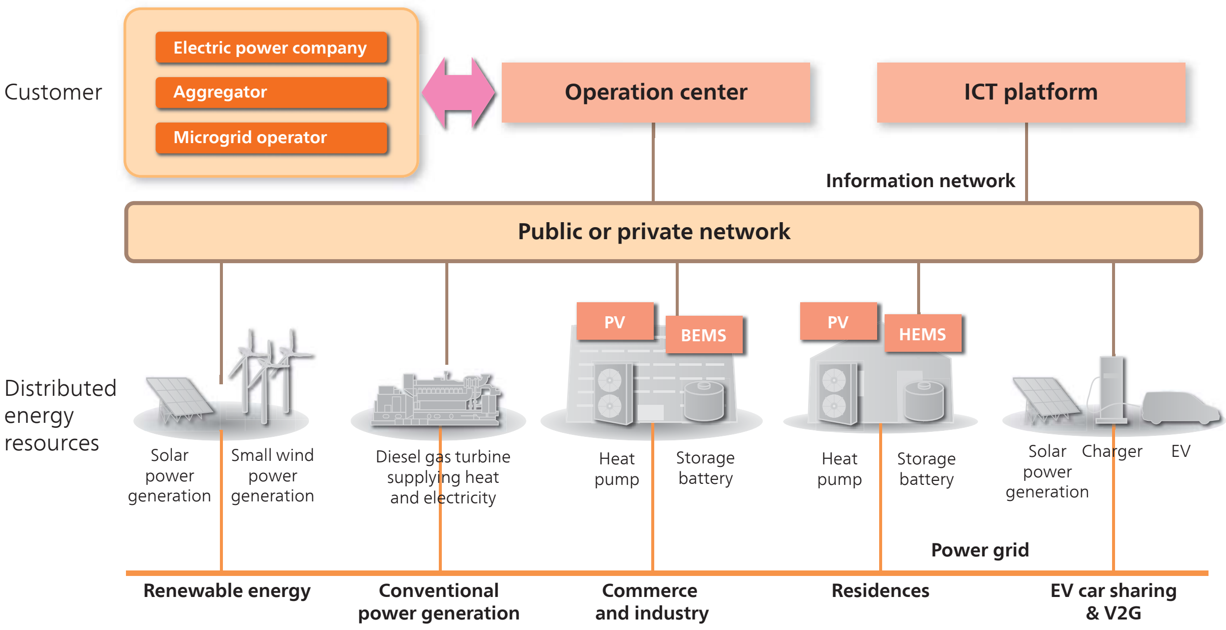
Energy Solutions



PV: photovoltaic, BEMS: building energy management system, HEMS: home energy management system, EV: electric vehicle, V2G: vehicle to grid

1 Virtual power plant

1 Virtual Power Plant

An increase in the use of solar power generation, storage batteries and other distributed energy resources is posing a range of problems on the grid. The virtual power plant (VPP) is a technology designed to centralize supervisory control based on information communication technology (ICT) for controlling and utilizing these items like a single conventional power source.

Hitachi is conducting demonstration operations of the VPP with the use of electric vehicles in the US state of Hawaii and with heat pumps in the UK city of Manchester*. In both locations, they are adopted as energy sources that are distributed to consumers and integrated into the grid. These systems are studied as a means of stabilizing the grid according to the fluctuations in the output of renewable energy in Hawaii and as a commodity to be traded in the power trading market in Manchester.

In Japan as well, a negawatt power trading market will be established in 2017. This fiscal year, the Ministry of Economy, Trade and Industry (METI) embarked on the virtual power plant construction and demonstration project.

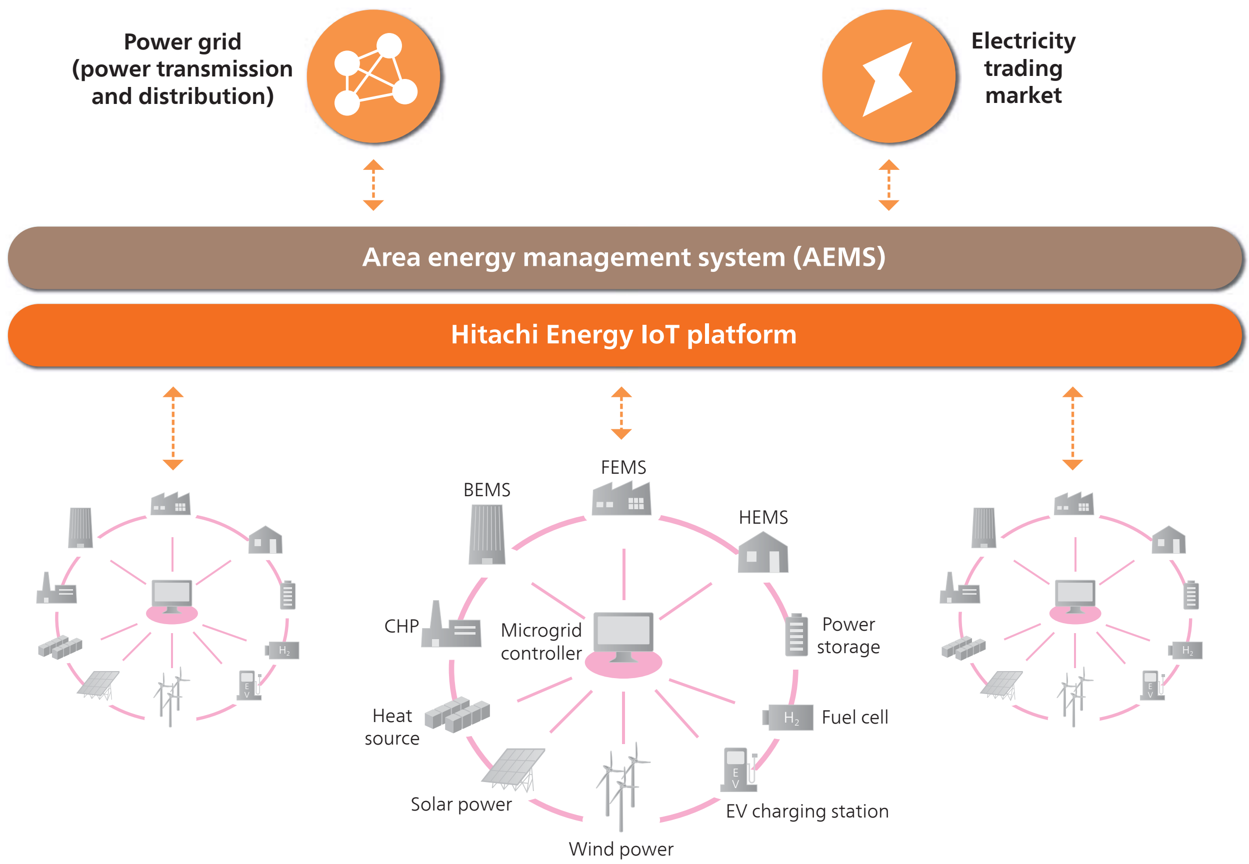
* A demonstration project commissioned by METI and by the New Energy and Industrial Technology Development Organization (NEDO).

2 Multiple Microgrid Operation and Management Solution

Microgrids are connected to the power grid to make the most of distributed power sources. On microgrids, it is vital to optimize the demand-supply balance of heat and electric power and to minimize operation costs. Amid the emergence of the impact of distributed power sources on the existing grid, the compatibility of microgrids with the power grid and with other microgrids is essential for their continuous operation.

The multiple microgrid operation and management solution is designed to implement integrated management and the operation of multiple microgrids to open the way for energy transfer between microgrids and to reduce the total cost of operating multiple microgrids.

In addition, it helps create posiwatt and negawatt power and stabilize the power grid, thereby maximizing the value of microgrids. Adopting international



AEMS: area energy management System, FEMS: factory energy management system, CHP: combined heat and power

2 Schematic of operation of multiple microgrids

standard communication protocols, the solution facilitates communication with systems on the utility side and with other microgrid systems, and ensures scalability.

With the use of the high reliability power control technology that has been nurtured by Hitachi and the Internet of Things (IoT), the solution achieves the continuous minimization of expenses and the stable supply of energy.

3 Power Storage Solution

Maintaining a stable supply of high-quality electricity is becoming an urgent issue as larger amounts of variable renewable energy like photovoltaic generation are being introduced to the power grid. Hitachi has been working towards the commercialization of a new hybrid battery energy storage system that combines lead-acid batteries and lithium-ion capacitors as safe and economical battery energy storage systems to provide a solution for this challenge. Hitachi is aiming to cover the range of control from the adjusting capacity of the inertial body of the power generator to the automatic frequency control (AFC).

For this purpose, Hitachi co-developed a 1.5 MW hybrid battery energy storage system with a group company, Shin-Kobe Electric Machinery Co., Ltd. (now Hitachi Chemical Company, Ltd.), as part of project subsided by NEDO. The demonstration project on Izu Oshima Island began in 2015 and has entered into a new stage as a joint research project with TEPCO Power Grid, Inc. The companies have been evaluating the efficacy of the monitoring control system and its effects on the operation of existing power plants.

Hitachi is aiming for the commercialization of the system by 2018 to contribute to stabilizing the supply of power for island regions.

3 New lead storage battery equipment installed on Izu Oshima Island

4 OCCTO operation center

4 OCCTO System Inauguration

The Organization for Cross-regional Coordination of Transmission Operators, Japan (OCCTO) is a new organization that was established in April 2015. It plans to construct power transmission networks that are necessary for the extensive utilization of power sources, monitors the supply-demand conditions of individual electric power suppliers and provides instructions on electric power supply from one power supplier to another when the supply-demand balance is tight. The OCCTO system collaborates with general electric utilities, power producers and suppliers and Japan Electric Power Exchange (JEPX) to monitor the supply-demand balance and the grid condition, manage reserve capacity and the use of interconnection lines, adjust wide-area frequency and publish grid information. The OCCTO system commenced operation in April 2016.

The main features of this system are as follows.

(1) A triplex hot standby system involving a geographical distance of hundreds of kilometers is introduced to the main site and the backup site.

(2) The leading model in the power grid system complies with IEC 61970-301 (common information model) and thereby achieved linkage with different systems and higher compatibility with package products, as well as a high level of scalability.

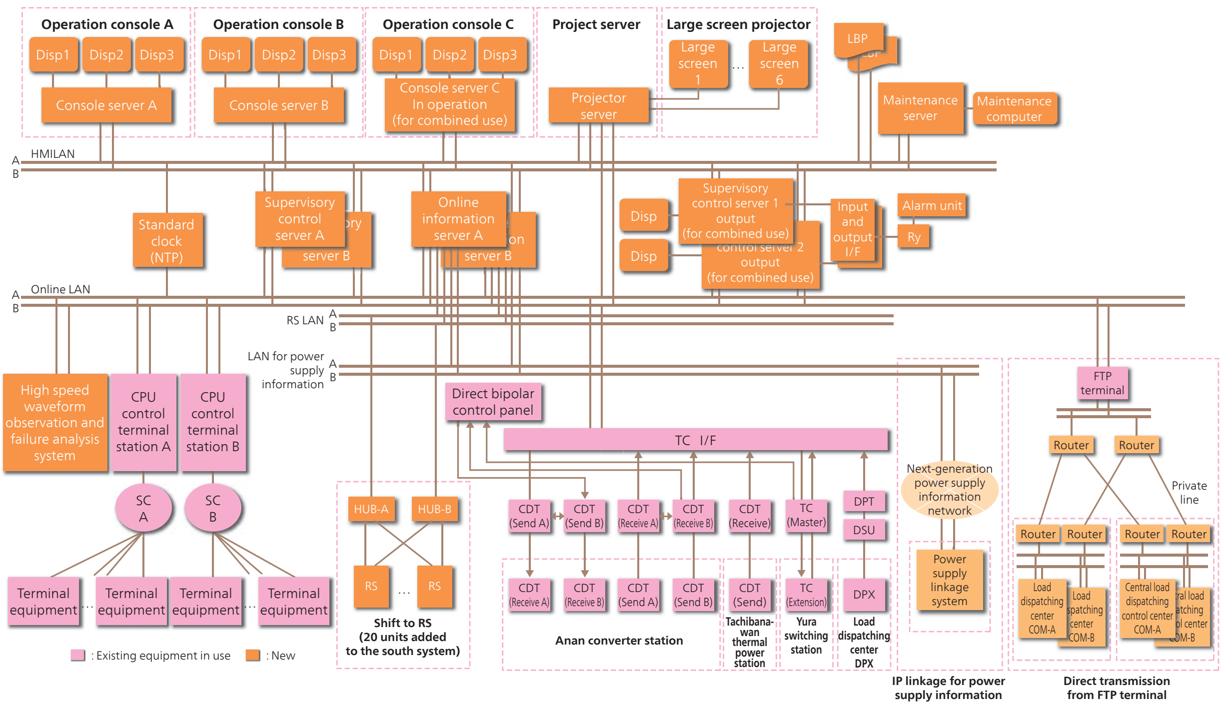
(3) The screen is designed with a focus on people to achieve the human machine interface (HMI) featuring the enhanced visibility of the position of electric power equipment located in an extensive space and the area where it belongs.

(4) Unauthorized intrusion is blocked by security measures that comply with different security guidelines.

In the future, Hitachi will continue to offer solutions in line with the progress of power system innovation.

5 Kihoku Converter Station, Kansai Electric Power Co., Inc. Replacement of Supervisory Control System

Following the addition of 500 kV power extraction equipment to the Kihoku Converter Station due to the south grid reconstruction, the supervisory control



Disp: display, LBP: laser beam printer, SC: star coupler, TC: telecontrol, I/F: Interface, CDT: cyclic digital transmission, DPT: data packet transmission, DSU: digital service unit, DPX: data packet exchange, FTP: file transfer protocol, COM: communication server

5 Configuration of supervisory control system at Kihoku converter station system was replaced.

The supervisory control server, the online information server, the operation console server, the system monitoring server, the maintenance server and other upper-level systems were replaced while the lower-level systems' central processing unit (CPU) control terminal station and terminal equipment were retained for continued use. Part of the terminal equipment was shifted to the remote station (RS).

The main features are as follows.

(1) Devices constituting the current system that cannot be supplied in the future were replaced with new models.

(2) The new system is configured to accommodate both devices from the conventional system and newly introduced systems.

(3) To improve maintainability, the architecture of servers at power supply stations and electric power facilities was adopted, which is the standard for the control systems of the Kansai Electric Power Co., Inc.

6 Izumi Substation, Hokuriku Electric Power Company Inauguration of STATCOM Var Compensator

The Izumi Substation faced an issue of addressing the voltage fluctuation that occurs during the start-up in pumping in a neighboring pumped storage power station. As a solution to this issue, a static synchronous compensator (STATCOM) was installed and commenced practical operation.

Prior to this, the voltage fluctuation on the 6.6 kV bus line of the Izumi Substation reached a maximum of 10% at the start-up of the pumped storage power station and around 5% prior to parallel operation. After the installation of STATCOM, the fluctuation is suppressed to ±2% to meet the voltage fluctuation requirement stipulated in the system interconnection regulations.

STATCOM's initial capacity was planned to be 16.5 MVA. In order to avert long-term constraints on pumped storage operation due to the failure of the conversion for transformer, the STATCOM was planned to consist of three 5.5 MVA units of which two units would be constantly required and the remaining would serve as a spare unit. In this project, cooperative tap control that combines the tap control of the 154 kV/6.9 kV transformer was devised to reduce the required capacity to 11 MVA (two 5.5 MVA units). Even in the event that only one unit (5.5 MVA) is operating after another unit has failed, the voltage fluctuation is still within ±2% to satisfy the requirement.

Item	Specifications
Rated capacity	11 MVA (two parallel units of 5.5 MVA each)
Rated voltage	6.6 kV (three-phase)
Rated frequency	60 Hz
Voltage fluctuation suppression	Within ±2%
Response time	Within 50 ms
Converter configuration	Parallel quadruplex three-phase three-level converters
Rated DC voltage	6,000 V
Main device	3,300 V, 1,200 A, IGBT
Modulation system	15-pulse multi-carrier PWM
Cooling system	Circulation water and air cooling
Harmonic filter	1,010 kVar

IGBT: insulated gate bipolar transistor, PWM: pulse width modulation

6 Specifications (top) and equipment at Izumi STATCOM (bottom)

7 The Kansai Electric Power Co., Inc. 500 kV PCM Current Differential Protection Relay Equipment

The pulse code modulation (PCM) current differential protection relay equipment for 500 kV power grids originally comprised two-panel configuration, consisting

7 500 kV PCM current differential protection relay equipment

of the main panel and the auxiliary panel. However, Hitachi's latest digital relay unit was applied to make the input auxiliary transformer shared for the main relay and the fault-detecting relay to reduce the number of panels. A slim system with a single-panel configuration was therefore created. In Japan, the protection relay system consists of the main relay and the fault-detecting relay, whose hardware configurations and relay functions are different from each other in order to prevent unwanted operation.

The main features are as follows.

(1) The input auxiliary transformer is shared for the main relay and the fault-detecting relay.

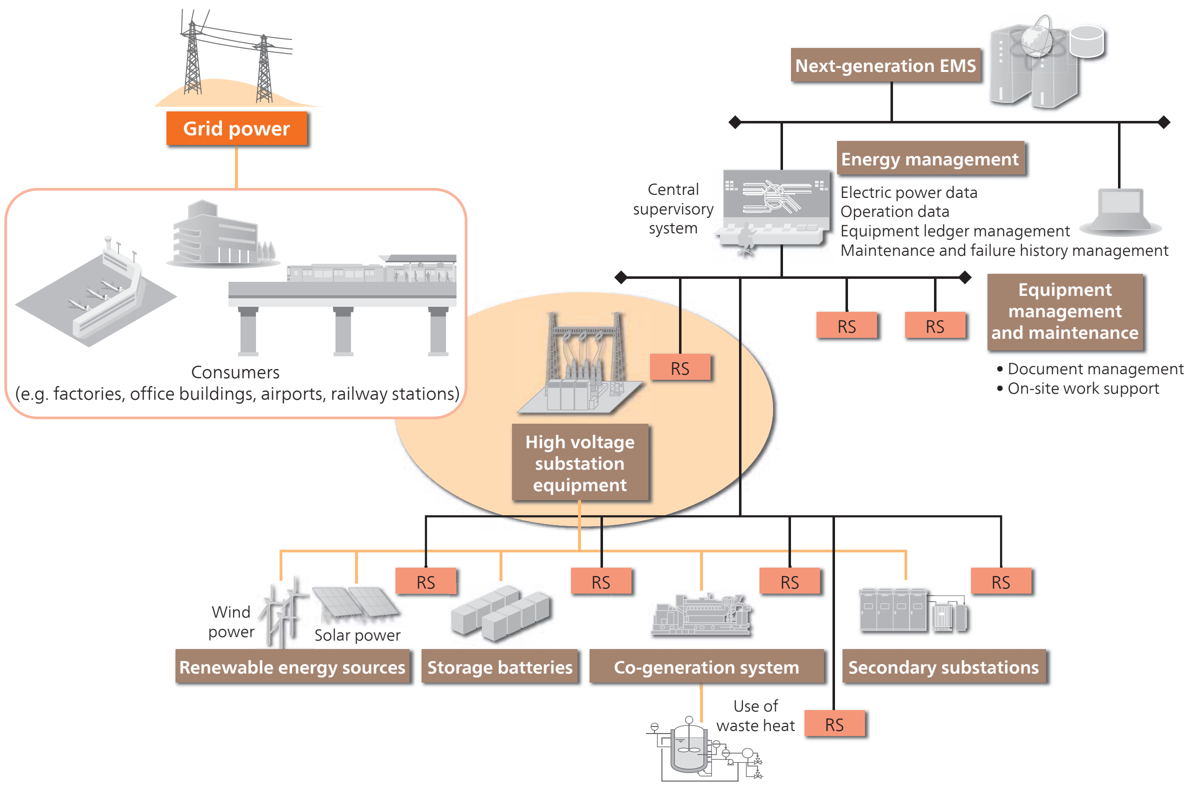
(2) It offers advanced out-of-step relay using 2-bit data transmission, with excellent selectivity, responding to power swings at high slip frequency.

(3) It complies with the immunity standard specified in JEC-2501 (electromagnetic compatibility test on protection relay) in consideration of the latest version of the B-402 Standards (digital protection relay and protection relay equipment).

After undertaking the type test witnessed by the Kansai Electric Power Co., Inc., this equipment was delivered to the operation site and preparations are being made for its operation. Hitachi will continuously develop products to provide a high level of reliability and to fulfill a wide range of needs.

8 Energy Solution Centered on Substation Equipment for Consumers

Today, the social circumstances surrounding energy are changing drastically amid the deregulation of the electric power and gas markets. For many energy consumers, it is a significant issue to make effective use of energy and equipment. After a decline in the workforce and failure to pass down technologies and expertise in the company as a result of the retirement of experts that previously worked on equipment operation, consumers are under increasing burdens of carrying out maintenance and management for the stability of equipment and equipment replacement planning. Under these circumstances, the desired forms of substation equipment at the heart of consumers' power source equipment are also changing. Hitachi has delivered substation equipment, private power generation equipment, supervisory control equipment and others. In the future, it will work to create and run a business of comprehensive energy system solutions for consumers including renewable energy, uninterruptible power system (UPS), power storage equipment and heat equipment as well as higher-value added solutions such as system failure prediction and energy management in combination with operational technologies (OT) and IT through collaborative creation with consumers.



EMS: energy management system

8 Energy solution centered on receiving substation equipment for consumers

9 Standardized Relay Unit for On-site Use at Receiving Substations

Many of the protective relays used by consumers in their on-site super-high voltage power distribution systems are of the analog type and static relays. Some of these systems have already been in service 30 years or more, and it is time for them to be replaced. For replacement purposes, functionally intensive digital relays, which are today's mainstream relays, will be introduced. Given that individual electrical rooms have many unique specifications for alarm items and others, Hitachi developed a protective relay unit for on-site super-high voltage power distribution with a standardized digital relay designed to meet individual specifications by means of hardware connection.

The main features are as follows.

(1) The power supply, the CPU, the input converter, the input/output circuit and others are housed in a single unit 349 mm wide, 267 mm high and 274.9 mm deep.

(2) The protection system of the in-house super-high voltage power distribution equipment is selectable from among the primary protection of the power line (current differential), the secondary protection of the power line, transformer protection and overload protection.

(3) For the output of external alarm, an output selection function has been added to enable arrangement for individual electrical rooms.

In the future, Hitachi will endeavor to add functions such as a transfer block function so that the unit can be more widely utilized.

9 Standard unit of relay equipment for receiving substation