Hitachi Review

July 2024 Series Technical Information

Transition to Carbon Neutrality in the EV Value Chain (2)

Development of V2X Systems for Enhancing Building Resilience and Prospects for Carbon Neutrality

#Carbon Neutral #Disaster Prevention and Resilience #Building Systems

Author

Toshifumi Hirano

GX for Growth Co-Creation PJ, Marketing Division, Hitachi Building Systems Co., Ltd.
Current work and research: GX strategy development for buildings

Ryota Kojima

Marketing Planning Department, Marketing Division, Hitachi Building Systems Co., Ltd.
Current work and research: V2X system development

Highlight

In recent years, large power outages caused by wide-area disasters and the resulting loss of social infrastructure services for long periods of time have become a major concern. This has in turn driven rising calls for high-rise buildings, condominiums, and other such facilities to have measures in place to maintain the water supplies needed for daily life and to ensure the continued availability of elevators for vertical transportation in these buildings. Instability in the electricity infrastructure has come to be recognized as an obstacle to the growing use of renewable energy and the spread of EVs. To address this, efforts are underway to increase the adoption of distributed generation by electricity users and to expand the power balancing markets.

These circumstances have fostered greater interest in V2X as a means of using EVs as emergency power supplies and as a resource for demand management. Hitachi Building Systems Co., Ltd. has trialed the use of V2X for the emergency operation of elevators and water supply pumps and is working to commercialize this practice as part of the shift toward carbon neutrality.

1. Introduction

With natural disasters becoming more severe, there is growing interest in measures that allow the public to continue going about their lives even under difficult circumstances.

The number of people living in high-rise buildings or condominiums in Japan is increasing, with the number of condominium titles totaling about 6,943,000 as of the end of 2022. This has led to strengthening calls for maintaining the availability of the elevators used to move up and down in these buildings(1). The need for emergency power supplies has arisen since the Great East Japan Earthquake in particular. Along with the need to deal with the scheduled outages and calls for voluntary power saving that were a response to the post-earthquake electricity shortages, this has also been driven by concerns about how climate change is making typhoons stronger and more frequent as well as the prolonged impact of the major power outages these storms cause. As a result, improving resilience has become a pressing issue for both companies and individuals, enabling them to better withstand disasters through measures such as installing batteries or emergency generators to provide backup power supplies.

The problem with equipment like batteries and emergency generators, unfortunately, is that they impose high costs on owners, being expensive to install and requiring periodic maintenance inspections.

With the uptake of electric vehicles (EVs) having grown rapidly in recent years, Hitachi Building Systems has responded to this situation by developing a hybrid power conditioning system (PCS) that can operate as an emergency power supply, working with vehicle-to-X (V2X)*1 systems to keep elevators running during power outages(2). The hybrid PCS features an alternating current/direct current (AC/DC) converter that is used for battery charging and discharging. The solution is also being further expanded to make it more appealing as a means of improving building resilience, including by demonstrating its use in operating water pumps(3). There is considerable demand for the ability to keep water pumps running during power outages.

The use of EVs as mobile batteries presents a wide range of possibilities, including their use as a resource for storing excess photovoltaic power generated during daylight hours and for electricity dispatch or the balancing of supply and demand within a particular distribution area. Hitachi is pushing ahead with commercialization in anticipation of progress on carbon neutrality in which the use of V2X to link EVs to the electricity grid plays a key role.

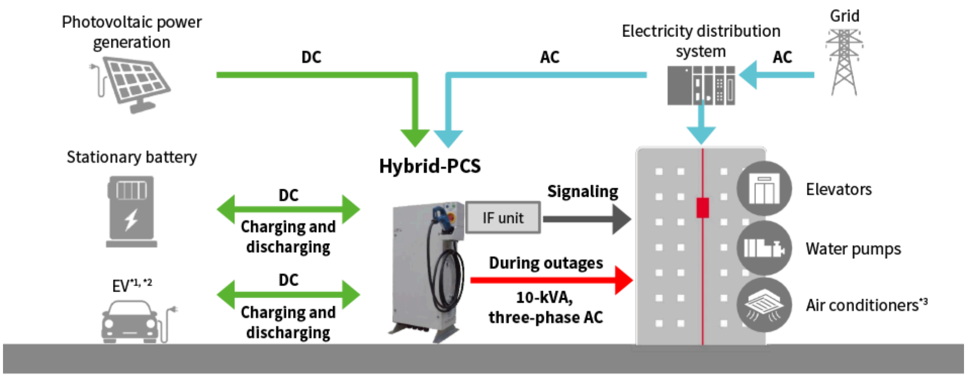
*1 A general term for technology that connects and interoperates vehicles with a wide variety of other equipment. The energy sector is seeing progress on the practical adoption of V2X systems that link EVs to the grid or to facilities such as condominiums and other buildings, enabling them to share electric power with one another.

2. Overview of Hybrid-PCS with Support for V2X Systems

A feature of the system is that it uses the EV battery charging and discharging capabilities of the hybrid-PCS to convert power from an EV to 200-V three-phase AC. This can then be used as a “power source” to operate heavy-duty electrical equipment such as elevators, water pumps, or commercial air conditioning systems that consume large amounts of power.

The hybrid-PCS combines two separate PCSs for photovoltaic power generation and batteries, respectively. A feature of this particular system is that it was designed specifically for applications where the building to which the EVs are connected is also equipped with photovoltaics (see Figure 1).

Figure 1—Diagram of V2X System Able to Source Electric Power from Photovoltaic Power Generation, Battery Storage, and EVs



DC: direct current, AC: alternating current, IF: interface, EV: electric vehicle, PCS: power conditioning system

*1 V2X-capable vehicle with a CHAdeMO charging interface

*2 CHAdeMO is a trademark of the CHAdeMO Association.

*3 Support for running air conditioners is to be added in the future.

The system delivers improvements in both energy efficiency and resilience.

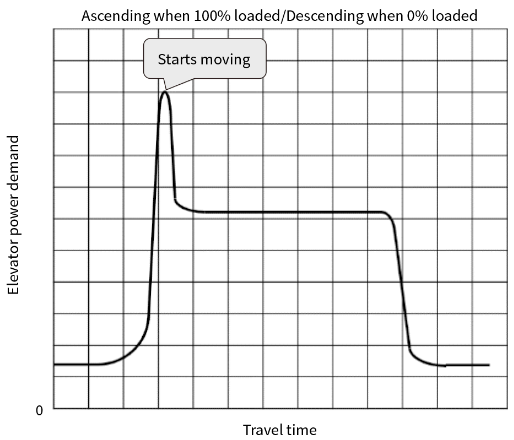
3. Approximately 15 Hours of Elevator Operation Powered by Hybrid-PCS

The hybrid-PCS and elevators exchange status information to monitor and interoperate with each other, with elevator control switching from its normal speed of between 45 and 105 m/min to slow-speed operation at 30 m/min or less. By doing so, the elevators are able to remain in service during electricity outages by drawing power from an EV.

Elevators draw a heavy electrical load when they first start moving. They also come to a sudden stop when their electrical demand exceeds the rated output of the power supply, which in the case of the hybrid-PCS is 10 kVA. In the worst case, this can leave passengers stranded in a stuck elevator. This is why development work was undertaken on elevator control to operate at lower-than-normal speed, reducing the startup load when running on EV power (see Figure 2).

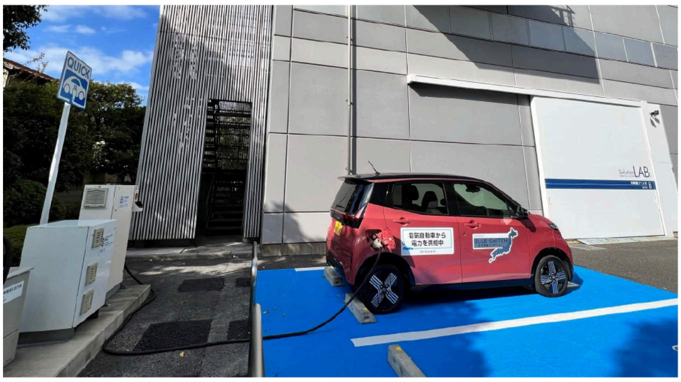
By having the respective systems monitor each other's status, the elevators are able to play an announcement and halt at the nearest floor when operation is about to shut down due to EV battery depletion. This avoids passengers being left stranded in a stuck elevator. When external power is restored, the elevators switch back to the mains power supply and resume operation at normal speed. While performance depends on the EV battery capacity and elevator specifications, an EV with a 20-kWh battery was able to keep the elevator in a six-story test facility in continuous operation for 14 hours and 56 minutes (see Figure 3 and Table 1).

Figure 2—Graph of Power Demand when Elevator Starts Moving



Elevator power demand spikes temporarily when the elevator starts moving.

Figure 3—Supplying Electric Power from an EV



The EV shown here has a 20-kWh battery and is being used to power an elevator in a six-story test facility.

Table 1—Outcomes of Demonstration Trial Using Electric Power from EV to Operate Elevator

Continuous operating time	14 hours and 56 minutes
No. of elevator round trips	416 (Carrying a load typical of actual use, with doors opening and closing at floors 1 and 6)
EV battery charge	100% ⇒ 10%

The trial ended after approximately 15 hours, at which time the EV battery had discharged down to its lower limit of 10% remaining charge.

4. Demonstration of Hybrid-PCS Powering Automatic Water Supply Unit for Condominiums

Since use of the hybrid-PCS with elevators was announced publicly, many customers have made the point that, during a power outage, water supply pumps have a higher priority than elevators. Accordingly, a demonstration trial was conducted in October 2023 in which the hybrid-PCS was deployed at Narashino Works of Hitachi Industrial Equipment Systems Co., Ltd. along with an EV with a 20-kWh battery and used to run a Hitachi Direct Water Ace automatic water supply unit (see Figure 4 and Figure 5).

The water supply unit used in this trial had a rated output of 7.5 kW and was operated at a water pressure suitable for supplying a 20-storey condominium (with a height of about 75 m).

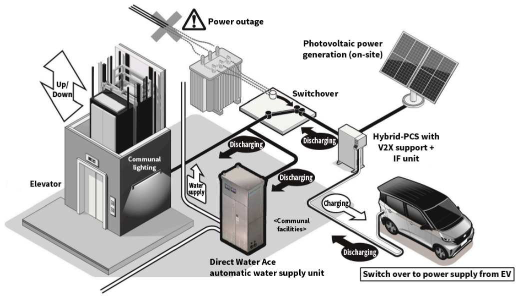
Under these conditions, the system was able to operate continuously for 1 hour and 31 minutes, delivering 21,171 L*2 of water in total. This equates to the daily needs of 8,468 people(4), *3 or 4,234 toilet flushes(5) *4 (see Table 2).

*2 Depending on the building design, waste water pump operation may also be required. This trial assumed a case where this was not necessary.

*3 Based on a required daily water intake of 2.5 L per person, obtained from food, beverages, etc.

*4 Based on 5 L of water per flush.

Figure 4—Overview of Demonstration Trial at Narashino Works of Hitachi Industrial Equipment Systems



V2X: vehicle to X

The figure shows an idealized scenario. The trial itself involved an automatic water supply unit only.

Figure 5—Use of EV to Supply Electric Power at Narashino Works of Hitachi Industrial Equipment Systems

Operation of an automatic water supply unit was trialed using an EV with similar specifications to that used in the elevator trial.

Table 2—Outcomes of Demonstration Trial Using Electric Power from EVs to Operate Water Supply Unit

Continuous operating time	1 hour and 31 minutes
Total volume	21,171 L (Equates to the daily needs of 8,468 people or 4,234 toilet flushes)
EV battery capacity	100% ⇒ 10%

This trial demonstrated that the system could also be used to run a water supply unit, an application with strong customer demand.

5. Conclusions

The hybrid-PCS is currently being promoted, primarily for new builds, as a business continuity planning (BCP) solution for keeping elevators and water pumps working during power outages.

However, the feedback from customers considering the use of the system is that, while they recognize its functional benefits, issues remain when it comes to adopting the system in practice. In the case of condominiums and other forms of communal housing, these are: (1) access to and billing for EV charging stations, and (2) the question of whose EV to use when emergency backup is needed. Hitachi is looking at addressing the first of these through collaboration with vendors of reservation and billing systems that can improve convenience for both building managers and users. Similarly, a shared use option is being considered for the second issue involving the provision of an EV car sharing service.

One of the challenges to adopting the system at existing condominiums is buildings where the management association is unlikely to agree to do so given that installing EV charging stations is only of benefit to those residents who own an EV. While the system is currently only able to operate with newly installed elevators, Hitachi intends to expand support to legacy elevators also. It is hoped that this will incentivize management associations to install the charging stations by promoting them as a means of improving condominium resilience that will enhance residents' standard of living, thereby making the proposition more attractive to non-EV owners.

Finally, while this article has explained how EVs can be used to boost resilience, Hitachi is also considering development that will contribute to a green society and improve users' standard of living. One possibility would be to adapt the system for use in net-zero-energy buildings (ZEBs)*5 and net-zero-energy houses (ZEHs)*6 that make effective use of renewable energy by incorporating photovoltaic power generation and operating the system routinely, not just during emergencies. Another would be use in tandem with energy management systems (EMSs) that facilitate electricity demand shifting by buildings, such as by storing excess electric power in batteries and then supplying it back during times of peak demand (demand cutting).

*5 Buildings that are intended to have zero annual primary energy consumption while still maintaining a comfortable indoor environment.

*6 Homes where the balance of energy used in the home and energy generated by photovoltaic or other means is such that annual energy consumption is roughly zero or less.

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