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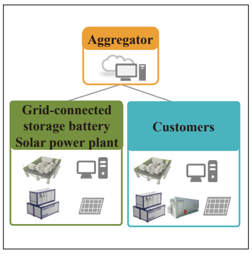

Solution Utilizing Energy Storage System

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The importance of investment in and utilization of renewable energy sources such as solar power is increasing as a result of increases in electricity consumption due to the new construction and expansion of data centers, the fossil fuel procurement risk arising from geopolitical factors, and efforts to achieve carbon neutrality by 2050. However, the output of renewable energy sources fluctuates depending on weather conditions and their large-scale integration leads to instability in the power system. One solution for maintaining stable and reliable operations is to ensure flexibility through the use of batteries. Nissin Electric Co., Ltd. provides a solution that integrates the entire system from storage batteries to substations. This paper introduces a battery utilization solution that combines Nissin Electric Co., Ltd.'s solution with Sumitomo Electric Industries, Ltd.'s energy management system, *s*EMSA (Sumitomo Energy Management System Architecture) in order to meet various needs regarding battery utilization.

Keywords: storage battery, balancing power, electricity trading market, energy management system, *s*EMSA

1. Introduction

In fiscal year 2022, renewable energy (RE) accounted for approximately 22% of Japan's power generation mix, with solar power at 9.8% and wind power at 1.1%. The "7th Strategic Energy Plan," published in February 2025, estimates that by fiscal year 2040, RE will account for 40–50% of the power generation mix, of which solar power is expected to represent approximately 23–29%, and wind power approximately 4–8%. Consequently, solar and wind power are highly expected to become major power sources as RE.[1]

However, solar and wind power are unstable sources (variable RE) whose output fluctuates with weather conditions. Introducing large amounts of these sources could destabilize the power grid. One important countermeasure being emphasized is balancing power.

Balancing power is electricity used for supply-demand adjustment and frequency fluctuation control. To secure this, the use of storage batteries is gaining attention.[2],[3] Storage batteries are distributed power sources*1 with fast charge / discharge response speeds. They can generate balancing power by flexibly charging and discharging according to the output of variable RE and supply-demand conditions.

Nissin Electric Co., Ltd. (Nissin Electric) offers a comprehensive solution for introducing storage battery systems, as shown in Fig. 1, encompassing the storage battery unit, power conditioner (PCS), storage battery control unit, and even substation equipment. Furthermore, in response to recent demand for balancing power and trends in storage battery utilization, Nissin Electric is jointly proposing storage battery utilization solutions that combine its technology and know-how with that of Sumitomo Electric Industries, Ltd. (Sumitomo Electric), which provides the energy management system (EMS) called Sumitomo Management System Architecture (*s*EMSA).

This paper first explains recent examples of storage battery utilization and *s*EMSA, and then introduces the storage battery utilization solution proposed by Nissin Electric and Sumitomo Electric.

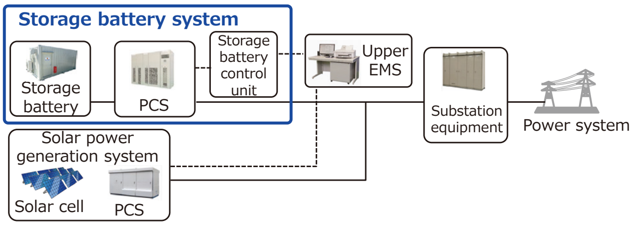


Fig. 1. Nisshin Electric's storage battery system

2. Electricity Trading Markets and Storage Battery Utilization Examples

As mentioned earlier, to expand the adoption of variable RE and stabilize the grid, efforts are advancing to secure balancing power and introduce and utilize storage batteries capable of providing it. This section outlines the mechanisms for securing balancing power and recent examples of storage battery utilization.

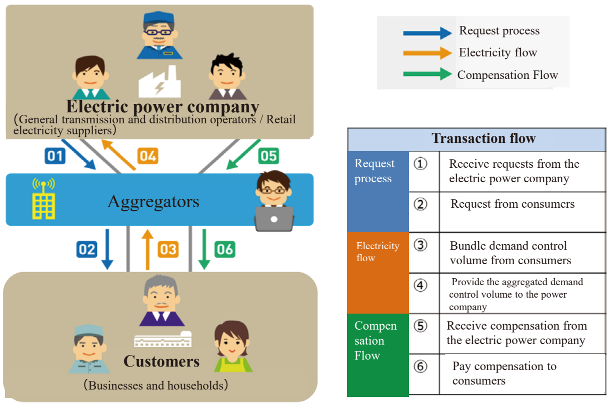
2-1 Electricity trading markets

Balancing power is traded in the supply-demand adjustment market, which is one segment of the electricity trading market (established in 2021) (Table 1).

Table 1. Classification and overview of electricity trading markets

Market name	Overview
Supply-demand adjustment market	Market for trading balancing power (ΔkW) to maintain electricity supply-demand balance
Capacity market	A market for trading future required generation capacity / supply capability (kW)
Wholesale electricity market	A market for trading electricity volume (kWh)

Balancing power is provided to the market by power producers and customers who possess sources or equipment capable of generating balancing power, such as generators or storage batteries, through intermediaries known as aggregators. General transmission and distribution operators then procure this balancing power, and the power producers, customers, and aggregators receive compensation from the market for providing it. Figure 2 shows the flow of balancing power transactions via aggregators.



Source: Figure from Reference (4): Reproduced with modifications from an illustration of megawatt trading

Fig. 2. Flow of balancing power (demand control) trading via aggregators

2-2 Examples of storage battery utilization

Examples of storage battery utilization are primarily categorized into three types: customer-installed storage batteries, grid-connected storage batteries, and RE source co-located storage batteries (RE co-located storage batteries) (Fig. 3).

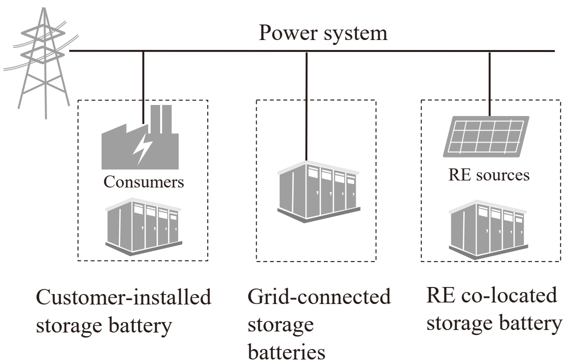


Fig. 3. Example of storage battery utilization

Customer-side storage batteries are installed within customer facilities such as homes and factories. They achieve peak shaving by discharging during peak electricity demand, thereby reducing electricity costs. They also serve as emergency power sources during disasters. When solar power generation is present at the customer facility, they enable effective utilization of RE by charging excess RE and discharging it during periods of high demand. In recent years, the development of electricity trading markets has enabled operations where storage batteries provide balancing and supply capabilities to the market in exchange for compensation.

Grid-connected storage batteries are directly connected to the power grid and are utilized for grid stabilization purposes, such as supply-demand adjustment and frequency fluctuation control. Support from subsidy programs, the development of electricity trading markets, and the launch of the Long-Term Decarbonized Capacity Auction*2 have encouraged the new installation and renewal of decarbonized power sources in capacity markets. Consequently, the introduction of grid-connected storage batteries is progressing.(5) Thus, grid-connected storage batteries serve as a power source that contributes to supply-demand adjustment for the power grid, while for operators, they become a business resource that generates revenue by being utilized in multiple markets.

RE co-located storage batteries are storage batteries installed alongside large-scale RE sources such as mega solar plants. These batteries enable effective utilization of RE generation by charging with power that would otherwise be curtailed due to overloaded solar panels*3 or output control*4 imposed by General Electricity Transmission and Distribution Utilities. Furthermore, by utilizing the Feed-in Premium (FIP) system*5 and operating the system to charge during periods of low market prices and discharge during periods of high prices, it is possible to increase electricity sales revenue.

3. Sumitomo Electric's Energy Management System *s*EMSA

EMS is a system that controls the charging and discharging of storage batteries to support optimal operation. This chapter focuses on *s*EMSA, the EMS developed by Sumitomo Electric.

3-1 Overview and system configuration of *s*EMSA

*s*EMSA is an EMS that creates optimal operation plans for distributed power sources and automatically controls them based on these plans. With the recent development of electricity trading markets, there has been an increase in cases where *s*EMSA is used as an EMS for aggregators (aggregator system).*6 *s*EMSA consists of an *s*EMSA server that integrates and manages multiple distributed power sources across multiple sites via the cloud and connects them to the electricity trading market system,*7 and *s*EMSA terminals, which are site EMS*8 installed at each site for distributed power sources (Fig. 4).

The *s*EMSA server formulates plans for the optimal operation of distributed power sources based on various information such as instructions and forecasts from the power trading market system, and transmits these plans to the *s*EMSA terminals. The server can incorporate various functions internally, including integration with the power trading market system, forecasting capabilities, optimal operation planning functions, and integration with subordinate systems (*s*EMSA terminals). The server is constructed by flexibly combining these functions based on customer needs.

The *s*EMSA terminal controls distributed power sources such as storage batteries based on operational plans transmitted from the *s*EMSA server. It also acquires actual values from distributed power sources and trading meters and interfaces with the *s*EMSA server.

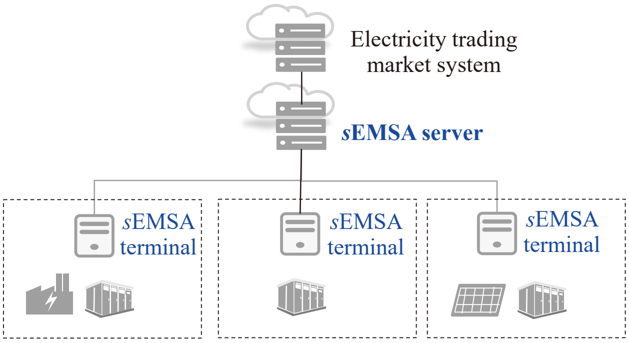


Fig. 4. Example system configuration applying *s*EMSA

3-2 Features of *s*EMSA

*s*EMSA's functions include optimal operation planning, control functions, and integration with electricity trading market systems. Utilizing these functions enables high-precision control of storage batteries and their utilization across multiple markets.

(1) Optimal operation planning function

The *s*EMSA server periodically creates 30-minute operational plans for distributed power sources based on electricity demand, generation forecasts, and distributed power source information, transmitting these plans to *s*EMSA terminals at intervals of several minutes. During the control operation, it monitors the control status of distributed power sources in real time. If a deviation occurs between the actual control performance value and the planned or target value, it sends additional control commands to correct the control deviation.(6)

(2) Control functions

The control functions of *s*EMSA are classified into two types: control based on the operational plan for the *s*EMSA server and control performed autonomously by the *s*EMSA terminal.

The *s*EMSA terminal performs monitoring and control on a per-second basis. Control methods include rule-based conditional control and feedback control. Rule-based conditional control ensures that demand at the power receiving point does not exceed a constant threshold at all times. Examples include demand control*9 and solar power reverse power flow prevention control.*10

Feedback control regulates power consumption at the point of delivery to maintain a constant value, and is required when high control precision is demanded, such as for planned simultaneous equalization*11 or tertiary balancing power*12 in the supply-demand adjustment market.(3) Furthermore, if control performance fails to meet the initial plan or target value even after feedback control, the *s*EMSA server modifies the operational plan and transmits new control commands to the *s*EMSA terminals. Figure 5 shows the optimal operational plan formulation and control flow for *s*EMSA.

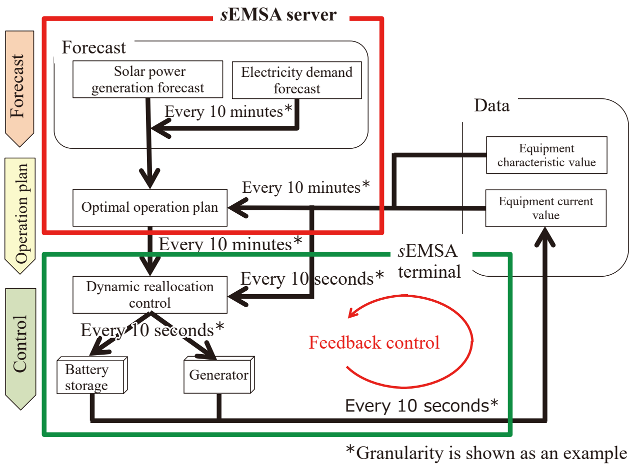


Fig. 5. *s*EMSA optimal operation plan formulation and control flow

This section introduces an example from the Ministry of Economy, Trade and Industry's Virtual Power Plant Construction Demonstration Project (until FY2020), where distributed power sources such as storage batteries and cogeneration units at two sites (Nissin Electric's Maebashi Plant and Sumitomo Electric's Yokohama Works) were group-controlled using *s*EMSA. Figure 6 shows the system configuration for the demonstration test of tertiary balancing power in the supply-demand adjustment market. Control was achieved to keep the total power intake at both sites within ±10% of the target value, confirming that the control accuracy required for tertiary balancing power in the supply-demand adjustment market (available supply capacity*13 within ±10%) could be attained (Fig. 7).(7)

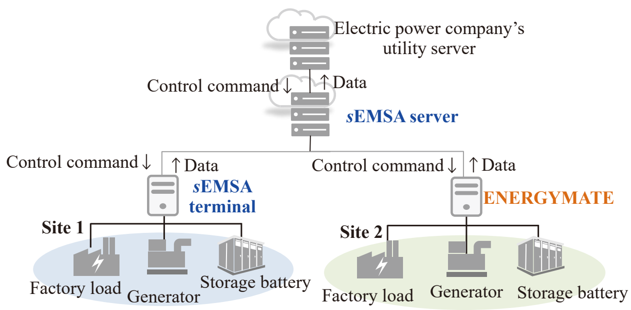
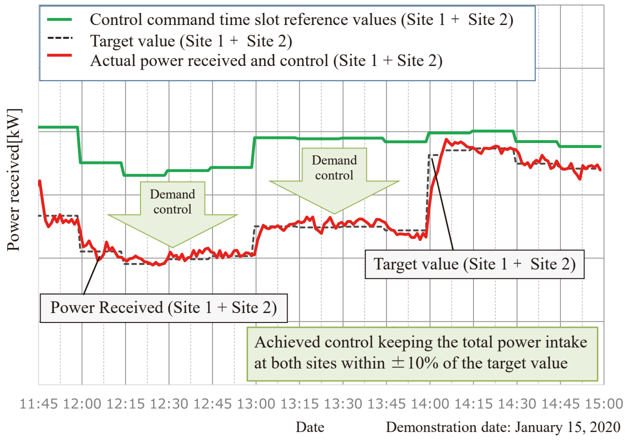


Fig. 6. System configuration for demonstration test of tertiary balancing power in supply-demand adjustment market



Source: Modified from Fig. 6 (p.14) in Reference (7)

Fig. 7. Demonstration test results

(3) Integration functionality with power trading market systems

The *s*EMSA server can interface with systems for the supply-demand adjustment market and the capacity market, receiving control commands from each market. If the same distributed power source participates in multiple markets, the aggregator system will receive multiple control commands. In this case, the *s*EMSA server updates the operational plan according to predefined command priorities and transmits the control command values, thereby enabling operation across multiple markets. Currently, the *s*EMSA server is utilized by multiple aggregators as a system for leveraging distributed power sources in both supply-demand adjustment markets and capacity markets.

4. Storage Battery Utilization Solutions

Nissin Electric contributes to energy savings, cost reduction, and carbon dioxide emission reduction not only through equipment sales but also by providing solutions that combine software and network technologies with substation equipment and power system devices.[8] Furthermore, in response to recent demand for storage battery utilization, it proposes storage battery utilization solutions incorporating Sumitomo Electric's *s*EMSA.

This chapter introduces solutions for battery utilization solutions for customer-installed storage batteries, solutions for grid-connected storage batteries, and solutions for RE co-located storage batteries.

4-1 Solutions for customer-installed storage batteries

The solution for customer-installed storage batteries provides comprehensive support to customers considering new storage battery installations, covering pre-construction consultations, system construction, and after-sales support. Figure 8 shows an example configuration of a customer-installed storage battery system. The proposed system includes the storage battery unit, substation equipment, PCS, storage battery control unit, and site EMS.

The output from solar power generation and the electrical load at the customer facility fluctuate, making advance prediction difficult. Therefore, determining the most cost-effective storage battery specifications for the customer is a key challenge during storage battery introduction. Nissin Electric conducts customer interviews and simple simulations prior to system construction. Based on these results, it proposes system capacity and equipment.

In recent years, new needs have emerged for operating customer-installed storage batteries in various ways: enhancing RE utilization rates by pairing a storage battery with self-consumption solar power generation, or utilizing them in supply-demand adjustment markets and capacity markets. While multi-purpose operation effectively enhances the benefits of storage battery introduction, it also increases the complexity of charge / discharge planning. Furthermore, when participating in the supply-demand adjustment market or capacity market via an aggregator, communication linkage is required between the site EMS at the customer facility and the aggregator system. Linking a site EMS with an aggregator system that lacks prior linkage experience may necessitate prior specification adjustments or software development.

To address these challenges, Sumitomo Electric's *s*EMSA server offers the following solutions. When operating solar power generation for self-consumption alongside storage batteries, the *s*EMSA server automates the creation of storage battery charge / discharge plans. Furthermore, even when installing solar power generation and storage batteries across multiple sites, a single *s*EMSA server set can create operation plans for multiple facilities. Regarding storage battery operation in power trading markets, when participating via an aggregator using the *s*EMSA server, the premise is that the site EMS (*s*EMSA terminal) and the aggregator system (*s*EMSA server) can interoperate. This offers the advantage of reducing the need for prior specification adjustments and software development costs.

Currently, when a customer participates in the supply-demand adjustment market, the control accuracy of the balancing power must be within ±10% of the available supply, with the data at the power receiving point as the evaluation target. For customers with significant load fluctuations, evaluation based on power receiving point data has been a barrier to market entry. However, starting in fiscal

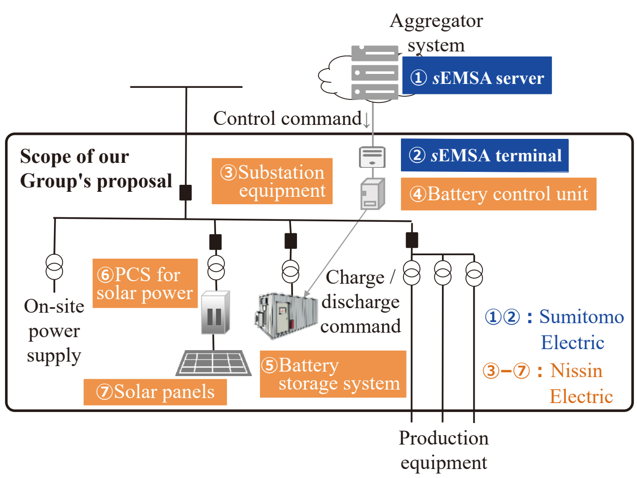


Fig. 8. Example configuration of customer-installed storage battery system

year 2026, device-end measurement*[14] is scheduled to be introduced, allowing evaluation based on device-level data. This increases the likelihood of meeting the required control accuracy compared to previous methods, suggesting that the utilization of storage batteries in the supply-demand adjustment market will likely increase going forward.[(9)]

4-2 Grid-connected battery solutions

For grid-connected storage battery solutions, we provide comprehensive support to operators developing grid-connected storage battery businesses, from pre-construction consultations to system construction and after-sales support.The system can be provided as a package including the storage battery unit, substation equipment, storage battery control unit, PCS, and EMS (site EMS, aggregator system).[(10)] An example configuration of a grid-connected storage battery system is shown in Fig. 9.

At the site where the grid-connected storage battery is installed (storage facility), equipment such as storage battery unit, substation equipment, PCS, storage battery control unit, and site EMS is installed. However, the sources for procuring these various pieces of equipment often differ. In such cases, the overall system at the storage facility is constructed by integrating equipment from different manufacturers. However, this can sometimes pose challenges, requiring significant time and effort for functional configuration of each installed device, specification adjustments for communication interfaces,*[15] and post-integration operational verification testing.

For grid-connected storage battery solutions, Nissin Electric and Sumitomo Electric pre-coordinate the interfaces for the storage battery unit, substation equipment, PCS, battery control unit, site EMS (*s*EMSA terminal), and aggregator system (*s*EMSA server), enabling their integrated deployment. This reduces the time and effort required for functional configuration and specification adjustments. Furthermore, since the aggregator system (*s*EMSA server) incorporates functions compatible with the supply-demand adjustment market and capacity market, connecting grid-connected storage batteries to the *s*EMSA server enables operation across multiple markets.

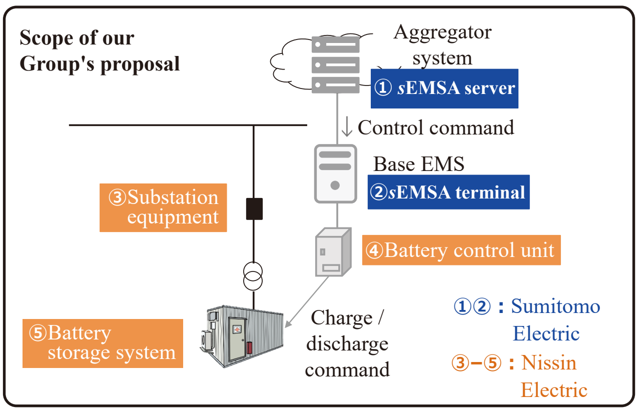


Fig. 9. Example configuration of grid-connected storage battery system

4-3 Solutions for RE co-located storage batteries

The solution for RE co-located storage batteries targets solar power plant operators considering storage battery installation.

As output control areas expand nationwide and output control volumes increase, demand is expected to grow for installing storage batteries at solar power plants to charge during output control periods. Furthermore, in areas with high solar power penetration, wholesale electricity prices often drop to low levels, such as 0.01 yen/kWh, during periods of excess generation. Utilizing the Feed-in Premium (FIP) system, operations are expected to maximize revenue by selling electricity during periods of higher market prices.

Regarding solutions for RE co-located storage batteries, Nissin Electric plans to combine its storage battery systems with Sumitomo Electric's *s*EMSA to support the introduction and operation of storage battery systems that enhance the effective utilization of solar power generation and increase electricity sales revenue.

5. Conclusion

The role of storage batteries is expected to become increasingly important for expanding the adoption of variable RE and stabilizing the grid. Customer needs for storage battery operation are also expected to diversify. In light of this situation, Nissin Electric is proposing solutions for storage batteries that incorporate Sumitomo Electric's *s*EMSA. For customers interested in customer-installed storage batteries, grid-connected storage batteries, or RE co-located storage batteries, we provide integrated systems including storage battery systems, substation equipment, and EMS. Furthermore, we support operations that enhance the added value of storage batteries, such as their utilization in electricity trading markets.

Moving forward, we intend to collaborate with the Sumitomo Electric Group to provide solutions that meet diverse needs.

Technical Terms

*1 Distributed power source: A generation facility distributed throughout the areas where customers are located, including solar power generation, cogeneration systems, and storage batteries.

*2 Long-Term Decarbonized Capacity Auction: An auction system designed to encourage new investments and replacements with decarbonized power sources that do not emit carbon dioxide. If a business investing in decarbonized power sources participates in the auction and wins the bid, the winning bid amount is paid for 20 years.

*3 Overloading: Installing solar panels exceeding the capacity of the power conditioner (PCS).

*4 Output control: The act of a power generation operator reducing the output of a solar power plant at the instruction of a general transmission and distribution operator for supply-demand adjustment.

*5 Feed-in Premium (FIP) system: A system in which power generators receive a subsidy called a premium in addition to their electricity sales revenue when selling electricity on the wholesale power market.

*6 Aggregator system: A system operated by aggregators to exchange data, such as control commands and control performance records related to the supply-demand adjustment market and capacity market, between general transmission and distribution operators and businesses. After receiving commands from the electricity trading market system (simplified command system), it transmits these commands to subordinate systems. It also receives actual performance values from subordinate systems and transmits them to the market (simplified command system).

*7 Electricity trading market system: An example of an electricity trading market system is the simplified command system, which is operated by general transmission and distribution operators to exchange data such as control commands and control performance related to the balancing market and capacity market with businesses.

*8 Site EMS: An energy management system installed on-site at customer facilities, storage facilities, and other locations to monitor and control distributed power sources. By communicating with a server, it receives control commands from the server and sends measurement data to the server.

*9 Demand control: Monitoring the average power usage (demand value) every 30 minutes and controlling electrical equipment to prevent exceeding pre-set target values, thereby suppressing the maximum demand value.

*10 Solar power reverse power flow prevention control: When the power generation from solar power systems at customer facilities exceeds the electricity demand, there is a possibility of power flowing back from the customer side to the grid. To prevent such reverse power flow, this control manages the output of the solar power generation.

*11 Planned simultaneous equalization: Aligning actual generation and actual demand with pre-established generation plans and demand plans.

*12 Tertiary balancing power: One category of balancing power traded in the supply-demand adjustment market. Market-traded categories range from primary to tertiary balancing power, each with distinct roles and requirements.

*13 Available supply capacity: The amount of balancing power that generation facilities, storage batteries, and other devices can provide.

*14 Device-end measurement: Measuring electricity usage for each individual piece of equipment or device.

*15 Interface: The connection points or standards for exchanging information between different devices and systems.

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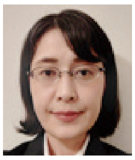

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