Energy Solutions

1 Upgrade Dam Integrated Management System for Hyuga Region of Kyushu Electric Power Co., Inc.

The integrated management system for dams in the Hyuga region is intended to provide safe and reliable management of dam operation by performing integrated remote monitoring and control from the Hyuga Civil Engineering Depot of the 10 dams under its supervision (eight on the Mimikawa river system and two on the Gokase river system). Those on the Mimikawa river system form an important series of dams that play an important role in the system.

The system was upgraded due to the aging of its hardware. The main features are as follows.

(1) Collect dam information and use the status of the dam and other equipment as a basis for remote monitoring from the dam control room and integrated remote control of gates.

(2) Added capability to carry out training independently on the Mimikawa and Gokase river systems. This provides the ability to perform simulation testing of events to improve the skills of operations staff. A training evaluation function has been added that also contributes to raising the skills of operations staff by identifying problems with the actions of training participants.

(3) The system provides integrated security management at the dam control room by acquiring industrial television (ITV) video from the dams, information on site access, and security information.

1 Integrated dam control room

2 Commencement of Operation at Western-side of Trunk Transmission Integrated Stability Control System of Chubu Electric Power Co., Inc.

As part of an upgrade of the existing grid stabilization system at Chubu Electric Power Co., Inc., Hitachi has developed an integrated stability control (ISC) system for grid stabilization on the trunk transmission system that incorporates a transient stability control (TSC) system and a system stabilizing controller (SSC) for frequency stabilization. The system commenced operation in May 2017.

The system consists of the ISC processing equipment (ISC-P), ISC control equipment (ISC-C), ISC sensing equipment (ISC-S) as fault detection and measurement units, and ISC transfer trip equipment (ISC-T). It was developed through a major project in which multiple vendors participated. Hitachi's responsibilities included the TSC and SSC functions, developing the ISC-P units (for system A) that perform control processing at the core of the system.

2 ISC-P (system A)

The newly developed trunk ISC system received a Technical Development Award from the Institute of Electrical Engineers of Japan (IEEJ) in recognition of its innovation and efficacy. A letter of appreciation was also received from Chubu Electric Power to mark system development and completion.

The main features of the system are as follows.

(1) Significantly slimmed-down design that integrates TSC and SSC.

(2) For the TSC function, a technique was developed and implemented in the ISC-P to respond to events triggered by changes in the state of the grid that simultaneously oscillate more than one power plant by selecting the optimal mix of equipment to control based on the energy associated with generator acceleration and deceleration.

(3) For the SSC function, operational efficiency was enhanced by automating the switching operations that were previously required when the grid configuration changed.

3 Distributed Regional Monitoring and Control System for Tohoku Electric Power Co., Inc.

Hitachi has supplied a control system for the service area of the Fukushima branch of Tohoku Electric Power Co., Inc. The system is equipped with functions for the monitoring and operation of the local grid in the service area of the Fukushima branch.

The main features are as follows.

(1) Reduction in lifecycle costs through the use of hardware developed in-house that provides high reliability and long-term maintainability. Also reduced space and power consumption through the use of high-performance servers and virtualization.

(2) The system configuration and functions are designed for regional integration with the control systems of adjacent branches for the wide service areas, providing operational continuity through mutual backup in the event of a disaster or other incident.

(3) Rapid sharing of online grid information with maintenance staff and lower operator workloads achieved by a function for providing information in real time to thin client terminals connected to the support network.

3 Distributed regional monitoring and control system for Tohoku Electric Power Co, Inc.

(4) A grid monitoring station provides a high level of visibility and flexibility through use of 55-inch liquid crystal display (LCD) screens (28-screen multi-configuration).

(5) Lower operator workloads achieved by augmentation and enhancements to automatic operation functions and a more advanced human machine interface (HMI).

It is anticipated that the system will enhance operations and boost efficiency.

4 Backup Automatic Load Dispatching System for The Okinawa Electric Power Company, Incorporated

The Okinawa Electric Power Company, Incorporated had, since 1983, maintained a single center of operations that handles everything from generator output control to the monitoring and control of grid and distribution substations. As part of a business continuity plan (BCP) that involves having a second site, Hitachi has now supplied and commissioned a backup automatic load dispatching system to provide backup for the system during disasters or other emergencies.

The main features are as follows.

(1) The main and backup load dispatching systems are equipped with management functions for switching control of individual power plants and substations.

(2) The ability to maintain uninterrupted operation when switching over to the backup system

4 Backup automatic load dispatching system for The Okinawa Electric Power Company, Incorporated

through the joint handing over and matching of operational data.
(3) A reduction in the amount of hardware by using virtual servers and thin client terminals.
(4) A function for switching online and offline functions between sites by changing the operation mode.

The system is expected to further enhance operational reliability and efficiency.

5 200-MVA Rotary Condenser for Shin Shinano Substation of TEPCO Power Grid, Incorporated Completion of Stator Winding Replacement

The 200-MVA rotary condenser (RC) (a synchronous phase modifier) at the Shin Shinano Substation of TEPCO Power Grid, Incorporated is used to prevent disturbances such as voltage instability or higher-order harmonic resonance so that the frequency converter (FC) can maintain reliable operation even when the short circuit capacity of the grid is low. 26 years after first commencing operation in 1991, an upgrade of the RC was undertaken to restore its performance after deterioration was observed in the dielectric strength of the stator winding.

Because the amount of power able to be fed through the FC is limited when the RC is out of service, it was essential to keep the downtime to an absolute minimum. Taking account of safety and practicality considerations, and adopting measures that included working through holidays, the shutdown that would typically have lasted for 185 days was reduced to 130 days and the replacement work completed on schedule.

5 Hoisting of RC stator for Shin Shinano Substation of TEPCO Power Grid, Incorporated

6 Retrofitting of Digital Transmission Line Protection Relay for Ultra-high-voltage Substation

As transmission line protection relays are important equipment with a core role in the distribution of electric power, any time spent out of service during the upgrading of aging equipment needs to be kept as short as possible. By adopting a retrofitting technique*, Hitachi has replaced existing equipment with

6 Digital transmission line protection relay for ultra-high-voltage substation

multi-function digital transmission line protection relays that feature the latest specifications.

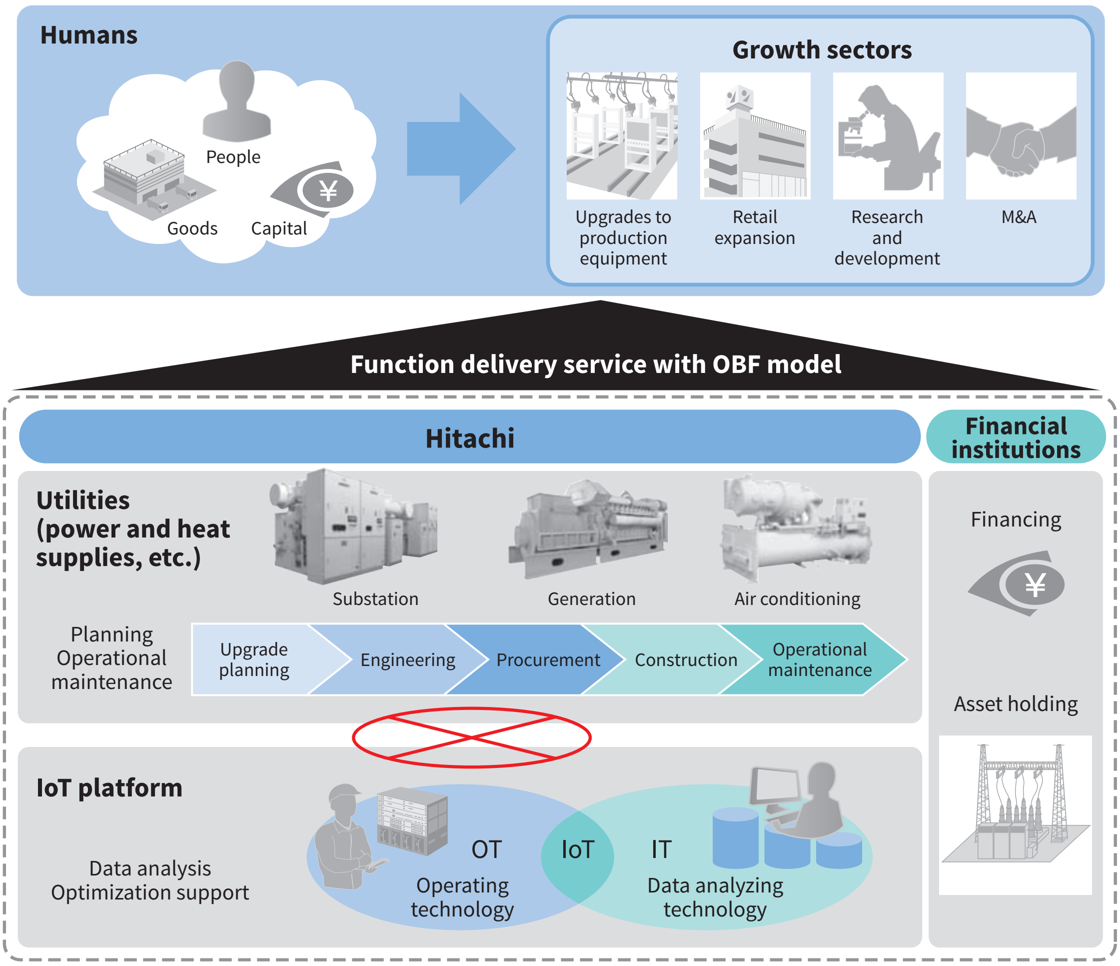
The main features are as follows.

(1) High reliability retained by using the latest series of digital relay units.
(2) A reduction in total cost, including communication systems, through the adoption of a transmission system that complies with international standards.
(3) Shorter customer installation times through use of housings and cables from existing equipment.

* A technique for the partial upgrading of degraded components in aging equipment, including core components like digital relay units.

7 Energy and Facility Service for Companies

While growth sectors (such as upgrading production equipment in factories, retail expansion, research and development, and acquisitions) are the top priority for investment by companies, failure to invest in the utilities that support these sectors only leads to their progressive



OT: operational technology IT: information technology

7 Energy and facilities service based on OBF service model aging. In the case of substation and other electrical equipment, it has been estimated that the amount of aging equipment that has been in service for 25 years or more in Japan is in the range of one trillion yen*.

In response to this problem for society, Hitachi offers an on-bill-financing (OBF) service model in which it acts as a one-stop shop on the customer's behalf covering the entire lifecycle from planning of optimization work (including upgrades) to engineering, procurement, construction, asset ownership, and operational maintenance.

The main features are as follows.

(1) No need for planning of up-front investment, with long term service agreements (LTSAs) feasible for running costs.

(2) Use of an Internet of Things (IoT) platform to provide optimal operation and maintenance of facilities.

(3) Use of an energy management system (EMS) for optimal energy use.

By providing these functions, Hitachi intends to support the growth of its corporate customers by allowing them to operate with fewer assets and by providing more efficient energy and facilities operation.

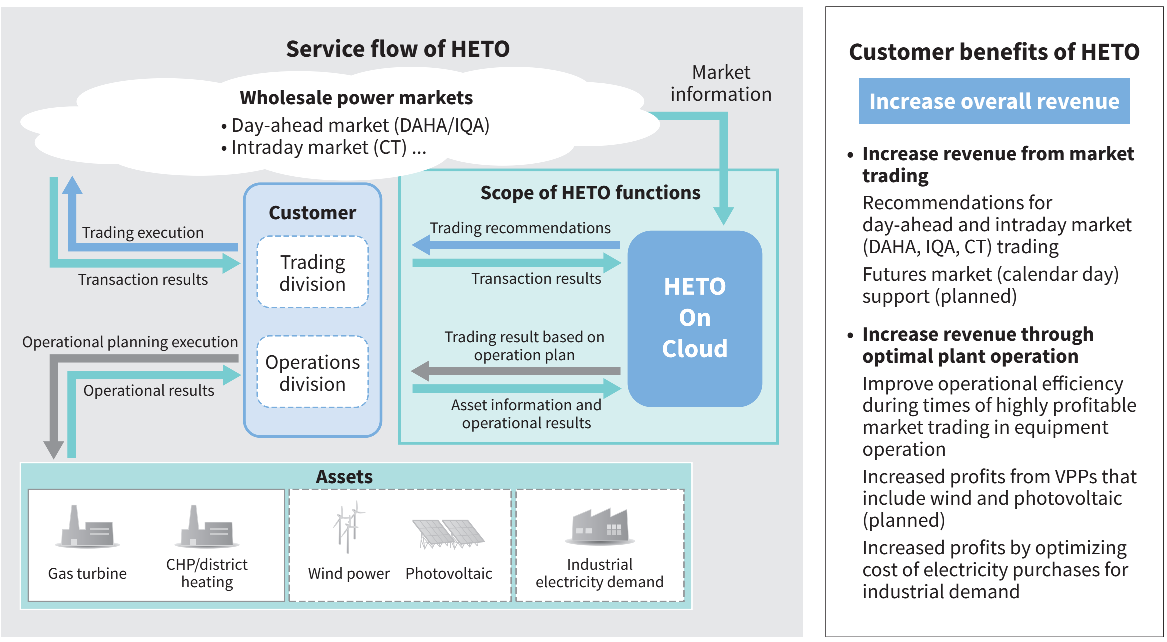
* As of December 2017 (based on research by Hitachi)

8 Support Service for Optimal Electric Power Generation and Electricity Trading by Local Utilities Operators

In Germany, the proportion of electric power from renewable energy resources is rising significantly. At the same time, utilities have an obligation to coordinate energy supply and demand balancing through electric wholesale markets, in which the utilities can trade power up to 30 minutes before physical delivery. A feature of these electricity markets is the large fluctuations in trading prices that follow the fluctuating supply of renewable energy.

Hitachi has launched Hitachi Energy and Trading Optimization (HETO), a service for these volatile electricity markets that supports the optimization of generation and electricity trading. The service utilizes Hitachi's digital technologies to make good use of power generating flexibility, which creates tradable excess electric power, to make possible power trading deals at premium prices. The service provides both optimization of power plant operation and trading at the same time.

Demonstration of the service is progressing with Entega AG, a city-owned company (Stadtwerke) that supplies infrastructure services in Darmstadt in the state of Hessen.



DAHA: day-ahead hourly auction IQA: intraday quarter-hour auction CT: intraday continuous trading CHP: combined heat and power VPP: virtual power plant

8 Support service for optimal electric power generation and electricity trading

9 Virtual Power Plants

The growing adoption of renewable energy sources such as photovoltaic or wind power is posing a variety of challenges for electricity grids. Hitachi is working on virtual power plant (VPP) solutions that utilize distributed energy sources such as electric vehicles (EVs), batteries, or heat pumps to perform demand response (DR), using information and communication technology (ICT) for aggregation[*1], planning, and control so as to combine these distributed energy sources in such a way that they can be controlled and utilized in much the same way as a conventional power plant.

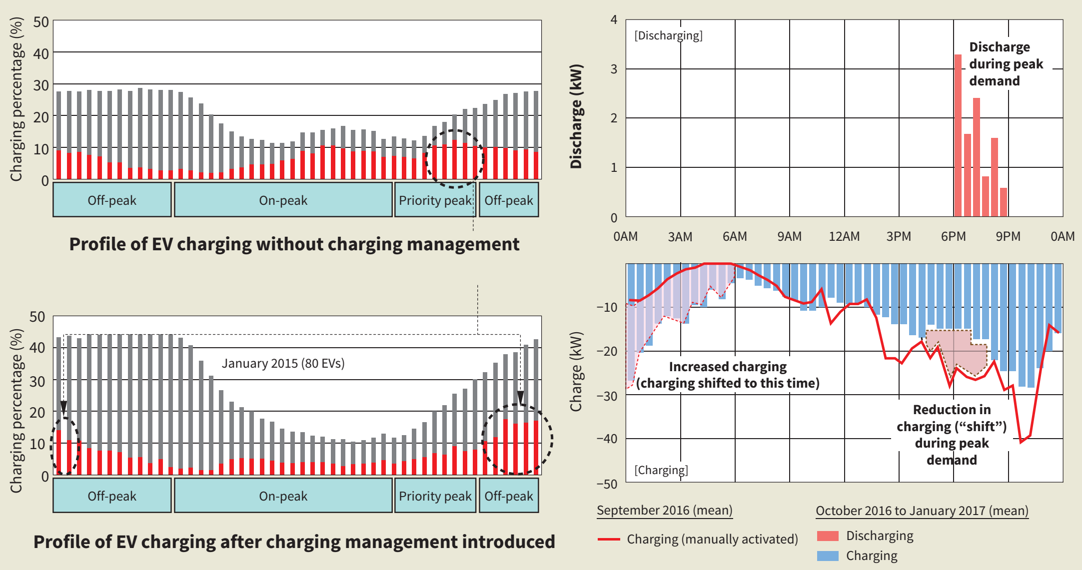
Hitachi has engaged in the trial operation[*2] of VPPs for use in grid operation that combine distributed energy sources as part of two programs in Hawaii in the USA.

The first was a DR program that involved fast-acting direct load control (DLC) of key household loads such as EVs and water heating for emergency load shedding during grid overloads and the preparing of schedules for load adjustments based on supply and demand planning. The program demonstrated that using DR in a way that takes account of the usage settings for each EV can succeed in cutting peak demand in a power system (see left of **Figure 9.1**).

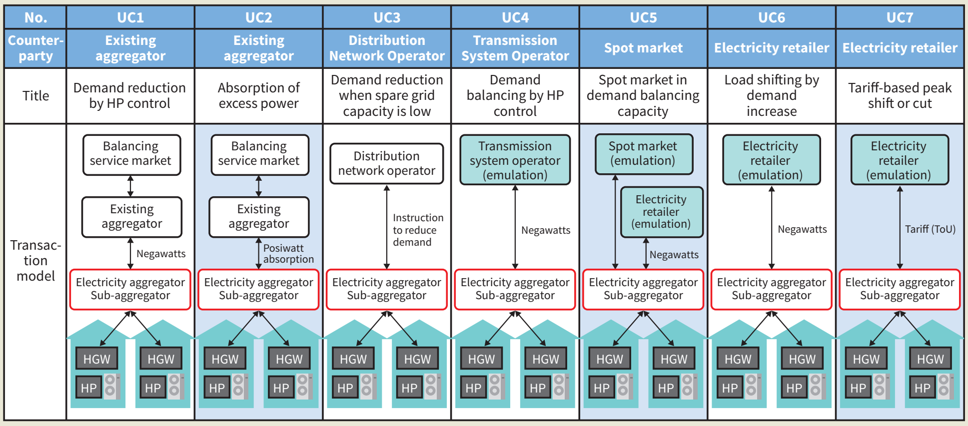
The second was a VPP program, a further development of the DR program described above, in which the VPP operated to balance supply and demand by aggregating large batteries with the capability to provide reverse power flows to the grid. The basic operation involved using power conditioning systems (PCSs) with a vehicle-to-grid (V2G) capability installed in homes with EVs to perform charging during times when excess supply is available, such as at night or when a large amount of photovoltaic power is being generated, and to discharge during times of peak demand such as the early evening. The solid red line in the graph on the right of **Figure 9.1** indicates the mean actual power consumption when the EVs are charged conventionally. In contrast, the bars in the graph that indicate charging or discharging show how charging and discharging were performed while the VPP program was running. These show that charging took place overnight, except during the power system's peak demand hours (from 6 to 9 PM), whereas discharging occurred during those peak hours.

These two trial programs demonstrated that the adjustment capacity provided by DR and VPPs can be utilized as a resource for grid operation.

A smart community demonstration project[*2] in Greater Manchester in the UK involved working



9.1 DR program (left) and use of VPPs to manage charging and discharging (right)



UC: use case HP: heat pump HGW: home gateway ToU: time of use
* Market transactions UC4 to UC7 are virtual transactions made by an emulator

9.2 Service use cases

with project partners to use a VPP made up of stored energy sources located at customer premises to conduct service trials of VPPs for providing services in a liberalized electricity market.

One of these trials was a VPP program that aggregated the load adjustment capabilities of 550 heat pumps installed in customer homes and traded the combined load adjustment capability on the electricity trading market or with electricity industry participants such as electricity retailers and grid operators. By incorporating functions to protect users and maintain convenience by automatically cutting out the DR program if there is a divergence of more than 2°C from the temperature set by the user or if the user operates the system manually, the trial found that more than 83% of users were able to use electric power without having to think about DR. Seven different use cases are available for utilizing the adjustment capabilities (see **Figure 9.2**). The trial achieved the initial target for the amount of negawatts made available and confirmed that DR satisfies the regulations when trading with aggregators.

A second trial involved a telecare service in the form of a data utilization program in which data acquired from the VPP business was utilized for the purposes of differentiation, customer acquisition, and revenue improvement. The trial demonstrated that improvements in the efficiency of telecare service operations and the benefits of data utilization services for enhancing business viability could be achieved by adopting IT. This included using electric power and temperature as well as data from door, motion-detection, and other special-purpose sensors to determine the situation in the home; the use of automated voice telephony to perform checks; and functions for chatting with care managers and collating care records.

These two programs demonstrated the viability of providing services using VPPs to electricity utilities in a liberalized electricity market.

The electricity business is undergoing a staged liberalization as it approaches the third stage of Japan's electricity market reforms due to be introduced around 2020. Developments in 2017 included the launch of a negawatt market, grid operators beginning to take bids for adjustment capacity, and encouragement for the introduction of VPPs that included the Ministry of Economy, Trade and Industry offering funding for demonstration projects involving VPP implementation. With the competition unleashed by liberalization having also led to rising demand for customer acquisition solutions, Hitachi intends to draw on operational know-how and the results of trials in overseas countries where electricity market liberalization is more advanced to take on the needs and challenges of the electricity business with VPP and data utilization solutions that are likely to be used by grid operators, retailers, and aggregators.

*1 Combining a group of distributed energy sources.
*2 A demonstration project funded by the Ministry of Economy, Trade and Industry and the New Energy and Industrial Technology Development Organization (NEDO)