t^-. The dynamic positive-sequence and negative-sequence reactive current increments shall respond to the voltage changes at the grid connection point and satisfy the requirements of Formula (5).

$$\begin{cases} \Delta I_t^+ = K_2^+ \times (0.9 - U_t^+) \times I_N, (0.6 \leqslant U_t^+ \leqslant 0.9) \\ \Delta I_t^- = K_2^- \times U_t^- \times I_N \end{cases} \quad \cdots\cdots\cdots\cdots\cdots\cdots (5)$$

Where,

ΔI_t^+---the positive-sequence dynamic reactive current increment injected by the electrochemical energy storage station, expressed in (A);

ΔI_t^----the negative-sequence dynamic reactive current increment absorbed by the electrochemical energy storage station, expressed in (A);

K_2^+---the dynamic positive-sequence reactive current proportional coefficient of the electrochemical energy storage station;

K_2^----the dynamic negative-sequence reactive current proportional coefficient of the electrochemical energy storage station;

U_t^+---the per-unit value of positive-sequence component of the voltage at the grid connection point of the electrochemical energy storage station;

U_t^----the per-unit value of negative-sequence component of the voltage at the grid connection point of the electrochemical energy storage station;

I_N---the rated current of the AC side of the electrochemical energy storage station, expressed in (A).

b) The dynamic positive-sequence and negative-sequence reactive current proportional coefficients K_2^+ and K_2^- can be determined in accordance with the actual situation of the power system and should not be less than 1.0.

c) The response time of the positive-sequence and negative-sequence dynamic reactive current of the electrochemical energy storage station shall not be greater than 30 ms.

d) During the voltage drop at the grid connection point, the maximum output capacity of reactive current of the electrochemical energy storage station shall not be lower than 1.05 times the rated current I_N.

e) When the positive-sequence component of the voltage at the grid connection point is less than 60% of the nominal voltage, the electrochemical energy storage station shall inject appropriate positive-sequence dynamic reactive current into the power grid and absorb appropriate negative-sequence dynamic reactive current from the power grid without increasing the voltage unbalance at the grid connection point.

8.1.4 For electrochemical energy storage stations that are not disconnected from the power system during voltage drops, after the fault is eliminated, they shall have the capability of quickly recovering the active power, and the change rate of active power recovery should not be less than 30% P_N/s.

NOTE: P_N is the rated active power of the electrochemical energy storage station, which is expressed in (kW) or (MW).

8.2 High-voltage Ride-through

shall respond to the voltage change at the grid connection point and shall satisfy the requirements of Formula (6).

$$\Delta I_t = K_3 \times (U_t - 1.1) \times I_N, (1.1 \leqslant U_t \leqslant 1.3) \quad \cdots\cdots (6)$$

Where,

ΔI_t---the dynamic reactive current increment injected by the electrochemical energy storage station, expressed in (A);

K_3---the dynamic reactive current proportional coefficient of the electrochemical energy storage station;

U_t---the voltage per-unit value at the grid connection point of the electrochemical energy storage station;

I_N---the rated current of the AC side of the electrochemical energy storage station, expressed in (A).

b) The dynamic reactive current proportional coefficient K_3 of the electrochemical energy storage station can be determined in accordance with the actual situation of the power system, and not be less than 1.5.

c) From the moment when the voltage at the grid connection point rises, the response time of dynamic reactive current of the electrochemical energy storage station shall not be greater than 30 ms. From the moment when the voltage at the grid connection point returns to below 110% of the nominal voltage, the electrochemical energy storage station shall exit the actively provided dynamic reactive current increment within 30 ms.

8.2.3 For electrochemical energy storage stations that are not disconnected from the power system during the voltage rise period and do not maintain the active power value before the fault, after the fault is eliminated, they shall have the capability of quickly recovering the active power, and the change rate of active power recovery should not be less than 30% P_N/s.

8.3 Continuous Fault Ride-through

8.3.1 Continuous low-voltage ride-through

The electrochemical energy storage station shall have the capability of continuous low-voltage ride-through. See the specific requirements below:

a) The electrochemical energy storage station shall have the capability of withstanding at least two consecutive low-voltage ride-throughs;

b) The time interval between two adjacent low-voltage ride-throughs should be 0.2 s ~ 2 s, which can be determined based on the fault reclosing action time of the outgoing

term flicker value caused by the grid connection point shall satisfy the provisions of GB/T 12326.

10.4 Voltage Unbalance

After the electrochemical energy storage station is connected, the voltage unbalance caused by the grid connection point shall satisfy the provisions of GB/T 15543.

10.5 Monitoring and Management Requirements

The electrochemical energy storage station shall be equipped with power quality monitoring devices that satisfy the requirements of GB/T 19862. When the power quality indicators of the electrochemical energy storage station do not satisfy the requirements, power quality management equipment shall be installed.

11 Relay Protection and Automatic Safety Devices

11.1 The design and configuration of relay protection, automatic safety devices and secondary circuits of the electrochemical energy storage station shall satisfy the requirements of the power network structure and main electrical wiring of energy storage stations, and shall comply with relevant provisions on power systems and anti-accident measures.

11.2 The configuration of relay protection and automatic safety devices of the electrochemical energy storage station shall be coordinated with the power grid-side protection and power grid-side reclosing, comply with the provisions of GB/T 14285, and satisfy the requirements of reliability, selectivity, sensitivity and quickness.

11.3 The grid connection point of the electrochemical energy storage station shall be equipped with a grid connection point measurement and control protection device, which has the protection functions of overcurrent, overload, zero-sequence overcurrent, overvoltage, undervoltage, over-frequency and under-frequency, etc.

11.4 For electrochemical energy storage stations connected to the power grid through voltage levels of 220 kV and above, the grid connection line shall be equipped with two sets of full-line fast-acting main protection; the secondary circuits and communication channels shall satisfy dual requirements. When fiber optic channel conditions are met, longitudinal current differential protection should be used for the full-line fast-acting main protection.

11.5 The electrochemical energy storage station shall be equipped with anti-islanding protection. When the electrochemical energy storage station operates in the grid-connected mode and detects an unplanned island, the electrochemical energy storage station shall be disconnected from the power grid within 2 seconds.

11.6 Electrochemical energy storage stations connected to the power grid through voltage levels of 35 kV and above shall be equipped with fault recording equipment. The connected analog quantities and switching quantities shall satisfy the requirements of the remote control and shall

have sufficient recording channels. The situation from 10 seconds before the fault to 60 seconds after the fault shall be recorded, and the wave recording information shall be remotely transmitted to the power grid dispatching institution.

11.7 The electrochemical energy storage station shall be equipped with automatic safety devices in accordance with the provisions of GB 38755 and GB/T 26399 based on the safety and stability calculation results of the connection scheme.

12 Dispatching Automation and Communication

12.1 The electrochemical energy storage station shall be equipped with dispatching automation equipment, such as: computer monitoring systems, electric energy measurement systems, secondary system safety protection equipment and data network access equipment, etc.

12.2 The telecontrol information collection range of the electrochemical energy storage station dispatching automation system shall satisfy the requirements of the telecontrol information access regulations of the dispatching automation energy management system of the power system.

12.3 The transmission channel, transmission mode and information transmission content between the electrochemical energy storage station and the power grid dispatching institution shall comply with the relevant regulations of the power grid dispatching institution, including providing telemetry signals, remote signaling signals, remote regulation signals, remote control signals, relay protection and automatic safety device signals, as well as the modes of providing signals and real-time requirements, etc.

12.4 The electrochemical energy storage station shall provide the following information to the power grid dispatching institution:

a) Electrical analog quantities: frequency, voltage, current, active power, reactive power, power factor and power quality, etc. of the grid connection point;

b) Electric energy and energy status: rechargeable / dischargeable capacity, charge capacity, discharge capacity and power station energy status, etc.;

c) Status quantities: breaking equipment status, charging and discharging status, fault information, telecontrol terminal status and communication status of the grid connection point;

d) Other information: other information required by the grid connection dispatching agreement.

12.5 The electrochemical energy storage station shall deploy network security protection equipment and connect information to the power grid dispatching institution. The network security protection shall satisfy the requirements of GB/T 22239, GB/T 36572 and security protection provisions of the power monitoring system.

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