Energy Solutions

1 Trends in the Energy Solutions Business

The business environment surrounding the world's electricity markets has been changing dramatically in recent years, with growing awareness of environmental problems, the development of alternative energy sources such as shale gas, increasing urbanization, and an expansion in demand for power generation capacity in emerging markets that is set against the aging of infrastructure in developed economies. This background has set the scene for debate on a shift from existing centralized power plants and large distribution networks operated by vertically integrated regional monopolies toward distributed generation, smart grids, and the entry of new operators made possible by progress on electricity system reform.

Including Japan's electricity market, these changes in the business environment affect on the energy value chain from upstream to downstream. Since the new value chain is characterized by many more stakeholders than in the past, it is expected to deliver the following new business opportunities.

(1) Businesses made possible by energy market liberalization

There has been ongoing debate over electricity system reform, including the separation of generation and transmission, that seek to reduce electric power charges by introducing competition. It is anticipated that energy market liberalization will increasingly see participants from outside the industry joined in the new electricity business including existing power companies. Hitachi plans to provide end-to-end supports from the procurement of power resource to the general works needed for power producer and supplier (PPS) operators.

(2) Renewable energy (RE) and other distributed energy resource (DER) businesses

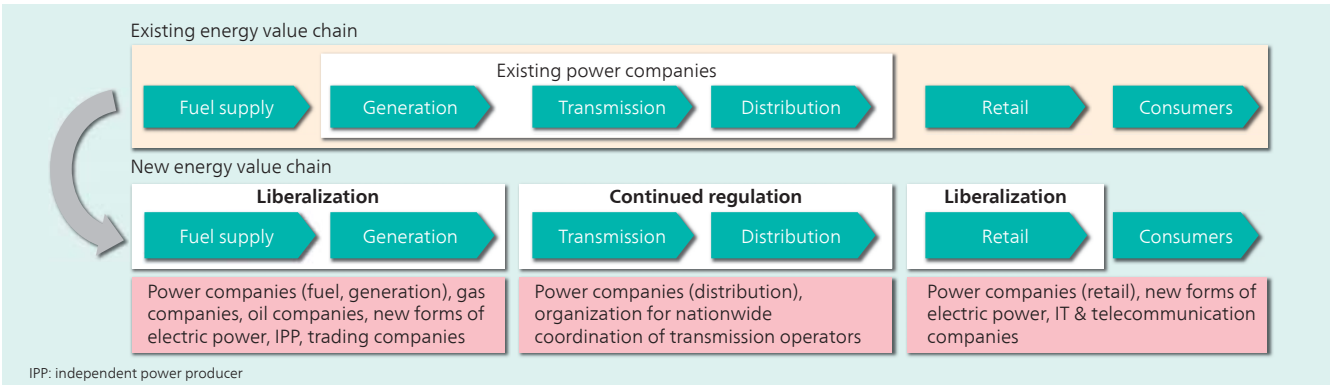
Energy security considerations are recognized as prompting growth in demand for locally-produced and locally-consumed business model in place of large centralized power plants. In addition, from the viewpoint of reducing the CO_2 emissions, photovoltaic, wind, and other forms of renewable energy will be also increasingly spreading.

(3) Businesses that combine information technology (IT) and operation and maintenance (O&M) with existing products

Along with its existing business of supplying equipment in accordance with customer specifications, Hitachi sees the potential solutions that include the use of big data for predictive diagnosis systems and maintenance, and the outsourcing of power plant operations.

The secret to the development of the solution business lies in a three-way strategy of differentiating from competitors by offering distinctive solutions, by categorizing expected market size, and by operating the business based on a global perspective. While the solutions that are too distinctive will compromise the market size by restricting them to a limited number of customers, it is difficult to differentiate from competitors when aiming for too wide of a market. In this respect, the keys to the success of the solution business are an ability to think in global terms from the outset, and the establishment of a business development organization that can work rapidly through the cycle of testing and discarding numerous potential business models.

In October 2014, Hitachi, Ltd. established its Energy Solutions Division as a "front engineering" (technical sales) organization, under the direct jurisdiction of the President, providing optimum solutions to energy and power system markets that are being reformed in Japan and throughout the world in a one-stop format that extends from power generation to power transmission and distribution and end-user systems. By consolidating engineering divisions from across Hitachi that are involved in the energy solutions, distribution, and renewable energy businesses, the new division will establish the infrastructure for the timely supply of one-stop solutions tailored to the needs of power companies and other stakeholders in the energy and power system markets.



1 Reforms to energy value chain in the Japanese electricity market

Power Generation Equipment and Systems

1 Overview of NYPA's Niagara Power Project (Lewiston is the power plant at the top) (left) and new pump-turbine runner under assembly (right)

1 New 42-MW Pump-turbine Runners Commence Operation at Lewiston Pump-Generating Plant of New York Power Authority

An upgrade to the first 42-MW pump-turbine was completed at the New York Power Authority's (NYPA) Lewiston Pump-Generating Plant, located downstream of Niagara Falls, and commenced commercial operation in September 2013. The plant features a maximum head of 36.6 m, which is very low for a pumped-storage hydro power plant. At the same time, the head range is about 18 m, which is large in proportion to the 36.6-m maximum head for these pump turbines.

The project to improve the characteristics of the existing pump-turbines, which were supplied by a different manufacturer and entered service in 1961, included runner replacement, changes to the shapes of the guide vanes and stay vanes, and refurbishment of the embedded components. These improved efficiency by about 2 to 5% in turbine mode, depending on the head, and increased turbine output by 8 to 20%, again depending on the head. Pump efficiency was also increased. The replacement runners have an outer diameter of 5.3 m. To ensure that the new runners would deliver a high level of hydrodynamic performance, Hitachi used stainless steel castings produced in Europe. The assembly; welding of the crown, band, and blades; and the machining and balancing were performed at Hitachi Works. Operational testing at the Lewiston plant confirmed the unit can operate reliably across the entire operating range, in accordance with the model test.

Refurbishment has also been completed on the second unit, which commenced commercial operation in May 2014, with on-site work on the third unit currently underway. The plant has 12 pump-turbines, with refurbishment of all units expected to be completed in 2020.

(Hitachi Mitsubishi Hydro Corporation)

2 20.6-MW Kaplan Turbines and Generators for Cheongpyeong Hydro Power Plant Units 1 and 2 of Korea Hydro & Nuclear Power Co., Ltd. Commence Operation after Major Overhaul

A major overhaul of Unit 1 and Unit 2 was undertaken at the Cheongpyeong Hydro Power Plant of Korea Hydro & Nuclear Power Co., Ltd., with Unit 1 recommencing commercial operation in May 2014 and Unit 2 in June of the same year.

The vertical-shaft Kaplan turbines and generators at the plant first entered service in 1943, with an upgrade to the turbine runners and the stator coils and cores of the generators being undertaken in 1993. The latest overhaul consisted mainly of repairs (machining) to the flow surfaces of the turbines and upgrades to the stainless steel guide vanes, as well as to the generator rotor, governor, exciter, unit control panels, and other electrical equipment.

The main features resulting from the upgrade are listed below.

(1) Improved turbine efficiency as a result of repairing the turbine flow surfaces and upgrading the stainless steel guide vanes

(2) Elimination of harm to the environment due to oil leaks as a result of adopting water bosses and water-lubricated bearings for the turbines

(3) Adoption of environmentally conscious digital governor that is compliant with the Restriction of Hazardous Substances (RoHS)

2 Cheongpyeong Hydro Power Plant Unit 1 (in the back) and Unit 2 (in the front) of Korea Hydro & Nuclear Power Co., Ltd. after completion of major overhaul

3 Unit 1 (top front) and Unit 2 (top back) of the Shuparo Power Plant of Hokkaido Bureau of Prefectural Enterprises, and Yubari Shuparo Dam and power plant (bottom)

(standard Hitachi Mitsubishi Hydro Corporation product)

(4) Better bearing reliability and lower losses as a result of using plastic bearings in generators

Hitachi Mitsubishi Hydro Corporation intends to continue supplying products for major overhauls of existing power plants, including features such as lower environmental risks and better maintenance and performance.

(Hitachi Mitsubishi Hydro Corporation)

3 New Hydro Generation Equipment for Shuparo Power Plant of the Hokkaido Bureau of Prefectural Enterprises

The installation of new hydro generation equipment at Unit 1 (24,800 kW) and Unit 2 (1,800 kW) of the Shuparo Power Plant of the Hokkaido Bureau of Prefectural Enterprises has been completed and commissioning has commenced with the aim of completing the project by March 2015.

This hydro power plant is located in Yubari, Hokkaido in Japan and is powered by water from the Yubari Shuparo Dam.

The main features of the hydro power plant are as follows.

(1) Highly efficient turbine runners designed using the latest techniques in computational fluid dynamics

(2) Air-cooled generator bearings that eliminate the need for cooling water supply

(3) Water-lubricated turbine bearings that do not require lubricating oil (Unit 1)

(4) Electrically operated guide vane, inlet valve and brake that eliminate the need for a hydraulic system

In the future, Hitachi Mitsubishi Hydro Corporation intends to contribute to new hydro power plant projects and scrap-and-build projects at existing plants by making better use of renewable energy, reducing environmental risks such as oil leaks, and providing easier maintenance.

(Hitachi Mitsubishi Hydro Corporation)

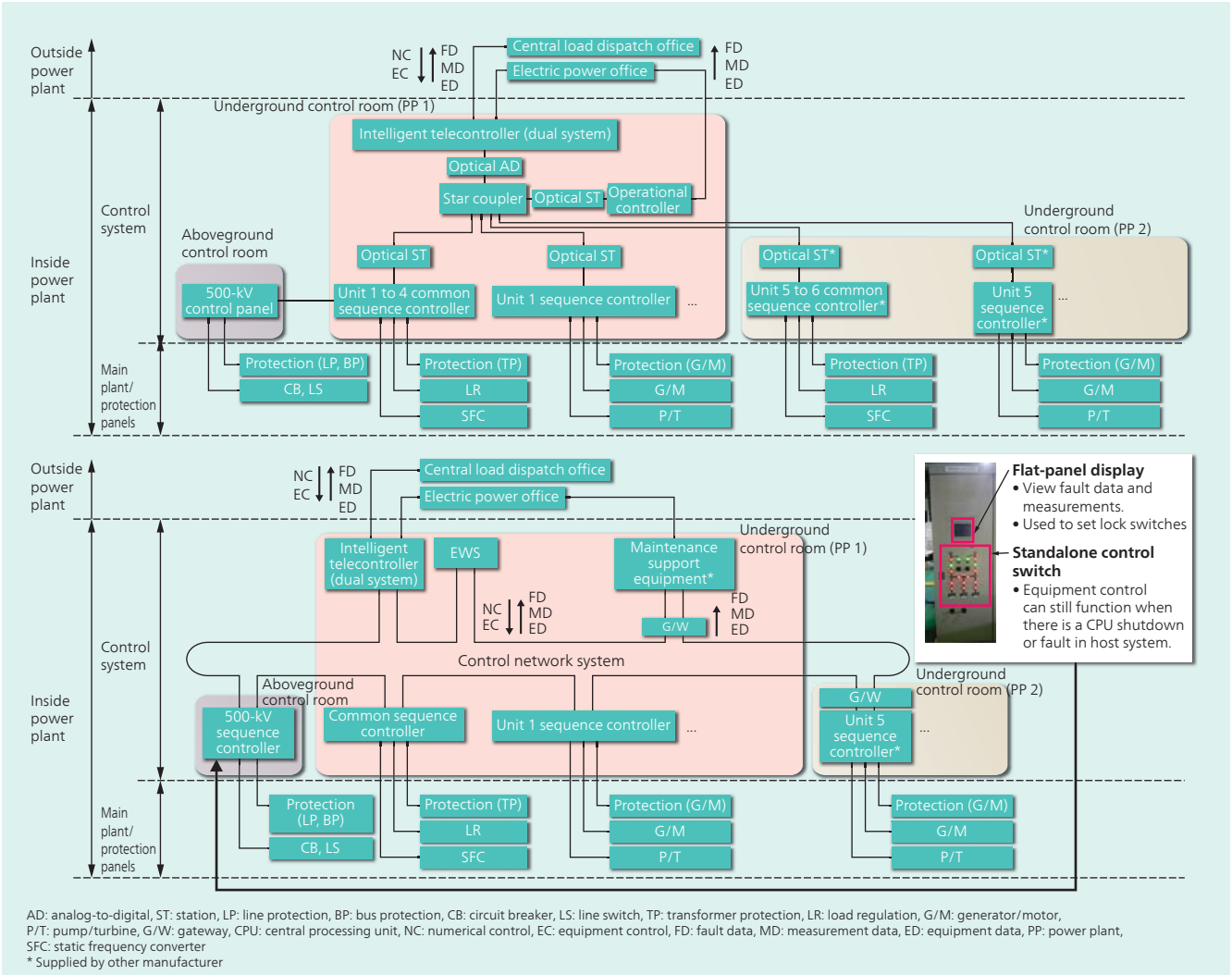
4 Replacement of Automatic Control System at Okumino Power Station of Chubu Electric Power Co., Inc.

The automatic control system at the Okumino Power Station of Chubu Electric Power Co., Inc. has been in use since the plant entered commercial operation in 1994. This project will replace the 500-kV sequence controller, common sequence controller, Unit 1 and Unit 2 sequence controller, engineering workstation (EWS), and intelligent telecontroller (ITC).

Installation of controllers occurred in early October 2014 following integration testing of the complete system at the factory. On-site commissioning started in November 2014, with Unit 2 scheduled to commence commercial operation in March 2015 followed by Unit 1 in May 2015. The common control functions of Units 3 through 6 will be made operational coincident with replacing them.

The main characteristics of the project are as follows.

(1) The plant's local area network (LAN), which is currently



AD: analog-to-digital, ST: station, LP: line protection, BP: bus protection, CB: circuit breaker, LS: line switch, TP: transformer protection, LR: load regulation, G/M: generator/motor, P/T: pump/turbine, G/W: gateway, CPU: central processing unit, NC: numerical control, EC: equipment control, FD: fault data, MD: measurement data, ED: equipment data, PP: power plant, SFC: static frequency converter
* Supplied by other manufacturer

4 System configuration of automatic control systems at Okumino Power Station of Chubu Electric Power Co., Inc. before (top) and after (bottom) replacement

based on existing star couplers, has been partly replaced with a 1,000-Mbit/s control network system to provide the data communication with high-reliable and fast-speed between controllers (there is a long distance between each control room).

(2) Monitoring and control of the 500-kV system have been changed from analog to digital, and an integrated monitoring and control system for transformation and generation has been created by designing on the same network with other sequence controllers.

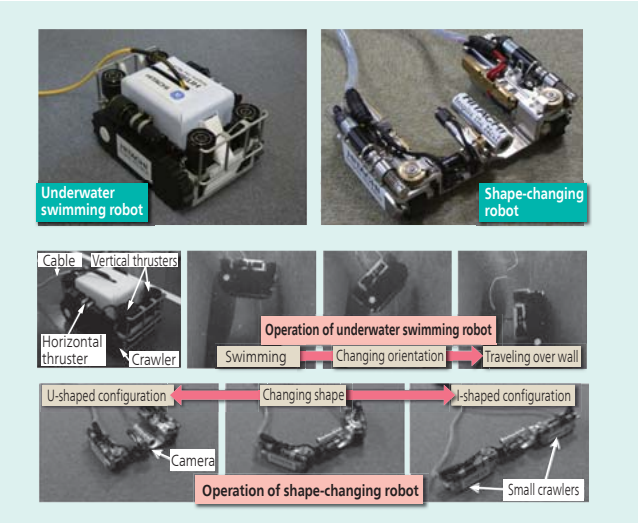
(3) The power system monitoring and control board have been changed from a mechanical board to an EWS with liquid crystal display (LCD), improved operation has been realized in terms of monitoring the power system, with an easy-to-use note-taking function for equipment shutdowns.

(Hitachi Mitsubishi Hydro Corporation)

5 Exploratory Robots for Use in the Removal of Fuel from Fukushima Daiichi Nuclear Power Station

Hitachi has developed two robots for use in the removal of fuel from Fukushima Daiichi Nuclear Power Station. The robots can conduct remote surveys over large areas, being able to change their shape and orientation to avoid obstacles, even in confined spaces.

The underwater swimming robot is used in the water-filled reactor building to perform underwater surveys for identifying the location of leaks of the pooled water. A feature of this robot is its ability to travel both over dry land and through water, being



5 Exploratory robots for use in the removal of fuel from Fukushima Daiichi Nuclear Power Station (top) and robot operation (bottom)

equipped with six thrusters (four vertical and two horizontal) and one set of crawlers. It entered use at the plant in July 2014.

The shape-changing robot, for use in highly radioactive environments, is able to enter the reactor containment vessel through a 100-mm diameter pipe and conduct extensive surveys. The robot consists of three articulated sections (the main body and two small crawlers) that form an I shape to pass through pipes and a U shape for travel over flat ground. This combines stable movement with the ability to enter through narrow access ways. It is scheduled to enter use at the plant in April 2015.
(Hitachi-GE Nuclear Energy, Ltd.)

6 Construction of New Nuclear Power Plants in Europe

In August 2014, Hitachi-GE Nuclear Energy, Ltd. commenced stage three of the Generic Design Assessment (GDA) conducted by the UK Office for Nuclear Regulation of the advanced boiling water reactors (ABWRs), which Horizon Nuclear Power Limited plans to build at Wylfa on the island of Anglesey and at Oldbury-on-Severn, South Gloucestershire. The GDA is progressing well and is scheduled to be completed by the end of 2017. The UK's first ABWR should commence generating electric power in the early 2020s.

With regard to the project to construct an ABWR at Visaginas in the Republic of Lithuania, meanwhile, following an agreement by all parties in the Lithuanian parliament to proceed with the project, Hitachi, Ltd. and the Lithuanian Ministry of Energy have agreed on a memorandum of understanding and are negotiating the establishment of an operating company. The Republic of Latvia and the Republic of Estonia also plan to participate in the project, which is scheduled to commence generation in the 2020s.
(Hitachi-GE Nuclear Energy, Ltd.)

7 5.0-MW Wind Power Converter

Hitachi first entered the Chinese market for wind power converters in 2008, having supplied 1.5-MW, 2.0-MW, 3.0-MW doubly fed (DF) models, and a 2.0-MW permanent magnet generator (PMG) model.*

In Japan, a 2.0-MW DF converter commenced field tests in January 2014. Hitachi has now developed a 5.0-MW PMG converter for use with large offshore wind turbines.

The main features of these converters are as follows.

(1) Water-cooled, direct-current (DC) 3.3-kV three-level inverter [capacity: 5,310 kVA (grid-side) and 5,460 kVA (generator-side), rated voltage: 1,800 V (grid-side) and 1,980 V (generator-side), and rated generator frequency: 132 Hz]

(2) Designed for use in offshore environments of vibration or salt-induced corrosion to allow offshore installation

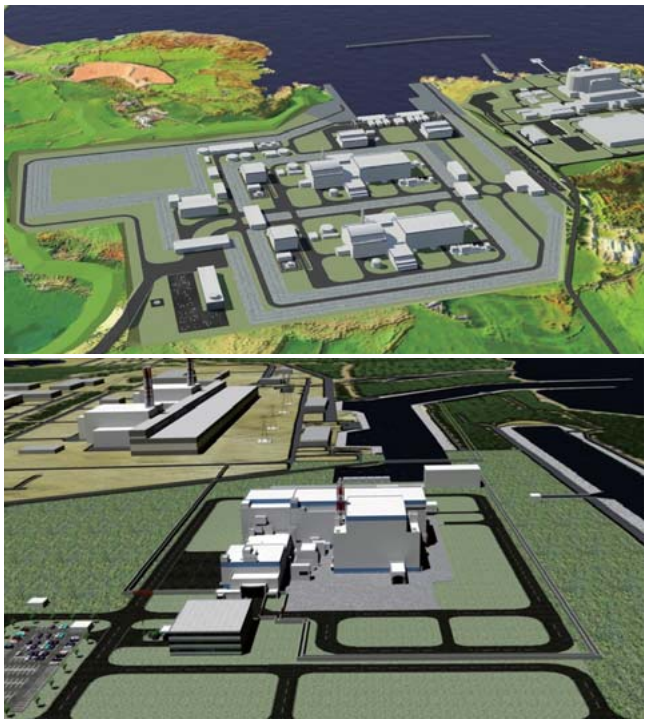
(3) Fault ride-through capability for maintaining operation during grid voltage drops (0% of rated voltage, 0.15 s) and frequency fluctuations (rated frequency ±10%) (compliant with JEAC 9701-2012 grid connection standard)

(4) 3,200 mm wide × 1,800 mm deep × 2,300 mm high (excluding filter and protruding parts), weight: 5,700 kg

(5) Uses vector control with no position sensor. This simplifies maintenance by eliminating the need for an encoder on the generator.

Utilizing the experience it has gained with offshore wind power generation in Japan, Hitachi aims to expand its overseas market share.

* The 1.5-MW DF model was released on the Chinese market in October 2010, the 2.0-MW DF model in July 2013, the 3.0-MW DF model in October 2013, and the 2-MW PMG model in December 2012.



6 Artist's impressions of completed Wylfa Nuclear Power Plant in the UK (top) and Visaginas Nuclear Power Plant in Lithuania (bottom)

7 5.0-MW wind power converter

8 1-MW container-type energy storage system for ancillary services (left) and 500-kW power conditioner (right)

8 Energy Storage System for Ancillary Services

Countries around the world are installing photovoltaic power generation and other forms of renewable energy in response to considerations such as environmental protection and security of energy supply. However, the weather-dependence of power output has led to concerns about the detrimental effects that these power plants have on grid stability and power quality.

In the USA, an ancillary services market has been established that reimburses operators for the charging and discharging of energy storage systems to help maintain frequency stability. With the aim of entering this market, Hitachi has developed a 1-MW container-type energy storage system.

The main features of this energy storage system are as follows.
(1) 1 MW/450 kWh of high-output, high-density lithium-ion batteries are packaged in a 40-foot container (12.2 m approx.).
(2) A chopper-less, three-level power conditioner ensures efficient charging and discharging of lithium-ion batteries.
(3) A battery management system provides integrated data collection and control of the status of the large number of lithium battery modules.

Based on technology it has developed, Hitachi is going to use energy storage systems to support the installation of renewable energy in Japan and elsewhere.

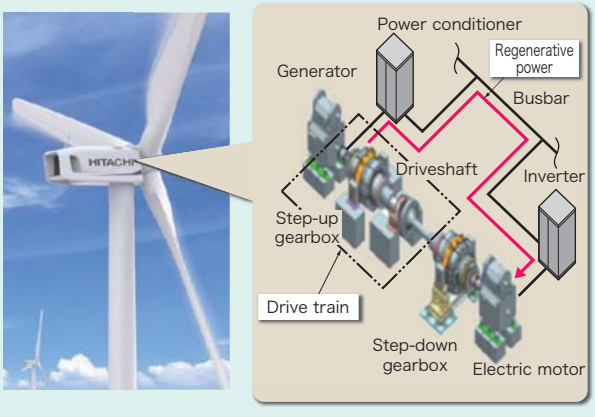
9 Large 5-MW Offshore Wind Turbine

Along with the accelerating pace of renewable energy development over recent years, it is hoped that offshore wind power generation in particular can form an important part of Japan's domestic energy supply. Against this background, Hitachi is working on the development of a large wind power generation system with a rated output of 5 MW.

Like the 2-MW wind turbine that is the current mainstay of Hitachi's product range, the 5-MW model has a downwind configuration with the rotor positioned on the downwind side of the tower. This provides a form of inherent safety that reduces the wind load by allowing "free yaw," meaning that the wind force causes the nacelle to reflexively orient itself during strong and gusty winds. Hitachi has also made the system lighter and more compact, and improved its reliability, through the combination of a newly developed permanent magnet synchronous generator and a medium-speed gearbox.

Prior to commencing commercial production, Hitachi is building a demonstration model of the large 5-MW wind turbine for testing the turbine's performance. Full load testing, in which the drive train was loaded up to test its performance and behavior, has already been completed, and nacelle assembly has commenced in readiness for product shipments.

A demonstration model will be constructed at a waterfront location in Kamisu City in Ibaraki Prefecture, and will commence trial operation during the 2014 fiscal year.



9 Full load testing of drive train for 5-MW wind turbine (top) and system configuration (bottom)

Electric Power Transmission Equipment and Systems

1 Meihoku Load Dispatch Control Center of Chubu Electric Power Co., Inc.

The supervisory control and data acquisition (SCADA) system supplied to the Meihoku Load Dispatch Control Center at the Nagoya Branch of Chubu Electric Power Co., Inc. performs monitoring and control of approximately 80 substations. The project involves the complete replacement of the second-generation load dispatch system installed in 1998 with the third-generation common application software for load dispatch control centers that Chubu Electric Power has been installing since 2002, and means that all 11 branch load dispatch systems at Chubu Electric Power now use the common software.

Development of the common software was split across a number of different vendors and provides the company with standard application software, which in the past was different at each load dispatch control center depending on the supplier. This has achieved uniform load dispatch system operation and reduced development times.

(Commencement of operation: February 2014)

2 Transmission Line Protection Relay

It has been four years since the first of the new series of digital relays entered service, during which time Hitachi has been working on the development and supply of standard transmission line protection relays for low-voltage power systems (with resistive grounding).

Now, Hitachi has developed and supplied Tokyo Electric Power Co., Inc. with transmission line protection relays (using a 54-kbit/s communication system) for main-line power systems (with direct grounding).

The main features of these relays are as follows.

(1) Faster current differential relay operation and integration with circuit breaker operation to achieve disconnection in three cycles.

(2) Computation method for reverse phase over-voltage and zero phase over-voltage relays that is in principle unaffected by third and fifth harmonics.

(3) Uses Hitachi's transmission line protection relay to reduce the number of central processing unit (CPU) boards to one-third as many as the previous system.

1 Meihoku Load Dispatch Control Center of Chubu Electric Power Co., Inc.

2 275-kV current differential protective relay panel

(4) Stainless steel housing frame that helps reduce carbon dioxide (CO_2) emissions by eliminating the need for painting.
(Commencement of deliveries: August 2014)

3 SCADA System for JR Kyushu

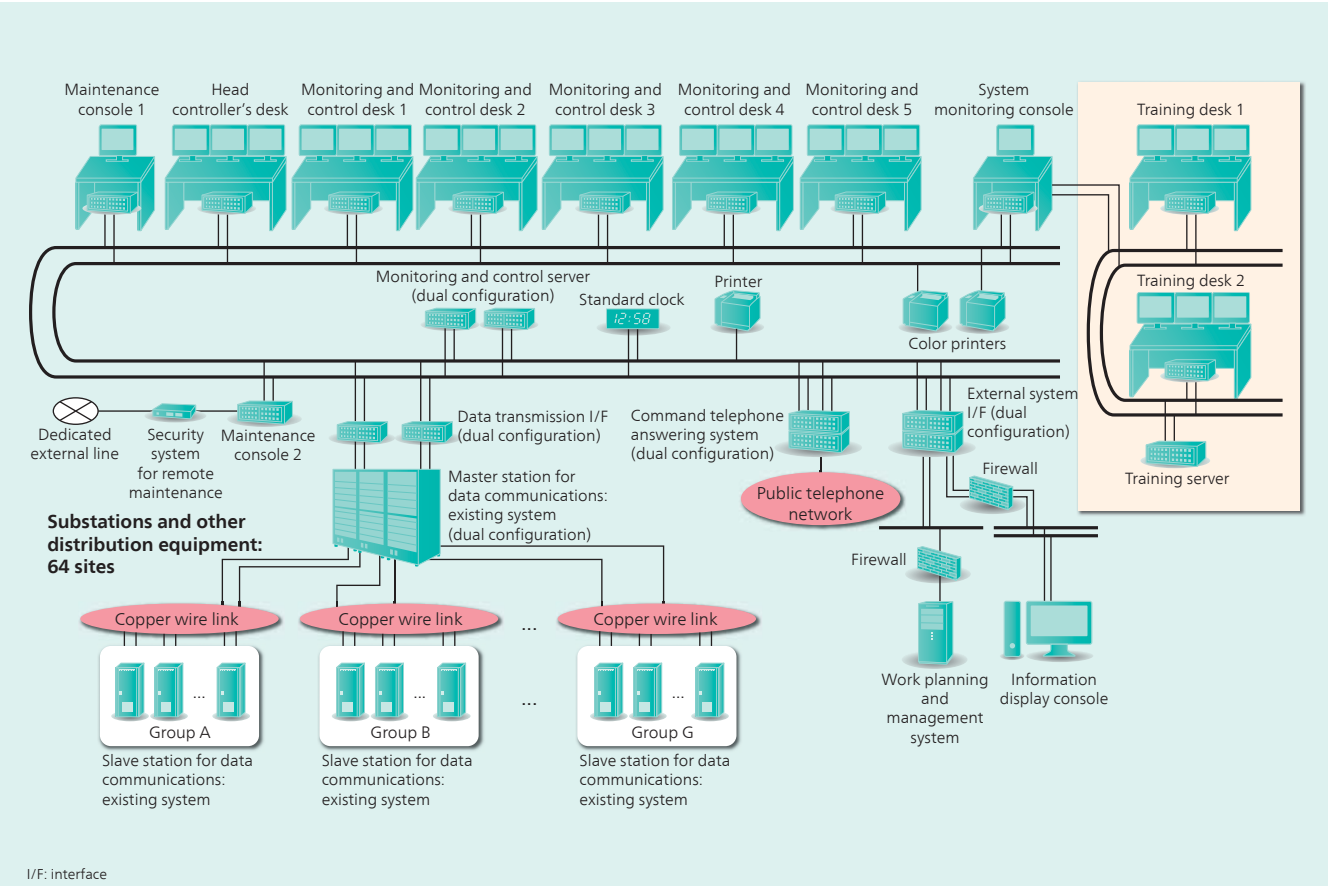
Hitachi has received an order for an electrical SCADA system for the main control center of Kyushu Railway Company (JR Kyushu) that will replace a system supplied by a different vendor, and is working on building the new system. Final commissioning tests are currently in progress prior to the commencement of operation, which is scheduled for March 2015.

The system is used for the monitoring and control of substations and other distribution equipment across 64 sites. It maintains the same operational format as the existing system, while also incorporating Hitachi's know-how in power management systems for railways. To ensure reliability, the system is based on a redundant configuration for both the network and servers, including the monitoring and control servers.

The main features of this system are as follows.

(1) With the requirement for a system configuration that permits the connection of existing remote control devices to ensure the reliability of SCADA data for existing equipment, Hitachi developed a data transmission and interface function for the remote control devices that was commissioned without major problems through a repeated process of thorough on-site testing and factory testing of connections to these devices.

(2) Control staff work efficiency was improved by equipping them with wide monitoring and control desks with three monitors that enabled such operational enhancements as a newly added ability to display images across multiple monitors and a wider display scope for the grid monitoring screens.



3 Block diagram of JR Kyushu SCADA system

(3) A dedicated training system was supplied to provide a training environment for control staff. The training system provides a training environment that is as close as possible to the actual operation of field equipment, including the addition of a simulation function that interoperates with field systems and a fault registration function.

4 Completion of Compliance Testing for New JEC Standard and Initial Product Deployment of 550-kV GCB for Japanese Market with Oil-immersed Hydraulic Operating Mechanism

Gas circuit breakers (GCBs) are protection devices for power systems that can perform rapid switching of high power at high voltage. Amid growing demand arising from the replacement of aging equipment in Japan in recent years, Hitachi has released a 550-kV GCB that complies with the latest standard and has undergone type approval testing.

The main features of the GCB are as follows.

(1) Uses an oil-immersed hydraulic operating mechanism to improve equipment reliability and maintenance. In a move toward maintenance-free operation, the oil-immersed hydraulic operating mechanism has been made more compact and its component count reduced by housing the mechanism inside the case that holds the hydraulic fluid.

(2) To satisfy market requirements, the GCB has been confirmed to be compliant with the relevant JEC-2300 standard for alternating current (AC) circuit breakers, which was revised in 2010, including changes to the interrupt duty such as faults on long-distance lines.

(3) Data for assessing the life of components with respect to factors such as the weakest point for insulation and the frequency of operation has been collected to improve reliability and maintenance. In the future, Hitachi intends to continue supplying reliable equipment with high added value for such applications as gas-insulated switchgear (GIS) and meeting the increasing demand for the replacement of aging equipment.

(Commencement of deliveries: April 2014)

4 Installed 550-kV GCB

5 72/84-kV C-GIS with Magnetically Operated VCB

Hitachi has developed a cubicle-type of gas-insulated switchgear (C-GIS) with a magnetically operated vacuum circuit breaker (VCB).

The C-GIS has a rated voltage of 72/84 kV, rated current of 1,200 A, rated interrupting current of 25 kA, and rated sulfur hexafluoride (SF_6) gas pressure of 0.07 MPa. It has passed type testing, which includes a short-circuit test, a dielectric test, a temperature rise test, short-time withstand current and peak withstand current test, and a mechanical operation test.

The main features of the C-GIS are as follows.

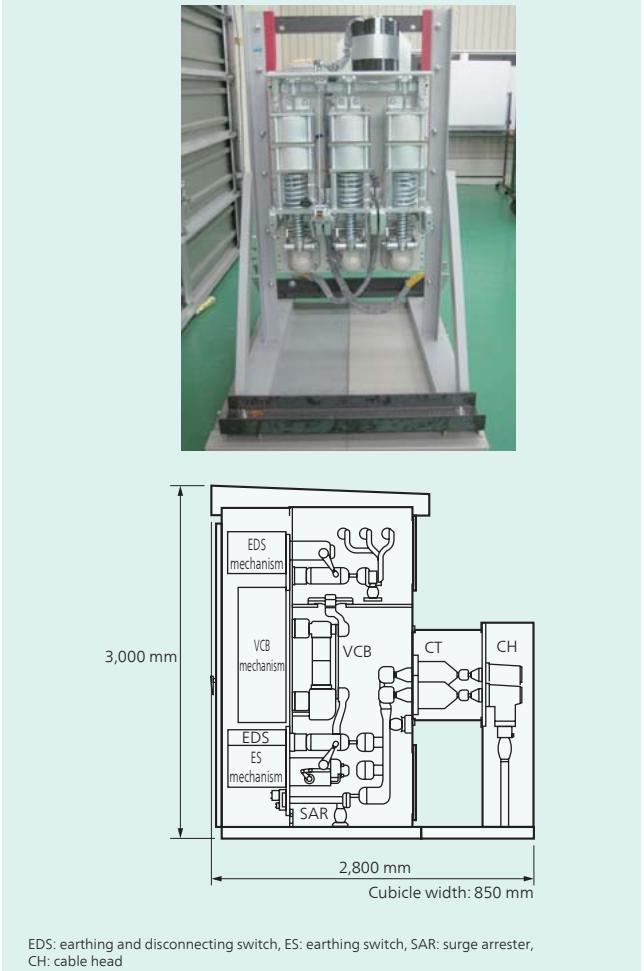
(1) Allows designs with fewer components and maintenance requirements than previous motor-operated spring-charged mechanism VCBs.

(2) Reduces on-site maintenance of network connection point current transformer (CT) by fitting multiple CTs in the gas tank that work with the standard model.

(3) Reduces cost as a result of sharing components (including the gas tank) between the network connection unit and transformer primary unit.

(4) Achieves short delivery times by consolidating unit manufacturing.

In the future, Hitachi plans to expand sales of electrical distri-



EDS: earthing and disconnecting switch, ES: earthing switch, SAR: surge arrester, CH: cable head

5 Magnetically operated VCB (top) and internal design of C-GIS (network connection unit) (bottom)

bution equipment for different uses, including factories, office buildings, transportation, and the public sector.

6 Train-mounted VCB Capable of Withstanding Low Temperatures and High Altitudes

Hitachi has been supplying high-voltage VCBs for commuter and Shinkansen railways since the 1970s. Hitachi has also developed models for use in high-speed railways in China, having supplied several thousand units since 2005.

Although most high-speed railways in China to date have operated between the coastal cities, the extension of this network to inland regions is planned. Accordingly, Hitachi has now developed a VCB for the line that has the most stringent environmental requirements and runs between Lanzhou and Xinjiang. The major differences are those required to cope with the temperatures, air pressures, and other environmental factors encountered at altitudes of 3,000 m or more.

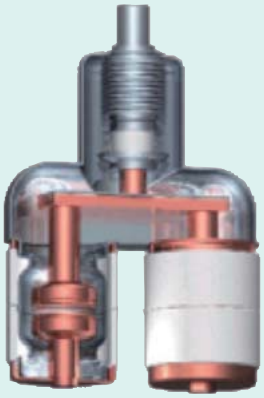
Measures adopted to ensure reliable operation in a harsh environment included materials that can withstand low temperatures and an insulation design that takes account of the high altitude. To maintain the 300,000-cycle operating life that is one of the features of existing models, Hitachi is also conducting field testing of VCBs in operational trains, as well as performing a variety of in-house testing that includes environmental testing and continuous operation testing.

While seeking to win orders for use of its newly developed low-temperature/high-altitude VCBs on the Lanzhou-Xinjiang Railway line, Hitachi also plans to market them for use on other railway lines in inland China.

No.	Parameter	Standard model	New low-temperature/ high-altitude model
1	Rated voltage	30 kV	←
2	Rated current	200 A	←
3	Operating life	300,000 cycles	←
4	Storage temperature	–25 to +40°C (same temperatures as in operation)	–40 to +40°C (–25 to +45°C in operation)
5	Altitude	< 1,500 m	< 3,610 m (testing conducted at 4,000 m) (4,000 m requires 1.38 times the pressure tolerance of 1,500 m)

6 Train-mounted VCB capable of withstanding low temperatures and high altitudes

Single-function vacuum valve



World-first* multi-function C-VIS vacuum valve

* Based on research by Hitachi, Ltd.

7 Use of vacuum valves in high-voltage applications

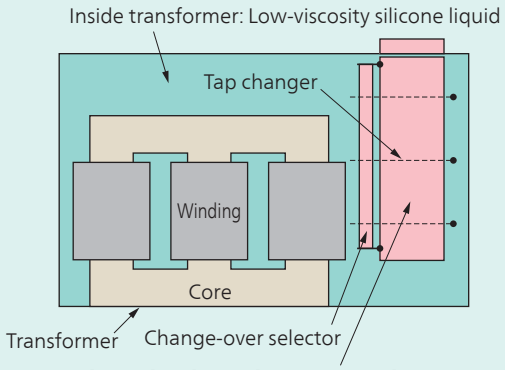
7 Use of Vacuum Valves in High-voltage Applications

Hitachi has been producing vacuum valves for 46 years since commencing production in 1968. Vacuum valves are widely used as a core component in the VCBs that play a critical role in electric power distribution systems in the electric power and electrical machinery sectors. Now, Hitachi has constructed a new factory that commenced operation in August 2014 with the aim of utilizing VCBs with low environmental load and easy maintenance, not only in medium-voltage (1 to 52 kV) but also in high-voltage applications (72/84 kV or higher).

Hitachi has sought to add value to its vacuum valves in a variety of ways in the past, including incorporating multiple functions and extending their operating life, while also supplying models that can be used with confidence in harsh environments such as in the power system equipment installed in trains, ships, or tropical regions. Hitachi also intends to continue working on research and development so that it can provide a greater number of customers with excellent products that incorporate its vacuum valves.

8 Low-viscosity Silicone Liquid-immersed Transformer with On-load Tap Changer

Targeting green innovation, Hitachi has developed a low-viscosity silicone liquid-immersed transformer (66 kV, 25 MVA, with



25-MVA, 64.5-kV low-viscosity silicone liquid-immersed transformer with on-load tap changer

8 Internal structure and exterior of low-viscosity silicone liquid-immersed transformer with on-load tap changer

on-load tap changer) that is designed for fire safety, low environmental load, and energy efficiency, and which is intended for use in the on-site electrical conversion system at the National Institute of Advanced Industrial Science and Technology.

The main features of the low-viscosity silicone liquid that serves as the main insulator in the transformer are as follows.

(1) Has a high flash point (250°C) to allow use as a "designated combustible material."

(2) Complies with Japanese Industrial Standards (JIS), with a high degree of oxidation stability for long life.

(3) Has low environmental load (hydrolyzable), is recyclable, and is not a greenhouse gas.

(4) Allows for smaller transformer design (with an installation footprint approximately 80% of a gas-insulated transformer).

The insulator in the insulation cylinders of the on-load tap changers (important ancillary components) is suited to the sliding operation performed when changing taps. The maintenance and running costs have also been reduced by eliminating the liquid filter unit, instead using a vacuum valve design with a synthetic ester that has a high flash point (300°C) and low environmental load (biodegradable).

In the future, Hitachi intends to continue developing highly reliable power transformers that satisfy customer needs.

9 154-kV-class Earthquake-resistant Transformer for Tohoku Electric Power Co., Inc.

Prompted by the considerable damage to social infrastructure caused by the Great East Japan Earthquake, there has been growing demand for improvements to the seismic performance of power system transformers in the 154-kV and higher classes. Given these needs, Hitachi has developed a 154-kV/150-MVA earthquake-resistant transformer for Tohoku Electric Power Co., Inc.

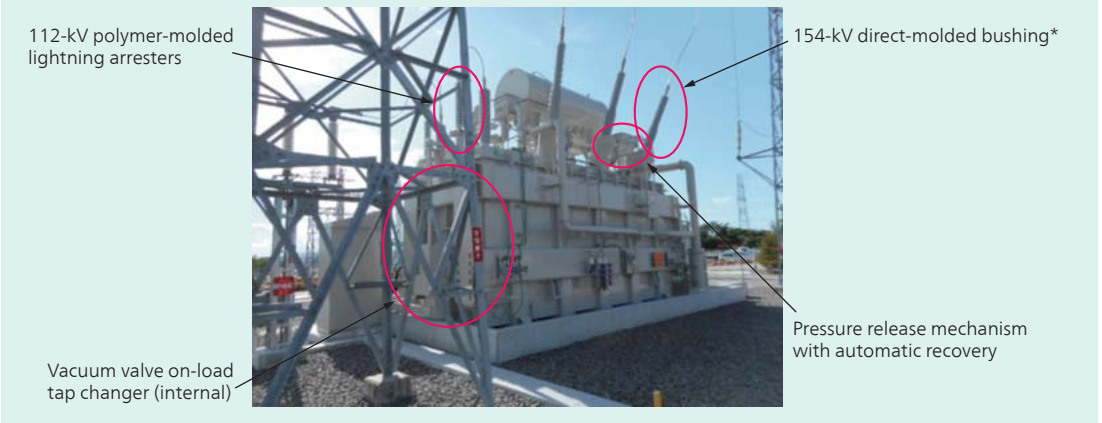
The main features of the transformer are as follows.

(1) Uses small and lightweight direct-molded bushings made of a new material and polymer-molded lightning arresters to prevent resonance with the dominant frequency of earthquakes by increasing the natural frequency of individual components. Earthquake resistance has also been improved by lowering the center of gravity of the transformer.

(2) Improvements to the internal integrity of the transformer by use of a pressure release mechanism with automatic recovery to release the pressure resulting from any oscillation of the insulating oil inside the transformer during an earthquake and immediately self-recover.

(3) As another new technology for improving seismic performance, it uses vacuum valve on-load tap changers, which improve maintenance by eliminating the need for a live line oil cleaner.

In the future, Hitachi intends to continue developing highly reliable power transformers that satisfy a variety of needs.



* Jointly developed by Hitachi, Ltd. and SWCC Showa Cable Systems Co., Ltd.

9 154-kV-class earthquake-resistant transformer for Tohoku Electric Power Co., Inc.