Expansion of Energy Management System Business Connecting Mobility and Energy

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The automotive industry is currently undergoing a once-in-a-century transformation, with the global adoption of electric vehicles (EVs) playing a significant role in reducing CO_2 emissions and mitigating global warming. Alongside, there is a growing need to manage power generation and load fluctuations in the power system that accompany the widespread implementation of renewable energy. In response, the Sumitomo Electric Group has made valuable contributions to society by introducing Traffic Vision Green, a mobility service product that supports comfortable EV driving, and *s*EMSA, an energy service product that generates optimal operation plans for distributed power sources. Looking ahead, we envision the development of efficient and cost-effective energy management systems (EMS) that consider EV operating conditions by integrating mobility and energy. This paper highlights Sumitomo Electric Group's past accomplishments and outlines our future initiatives for integrated energy management systems that merge mobility and energy sectors.

Keywords: CASE, EV, EMS, VPP, power trading market

1. Introduction

To achieve carbon neutrality, electric vehicles (EVs) are being introduced all over the world. With the increasing penetration of renewable energy sources, fluctuations of power generation and loads in power grids have become a problem, and the securement of effective and economical power-balancing capacity is needed.

The Sumitomo Electric Group (hereinafter referred to as the "Company") has made efforts to develop the telematics system, which provides information services through bidirectional communications between vehicles and the center, and the energy management system (EMS), which optimally controls distributed power sources, such as batteries. By establishing a total system that connects automobile manufacturers and power companies, the Company will be able to provide an effective and economical EMS that considers EV operations. In this report, we summarize the Company's past achievements and future efforts toward the EMS, which combines the Company's mobility and energy technologies.

2. Trends of the Automotive Industry

2-1 Market trends

The automotive industry has been undergoing a once-in-a-century paradigm shift, and "CASE," which was proposed by Daimler at the Paris Motor Show 2016, is the keyword of the trend. CASE is an acronym for "Connected," referring to interconnectivity with communication systems outside of a vehicle, "Autonomous," referring to autonomous driving, "Shared & Services," referring to addressing the need for shared mobility services, and "Electric," referring to electrification. Among these, actions for Electric have been rapidly accelerated in recent years to reduce CO_2 emissions, which are one of the causes of global warming. The ratio of EV sales to total car sales significantly increased in 2022 in Europe, China, and North America. EVs roughly accounted for 7.74 million of the 78.7 million vehicles sold worldwide, or almost 10%. While EVs still accounted for 2.2% of new passenger car sales in Japan, thus lagging behind the abovementioned areas, the government aims to make EVs and PHVs (plug-in hybrid vehicles) account for 20 to 30% of sales of new vehicles by 2030. Positive activities for prevalence will continue.[(1)] For automobile manufacturers, electrification will create new business opportunities, such as charging services essential for driving, utility services based on those charging services, and points of contact with customers. A wide range of domestic and international activities, including coordination with companies in other industries (power companies, charging service providers, and transportation companies) have been initiated.

2-2 Our past achievements

For the widespread use of EVs, offering a safe and comfortable driving environment for EV users is necessary. In particular, alleviating concern over battery depletion (becoming stranded due to a depleted battery) is important, and to address this concern, the Company launched Traffic Vision Green in 2019. This product calculates recommended routes at the telematics center*[1] in combination with EV information, such as remaining battery power, weather information, and traffic information, and provides the EV user's smartphone with a navigation solution to the destination, including guidance to the optimal charging station (Fig. 1). The Company also released Eagle Sight, which provides transportation companies with vehicle management, operation planning, and operation management services on the cloud in 2021. The combination of Eagle Sight and Traffic Vision Green, which can predict power consumption, enables EV operation management according to actual transportation and delivery operations, such as dispatching EVs for short-distance driving and conventional gasoline vehicles for long-distance driving. It also

offers information on vehicle driving hours, which will assist in the use of surplus power for offices when EVs are not in use (See 5-2).

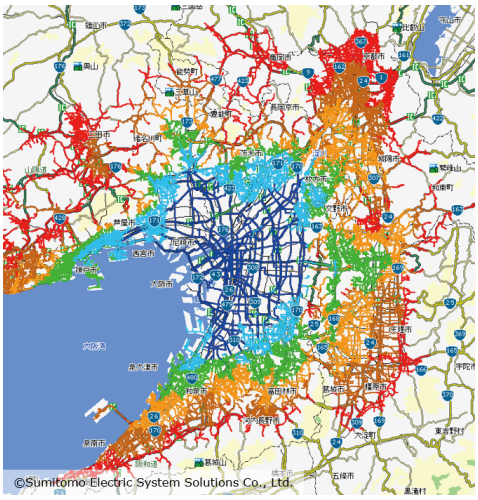

Fig. 1. Power consumption prediction by Traffic Vision Green

3. Trends of the Electric Power Industry

3-1 Market trends

In an effort to create a decarbonized society, Japan, Europe, and the United States are shifting their main energy sources from fossil fuels to renewable energy sources, such as solar power and wind power. However, since the output of renewable energy sources fluctuates depending on weather conditions, developing electric power grids and reserving balancing capacity are urgent issues for providing a stable electricity supply. In Japan, to reserve the balancing capacity, the Electricity Business Act was amended in 2022, defining a grid-scale battery as a stationary battery that is connected to an electric grid, and projects subsidized by the national and local governments have been promoted to accelerate the deployment of grid-scale batteries. The design of legal systems that effectively procure and use stationary batteries and other energy resources as balancing capacity is now being proceeded. A power trading market*2 in which balancing capacity is traded was established in April 2021, and new trading menus, such as a balancing market,*3 are planned going forward.

3-2 Our past achievements

*s*EMSA is an EMS featuring proprietary forecasting algorithms for load demand and photovoltaic generation, and based on the forecasting results, draws up an optimal distributed power source operation plan for up to 48 hours ahead by using mathematical programming. Since the time granularity of the operation plan is set to 10 minutes, shorter than the conventional demand time limit of 30 minutes, *s*EMSA can design a highly accurate operation plan, and also minimize relative errors from the actual result. In addition, with a unique dynamic reallocation control system that monitors power at receiving points at intervals of several seconds and performs feedback control after taking the plan into account, *s*EMSA accurately responds to control values from the upper systems.

(a) Activity 1: Balancing market

*s*EMSA achieves optimum control of power at receiving points in the sequence of (1) prediction, (2) optimum planning, and (3) real-time control. Figure 2 shows the results of a demonstration, and it shows that this control technique can satisfy the control levels required by the balancing market. At the receiving point of a consumer who uses an extra-high voltage power service, all of the control results are between the upper and lower limits of the acceptance range required by the tertiary balancing capacity [2] for the demand response*4 period, with a granularity of 5 minutes. In this demonstration, the control target is large storage batteries, and the charge/discharge switching of the batteries and the real-time control technique of *s*EMSA absorb load fluctuations of the consumer who uses the extra-high voltage power service.[2],[3]

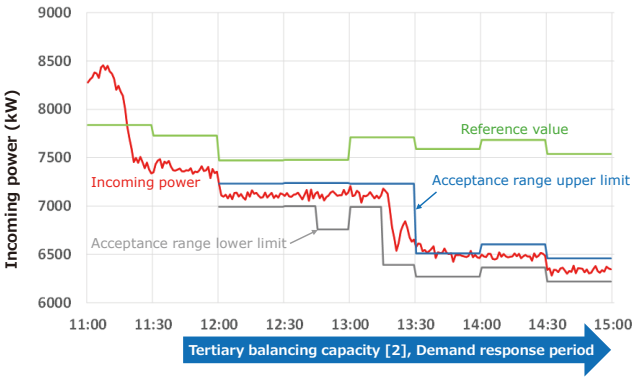

Fig. 2. Demonstration results of tertiary balancing capacity [2]

(b) Activity 2: Multiple-use storage battery

To introduce larger quantities of renewable energy, such as solar power and wind power, developing electric networks and securing balancing capacity have become urgent issues. Grid-scale batteries connected to power grids absorb (charge) electricity when there is a surplus of renewable electricity and discharge electricity when the supply-demand balance is tight, thereby contributing to the stabilization of the supply-demand balance in power grids. In addition, they can be applied to multiple uses, such as the provision of balancing capacity and supply capacity in various kinds of power trading markets, and are attracting attention as a new business model that generates multiple revenues. As shown in Fig. 3, the Company's system consists of a *s*EMSA server created on the cloud and *s*EMSA terminals connected to grid-scale battery storage sites, photovoltaic sites, and EVs, enabling the group control of multiple grid-scale batteries and on-vehicle batteries. The *s*EMSA server acquires information on each power trading market and creates battery charging/discharging plans that maximize the operator's profit, thereby enabling multiple uses for grid-scale batteries.[4]

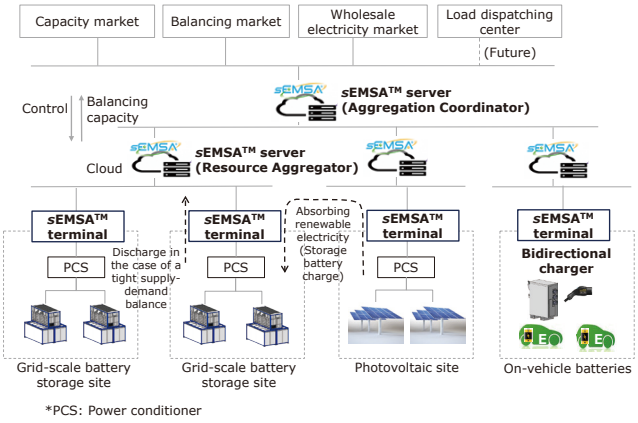

Fig. 3. Multiple-use storage battery system

4. Enterprise Vision in the EMS Business

In "Sumitomo Electric Group 2030 VISION,"[5] we will focus on three key areas—energy, mobility, and info-communications—and the overlapping areas will also greatly contribute to Green, our newly added value proposition.

As mentioned above, to achieve global-scale targets, such as decarbonization and carbon neutrality, the automotive industry and the electric power industry have rapidly accelerated their efforts independently. In line with their efforts, the Company has developed technologies and systems necessary for their achievement, and offered them for demonstration tests and commercial systems. The Company has so far implemented these approaches by improving technologies accumulated in each field, and from now on aims to create new value propositions by fusing these technologies. The Company aims to contribute to solving global-scale issues under "2030 VISION" by combining the two industries based on the technology and trust relationships with customers the Company has built.

Figure 4 shows the overview of the EMS the Company is aiming at. The left side of Fig. 4 shows the EMS the Company has provided mainly for the electric power industry, while the right side shows the telematics system the Company has provided for the automotive industry. Since the rapid penetration of EVs in recent years raises the possibility of realizing a combined system that will offer advantages to both sides, the technology development and commercialization are urgent issues. To accommodate the power demand that an increasing number of EVs will require, the electric industry is required to use carbon-neutral power generation, such as photovoltaic power generation, whose output fluctuates considerably. To stably satisfy the demand, some form of balancing capacity is required, and aggregating on-vehicle EV batteries can offer sufficient capacity.

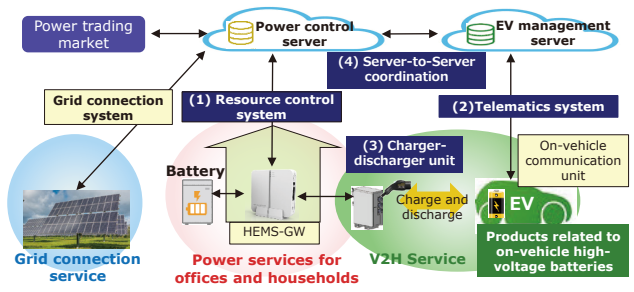

Fig. 4. Future targets of EMS business

On the other hand, since most EVs are more expensive than conventional gasoline vehicles due to the high costs of batteries, the automotive industry is required to offer new added value for EVs other than as a means of transportation. Since EV users can expect lower power rates or use EVs as emergency power sources in the case of wide-scale power outages, such as the massive power outage that occurred in Chiba Prefecture in 2019, using EVs as balancing capacity for electric power networks may be beneficial. Furthermore, automobile manufacturers and EV dealers are developing a business model to enter the market, whereby they aggregate EVs and provide balancing capacity for electric power networks.

To meet these new needs, the Company will establish and provide the system shown in Fig. 4, which bridges the automotive industry and the electric power industry, aiming to contribute to solving the issues of both parties, and ultimately solving global-scale issues. To realize these visions, the Company must innovate the abovementioned technologies, such as by (1) extending EMS functions, (2) sophisticating EV telematics, (3) developing V2H (vehicle to home) charger-discharger units that connect EVs and offices/households, and (4) coordinating servers with EV information (position, battery charging status, rechargeable period, etc.) and servers with demand-supply balancing information on the cloud.

5. EMS Related Technologies and Products to Achieve Our Vision

5-1 *s*EMSA: Extended functions

The Company participated in the virtual power plant (VPP*[5]) construction demonstration project (2016–2020) and the demonstration project for further utilization of distributed energy resources (DERs) (2021–2022), both subsidized by the Ministry of Economy, Trade and Industry. It has developed and constructed a resource aggregation (RA) system, which uses EVs as a resource to enter into the electric power exchanging market and the balancing market and obtains incentives for EV owners. The main development item was the energy management function for grouped EV resources that controls the aggregated actual power value within ±10% of the target value by independently controlling the charging and discharging of several hundreds to tens of thousands of EVs.

In the VPP construction demonstration project, the Company verified the positive DR (demand response) control, which shifts the EV charging time to the period when photovoltaic power plants generate surplus power, using about 80 EVs. The RA server,*[6] which receives the command values from the AC server,*[7] checks the charging status (charging/waiting) of each EV every two minutes, and adjusts the charging power by using the feedback control function to satisfy the requirements for entry into

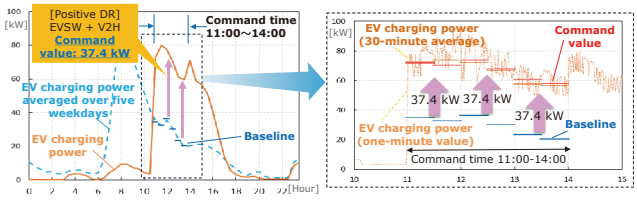

Fig. 5. EV demonstration results (tertiary balancing capacity [2], positive DR)

the balancing market (tertiary balancing capacity [2]) and the wholesale electricity market, for three hours (30-minute time slot, consecutive six slots) (Fig. 5).[6]

In the demonstration project for further utilization of DERs (2022), the Company is verifying the utilization of EV resources for demand-supply balancing (tertiary balancing capacity [1], secondary balancing capacity [2], etc.), which requires a higher-speed response (in the range of several tens of seconds). In this demonstration, the Company is also verifying the negative DR control, which provides balancing capacity when the supply-demand balance is tight by discharging electric power from about 80 EVs using V2H charger-discharger units. The demonstration results show the high response performance of the system, and the ability to reduce the difference between the aggregated actual values and the target value through feedback control of EVs in a short cycle by the energy management function for grouped EV resources. The results satisfy the requirements for trading in the balancing market (one-minute time slot; 90% or more of 30 slots in 30 minutes pass the criteria: within ±10% of the target value) for three hours, showing that entry into the balancing market is possible (Fig. 6).[7]

In addition, the demonstration results mean that entry into the balancing market with EVs and other low-voltage resources from FY2026 is just in sight.

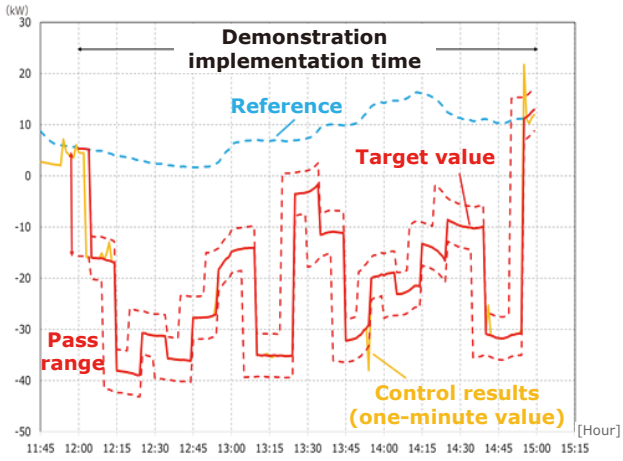

Fig. 6. EV demonstration results (secondary balancing capacity)

5-2 EV telematics

The EMS that uses EVs is strongly required to contribute to carbon neutrality first, and it is expected to be introduced to commercial vehicles (buses and trucks) with high-capacity batteries. Especially regarding EV buses, the industry organization plans to introduce a total of 10,000 buses by 2030 from about 150 buses as of the end of March 2022, and the number of EV bus operators is rapidly increasing. Under the circumstances, charging control of EV buses and reduction of power rates (contractual powers) become the main issues. To address these issues, the Company has been developing the V2B Controller, an EV bus charging management system, and has provided it to a bus company as part of the EV bus package service operated by a power company since April 2023.[8]

The V2B Controller predicts power demand based on the consumed power detected by a power meter at the receiving point, charging EV buses during off-peak demand hours and discharging or stopping charging during peak demand hours to suppress the peak. The system can automatically select EVs whose charging/discharging it can control according to the remaining battery power. It can maintain a certain level of remaining battery power and finish charging by the specified time to the specified remaining battery power. Its calendar function enables detailed charge/discharge control by registering various charge/discharge patterns depending on the power demand for each season, weekday, or holiday.

Expecting the charging of several hundreds of EV buses at bus depots and wireless charging while driving, the Company is developing a new system on the cloud to support EV quick chargers (of several manufacturers and types). In the future, the functions can be extended to reduce the electricity bill by charging according to variable power rates, such as dynamic pricing, and to obtain an incentive from supply-demand balancing. As for communication protocols between chargers and V2B controllers installed at local sites, the system has supported ECHONET-Lite, commonly used in Japan, and ModBus/TCP, mainly used for industrial applications, and will support Open Charge Point Protocol (OCPP), which is being adopted in foreign countries.

The Company has also participated in the “Program to Develop and Promote the Commercialization of Energy Conservation Technologies to Realize a Decarbonized Society” by the National Research and Development Agency, of the New Energy and Industrial Technology Development Organization, since FY2021, and is developing energy management systems that effectively use surplus renewable energy by using wireless in-road EV charging systems. Charging EVs through an on-the-go EV charging system during the daytime, when surplus power is prone to be generated by photovoltaic generation, can maximize the use of renewable energy. By combining the position information management by telematics and the remaining battery power management by the EV service, and optimizing urban charge/discharge infrastructure, it is possible to reduce investment costs for electric power infrastructure needed to accommodate the power usage for increasing EVs.

5-3 V2H charger-discharger unit

In Japan, while the introduction of photovoltaic power generation is facilitated, the phased-out feed-in-tariff (FIT) system for renewable energy increases the demand for self-consumption.[1] To satisfy these needs, the Company

has developed and commercialized *s*EMSA and other EMSs, batteries for household use, and environment- and energy-related products. This time, the Company has developed a V2H charger-discharger unit that charges EVs and provides electric power charged in EVs to houses and offices.

The developed V2H charger-discharger unit employs a circuit with higher internal power conversion efficiency, achieving reductions in size and weight (Table 1). It features high power conversion efficiency in low-power areas, resulting in small power conversion loss in power areas that ordinary households use (mainly less than 1 kW). In addition, it has a function to monitor the status of the charge/discharge connector to the EV and notify the unconnected status, resulting in improved usability.

Table 1. Specifications of V2H charger-discharger unit

Size		W426 × H1, 181 × D300 mm (excluding protrusions)
Weight		About 65 kg
Charging cable		About 7.5 m
Output power	Charging	Max. 5.9 kW
	Discharging (Grid-connected)	Max. 5.9 kW
	Discharging (isolated)	Max. 5.9 kVA
Installation conditions		Outdoors, at an altitude up to 2,000 m, -20 - +50°C
Operations		Switches on the body, smartphone app (iOS/Android)
Warranty period		10 years

(a) V2H charger -discharger unit (b) Smartphone App

Fig. 7. V2H charger-discharger unit and dedicated smartphone app

It also features a connection type supplying AC power that helps retrofit the unit in a household or office that has already introduced a photovoltaic generation system or power storage system. In the case of a power outage due to a disaster, it can back up all household appliances, including 200 V appliances (air conditioners, IH cookers) and 100 V appliances, using EV batteries, thereby securing everyday-life needs. The dedicated smartphone app (Fig. 7, right) allows remote control while away from home.

6. Future Outlook for the Energy Management System

The latest trends in EMS-related markets are shown in Fig. 8.

In the power trading market, the balancing market has already been launched. In the future, the development of grid-scale battery storage stations is expected to be enhanced, and a capacity market that uses the stations for power sources (power stations) will be launched around 2024. In line with the launches of these markets, electric power systems will be changed from conventional centrally controlled systems to local production for local consumption-type power systems centering on renewable energy sources, such as photovoltaic power generation and storage batteries, and ultimately extended to microgrids.

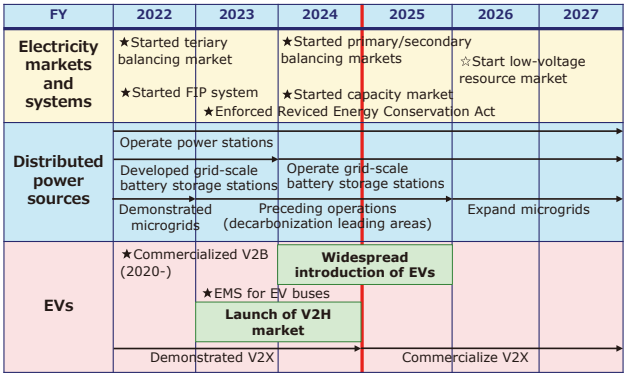

Fig. 8. Related market trends

Regarding EVs, while they have a 20% or greater share of total new car sales in China, Japan's transition to EVs has just begun; however, the introduction of EVs will be accelerated amid efforts toward decarbonization. EVs will be first introduced to public transport systems and commercial vehicles that are strongly required to contribute to carbon neutrality, and as costs for EVs decrease, the adoption of passenger EVs will significantly surge after 2025.

Currently, power generated by photovoltaic generation and discharged from EVs is limited to supply to houses and offices (V2H), and a system that allows the use of EVs as a distributed power source (V2G) will be established around the same time frame. The trends of both industries ensure that an energy management market using EVs will rapidly emerge around 2025. To address these situations, the Company is developing the technologies and products described in Chapter 5. Towards the period of popularization, the Company plans to continue to develop extra functions, improve performance, and cut down costs.

7. Conclusion

While EVs and renewable energy are being introduced to reduce environmental burdens, the use of EMS that integrates mobility and energy will be essential. Setting forth a consistent vision—building a safer, more secure, more comfortable, and greener society—the Company will continue working to contribute to a greener society through the products and technologies described in this paper.

Technical Terms

∗1 Telematics center: A center that generates and delivers car navigation information based on the information from on-vehicle units and traffic information.

∗2 Power trading market: The power trading market includes a wholesale electricity market, in which power (kWh) is traded, a balancing market, in which balancing capacity (ΔkW) is traded, and a capacity market, in which supply capacity (kW) is traded, and these markets will be established by FY2024.

∗3 Balancing market: A balancing market is one of the power trading markets. In the market, general transmission and distribution utilities procure and use balancing capacity to control frequency and balance supply and demand. There are three types of balancing capacity: primary, secondary, and tertiary. The tertiary balancing power [2] is the balancing capacity for renewable energy output forecast errors, whose market was established in April 2021.

∗4 Demand response: Controlling the use of power by consumers in order to balance the supply and demand of electricity.

∗5 VPP (virtual power plant): A system that provides the same functionality as an actual power plant through the control of power storage systems and other energy resources

∗6 RA (resource aggregator) server: A server for an operator that controls energy resources upon directly entering into VPP service agreements with electricity consumers.

∗7 AC (aggregation coordinator) server: A server for an operator that aggregates power loads controlled by resource aggregators and directly engages in power transactions with general transmission and distribution operators and retail electric companies.

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