Visionaries 2015

Taming Energy

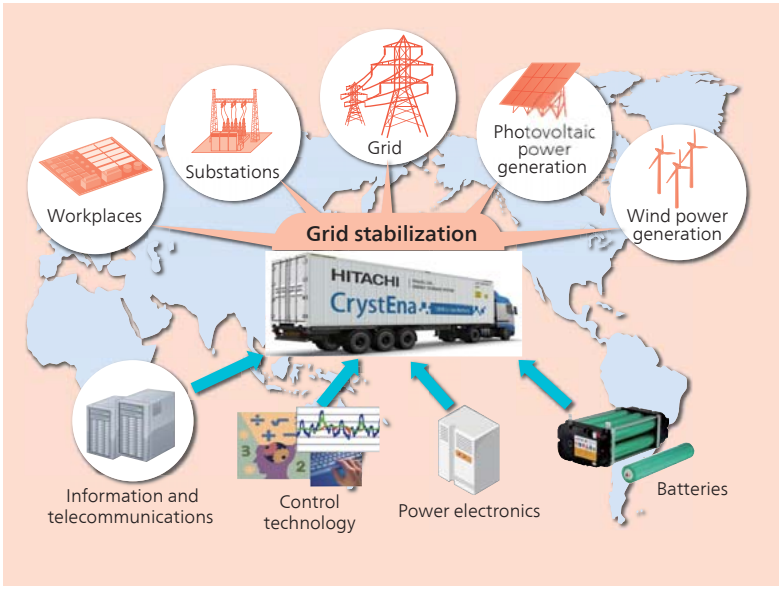
— Energy Storage System Solutions —

The growing deployment of renewable energy, in the form of hillside and offshore wind farms, extensive megawatt-class solar power plants, and household photovoltaic panels has created an urgent need for commercializing solutions to stabilize the power grid, which enable the large-scale installation of fluctuating renewable energy sources.
Hitachi is combining the technologies across its group to develop an energy storage system that can stabilize power grids.
A demonstration project using a container-type energy storage system commenced in the USA in the summer of 2014, and another using a large hybrid energy storage system based on lead-acid batteries will commence on Izu Oshima island in early 2015.

Demonstration Projects Underway for Commercialization

Renewable energy is being developed and installed throughout the world with aims that include satisfying the growing demand for electric power and reducing emissions of carbon dioxide (CO_2). National governments are making an effort to support this process, with the Japanese government having introduced a feed-in tariff scheme for renewable energy in July 2012 following the Great East Japan Earthquake.

Along with the growth in the proportion of these energies such as wind, photovoltaic, and other power sources with outputs that vary depending on the weather, the problem about grid instability will get more serious because the regulatory capacity is not so high. Supply-demand imbalance for electric power will cause fluctuations in its frequency, one of the important power quality, which leads to major outages. On the other hand, there is also a need to reduce power generation when demand is low. This is currently dealt with through regulation by adjustable-speed pumped hydro and thermal power generation based on fre-



Concept behind Hitachi' s energy storage systems. Hitachi contributes to grid stabilization by combining different technologies, including information and telecommunications, control technology, and power electronics as well as batteries.

quency control commands issued by a central load dispatching center. However, it will be difficult to provide sufficient capacity if the amount of renewable energy generation grows rapidly over a short period of time. Because it is difficult to obtain sites for new building or upgrading plants for adjustable-speed pumped hydro and thermal power generation, and requires long construction times.

This has led to raised expectations for energy storage systems that can store large amounts of electric power. Hitachi has developed energy storage systems that can rapidly adjust supply and demand over a time frame of a few seconds by combining technologies of battery materials, battery development and manufacturing, power conversion, control, information systems and so on.

With a view toward commercialization, Hitachi has been putting the finishing touches on its systems by participating in the demonstration projects that combine renewable energy with large energy storage systems undertaken by the New Energy and Industrial Technology Development Organization (NEDO) in places like New Mexico and Hawaii in the USA, and in a residential smart grid demonstration project involving a wind farm with a large battery capacity in Rokkasho-mura in Aomori Prefecture.

Now, finally, the commercialization of an energy storage system for grid stabilization is about to get underway in the USA.

Providing Container-type Energy Storage System for Ancillary Market in USA

A 12-m (approx.) container was delivered on a large trailer to a site in New Jersey, USA. This is the Hitachi container-type energy storage system that is being used in a demonstration project with Demansys Energy LLC, a company that supplies demand control services for electric power.

The liberalization of the electricity market in the USA has included not only the opening up of markets for transmission networks but deregulation of electricity retailers as well as generation. The USA is also the world's largest generator of wind and photovoltaic power. There are concerns that frequency fluctuations, and in some cases consequent power outages, will be brought about by supply-demand imbalances of electric power with the growing adoption of renewable energy. This has created an ancillary market, in which the adjusting capacity for stabilizing electric power itself can be traded in the market, moving to turn it into a business. In particular, pioneering initiatives in the ancillary market are taking place in New Jersey, home to the current demonstration project, and other parts of the northeast USA.

Atsushi Honzawa (Senior Engineer, Power System Information & Control Department, Energy

Atsushi Honzawa

On-site installation at project in New Jersey, USA

Solutions Business Management Division, Hitachi, Ltd.) who is engaged as the project manager for this project, comments:

"We promptly focused attention on this ancillary market targeting it to establish an energy storage system business in the USA and developed the container-type energy storage system to serve as a solution that enables the power grid to be stabilized."

Hitachi developed the container-type energy storage system in 2013. In a demonstration project launched in conjunction with Demansys Energy in the summer of 2014, it was able to demonstrate the benefits to grid stabilization of rapidly adjusting input and output over a time frame in the order of a few seconds in response to the ancillary market signals, which vary over short time periods.

To put the results of the demonstration project into practice, Hitachi intends to proceed with the project connected to the actual power grid.


Taichi Nomura


Hiroshi Arita

Achieving a 10-year Life

The container-type energy storage system supplied to the New Jersey demonstration project was an all-in-one package that includes approximately 1,600 lithium-ion batteries, a control unit, and a power conditioner fitted inside a container. This containerization reduces the time and cost of installation. It also means that a large system can be configured easily by installing a number of systems in tandem.

The first hurdle that the system had to overcome on the way to commercialization was the development of a battery system with a life of 10 years or more. Looking back on this challenge, development team member Taichi Nomura (Senior Engineer, Energy Business Development & Management Center, Energy Solutions Business Management Division, Hitachi, Ltd.) comments:

"Achieving a 10-year operating life was one of the objectives for ensuring the economics of the system. We were also able to combine system reliability and safety with a compact design that could be housed in a container."

Hitachi has three types of battery for industrial applications: long-life, low-cost lead-acid batteries; high-output lithium-ion batteries; and lithium-ion capacitors with even higher output. Of these, the new energy storage system selected lithium-ion batteries. Hiroshi Arita (Senior Engineer, System R&D Department, Energy Devices & System Development Center, Hitachi Chemical Co., Ltd.), who worked on battery development, explained the reason as follows.

"With their ability to handle charging and discharging of large amounts of electric power and to provide sufficient capacity for ancillary applications where the objective is to stabilize short-term fluctuations in electric power, lithium-ion batteries are a suitable choice. However, giving lithium-ion batteries a 10-year operating life was a major hurdle. Nevertheless, thanks to battery cell enhancements, we were able to develop a lithium-ion battery that satisfied our operating life target, being able to withstand a high discharge rate (225 A, 3C) and more than 8,000 charge/discharge cycles."

In terms of safety, the batteries have an electrode structure that is resistant to internal short circuits and a system that performs continuous monitoring and management of the voltage, current, and temperature of each cell through interoperation between the cell controllers and battery management system. Reliability has also been improved by cell voltage equalization and the balancing of charging and discharging as well as by an efficient heat flow design that takes account of outdoor in-

stallation and the fact that battery cells are influenced by temperature variations, spreading the air flow from the cooling fan equally across the battery panels.

Kazuyuki Tsunoda (Engineer, Energy Systems Engineering Department, Power System Protection Automation & Solution Center, Infrastructure Systems Company, Hitachi, Ltd.), adds the following comment:

"To ready the control side for commercialization, we sought to improve the power conditioner efficiency, reduce the power losses in charging and discharging, shorten maintenance inspection times, and reduce failure rates. We also fitted multi-layered safety measures that included disconnection in the event of an emergency and an automatic fire fighting system."

The research and development division plays an important role in developments like this. The Hitachi Research Laboratory (part of Hitachi, Ltd.) has been engaged in basic research into energy storage systems for electricity grids for many years. In addition to utilizing research into battery materials, control techniques, power conversion, and safety, the project also included an evaluation of performance over 10 years, which was done by developing a simulator for predicting battery life. Kenji Takeda (Senior Researcher, Battery Research Department, Materials Research Center, Hitachi Research Laboratory, Hitachi, Ltd.) describes this as follows.

"Battery life is influenced by both the degradation that occurs over time and the degradation that results from repeated charging and discharging. We developed the lifetime prediction simulator by conducting basic experiments aimed at predicting this compound performance degradation. How the energy storage system is operated also significantly influences its life, so we suggested to the customer that they operate the batteries in the way that this work identified as being the best."

In this way, Hitachi combined the comprehensive capabilities of the entire Group to complete the 1-MW container-type energy storage system as a single package.

Mr. Honzawa describes the work planned in the lead up to commercialization as follows.

"Through the demonstration project we are currently operating in the ancillary market, we are optimizing the input and output characteristics and capacity of the batteries and verifying the actual performance in terms of durability and other factors. Based on the results of this work, we are undertaking developments that we will utilize in the commercial system, including making the system more compact, with lower cost and longer life, and enhancing the control algorithms for maximizing user revenue from power sales."

Izu Oshima Island Demonstration Project Commences

In Japan, meanwhile, a demonstration project involving a new large energy storage system is being readied to commence in the spring of 2015 on Izu Oshima island, southeast of the Izu Peninsula. Since the island relies primarily on diesel generators, the active adoption of renewable forms of energy such as wind and photovoltaic power generation in particular is expected to cut fuel costs.

In parallel with the demonstration projects in New Mexico and Hawaii, Hitachi has also since 2011 participated in the "Development of Safety and Cost Competitive Energy Storage System for Renewable Energy" project run by NEDO. This project developed a hybrid energy storage control system that combines low-cost lead-acid batteries that have a long operating life and high capacity with high-output lithium-ion capacitors, with the batteries being manufactured by Shin-Kobe Electric Machinery Co., Ltd. among others.

Yoshikazu Hirose (Engineer, Battery Design Department, Shin-Kobe Electric Machinery Co., Ltd.) expresses his enthusiasm as follows.

"Long life, reliability, and cost are important for use as electric power infrastructure. As with the batteries for the container-type energy storage system, we focused on the construction of the battery cell to produce a battery with high levels of dura-


Kazuyuki Tsunoda


Kenji Takeda

Parameter	Specification	Remarks
System capacity	±1 MW	System-side
PCS configuration	2 × 500 kW (parallel)	
PCS efficiency	97% or higher (30% or higher load)	
Batteries	Lithium-ion batteries 450 kWh	Modules: CH75-6 (75 Ah-22.2 V)
Applicable standard	PCS: UL 1741	
Expected life	10 years or more (system)	When installed in the specified environment and subject to specified maintenance
Cooling	Air cooled	
Container size	12 m (approx.)	

PCS: power conditioning system

Internal components of the container-type energy storage system (1-MW container package) and its main specifications. The container houses batteries, a power conditioner, controllers, a data logger, air conditioning, and other components.

The container-type energy storage system was developed by bringing together knowledge from across Hitachi, including technology for batteries, safety design, and control.


Yoshikazu Hirose

bility and reliability and competitive costs, and we worked to achieve internationally competitive battery manufacturing."

Talking about the system, Mr. Tsunoda comments:

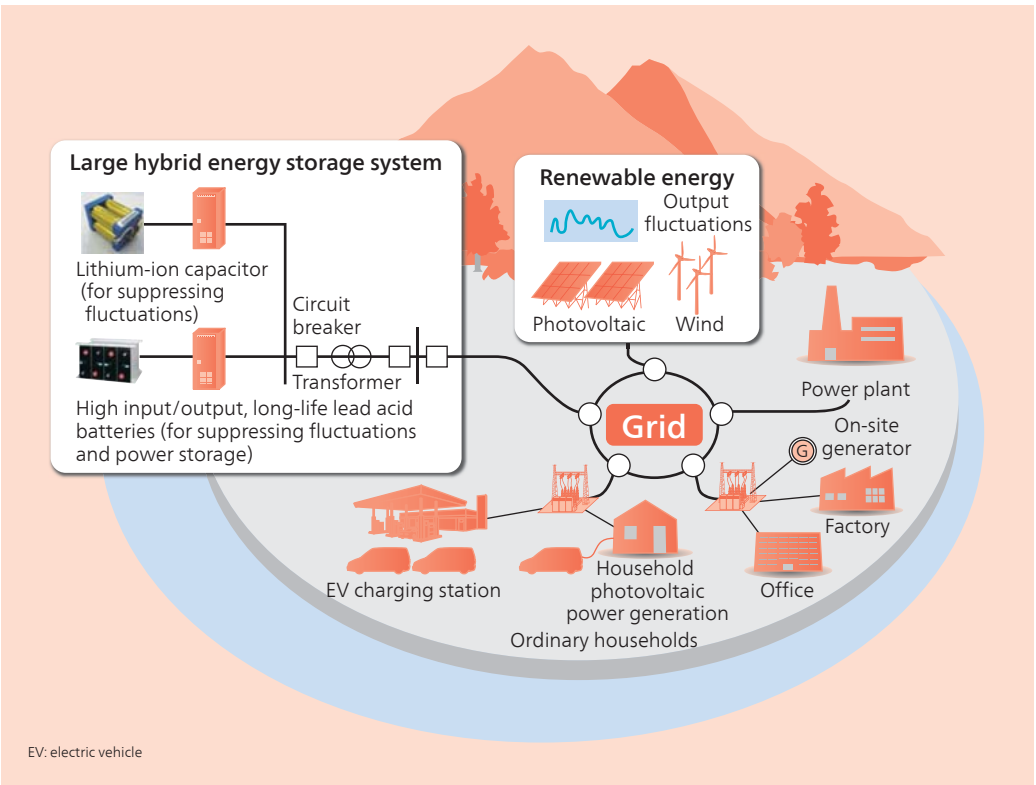
"As peak shifting is an important application for large energy storage systems, which are not only intended for use with renewable energy, we developed and designed an energy storage system that could substitute for adjustable-speed pumped storage hydro power generation. Anticipating that islands will be among the first places to face problems with the grid as greater use is made of renewable energy, we are including measures to make the system suitable for islands by using remote monitoring to improve operation and maintenance."

Shin-Kobe Electric Machinery achieved major successes in terms of specific technologies, including improved battery characteristics (approximate 1.7-fold* improvement in input and output currents) and an anticipated extension of the battery life to 20 years. Hitachi has developed a grid interconnection simulator that can model the effects of installing renewable energy on an actual grid, and another simulator that can model the optimal energy storage system configuration required for grid stabilization. It has also developed optimal operation control for hybrid energy storage systems that combine a number of different types of batteries. Hitachi plans to utilize these technologies to build a 1.5-MW energy storage system on Izu Oshima island and embark on a demonstration project for the use of large energy storage systems on the grid in collaboration with the Tokyo Electric Power Co., Inc.

* Compared to previous Shin-Kobe Electric Machinery model (LL1500-WS)

Targeting Global Markets

Electric power distribution, including energy storage systems, is at the core of Hitachi's power systems business, and it is seeking to expand its solutions business that combines information



Overview of large hybrid energy storage system installed on an island. The system helps maintain grid stability when a large amount of renewable energy generation is installed.

Creating a Growing Business from Energy Storage Technology


Kei Hosoi

Kei Hosoi (Director, Smart Community Department, Electricity Storage Technology Development Division, NEDO) is involved in work that includes the development of energy storage technology, fostering growth industries in Japan, and enhancing their international competitiveness.

"We are undertaking a strategic energy storage technology development project at NEDO with a mission of resolving energy and global environmental problems and enhancing industrial competitiveness. In the grid demonstration projects utilizing energy storage systems that we have undertaken to date, not just in Japan, but also in such places as New Mexico and Hawaii in the USA, there has been considerable interest in Japan's advanced energy storage systems from many partner nations and institutions.

Energy storage systems are a key technology with a central role to play in facilitating the introduction of renewable energy and encouraging the spread of smart communities and the next generation of vehicles. The government's Basic Energy Plan (4th Strategic Energy Plan) issued in 2014 includes encouragement for their introduction, with aims of international standardization, cost reduction, and performance enhancement. Batteries are recognized as being a high-added-value product for Japanese industry with the potential for considerable growth in global markets. The Storage Battery Strategy issued by the Ministry of Economy, Trade and Industry in 2012 estimated a global market worth 20 trillion yen in 2020 and set a market share target for Japanese companies of 50%. While international competition is naturally becoming more intense, we can look forward to improvements in battery technology with the expectation of growing demand from next generation vehicles and other uses. The key subjects of NEDO's work on energy storage technology are automotive lithium-ion batteries, large batteries for electricity grids, and innovative batteries (which can exceed the lithium-ion battery) looking ahead to 2030. Hitachi is participating in all of these projects. In the case of large batteries for electricity grids, a demonstration project is underway on the electricity grid of Izu Oshima island and I look forward to the results of this work leading to new business activities and to making a contribution to the growth of Japanese industry."

technology (IT), control technology, and power electronics. Some of the participants in this article describe their enthusiasm for the expansion into global markets as follows.

"I am looking forward to completing the systems for the ancillary market and establishing highly competitive systems that help reduce the load on the environment." (Nomura)

"We are seeking to develop low-cost battery systems that are compact, have high output, and can serve as the next generation of energy storage systems." (Arita)

"In addition to improving temperature tolerance to lengthen operating life of battery systems, and conducting fundamental research on how to ensure the safety of electricity grids that operate as essential services, we intend to engage actively in field work to utilize this in the building of systems with excellent operating characteristics." (Takeda)

"The brand name represents overall energy storage system solutions made by Hitachi group. The brand name was created by combining "Crystal" from state-of-the-art technologies in the Hitachi group and "Energy." We want to help create a clean society by installing these systems, not only in power grids, but also in a wide variety of other areas including demand-side applications in factories or other buildings." (Honzawa)

The process of delivering generated electric power to consumers is supported by numerous technologies that can be thought of as providing ongoing energy links. Hitachi intends to contribute to the spread of renewable energy and the reliable supply of electric power by deploying its energy storage systems globally.