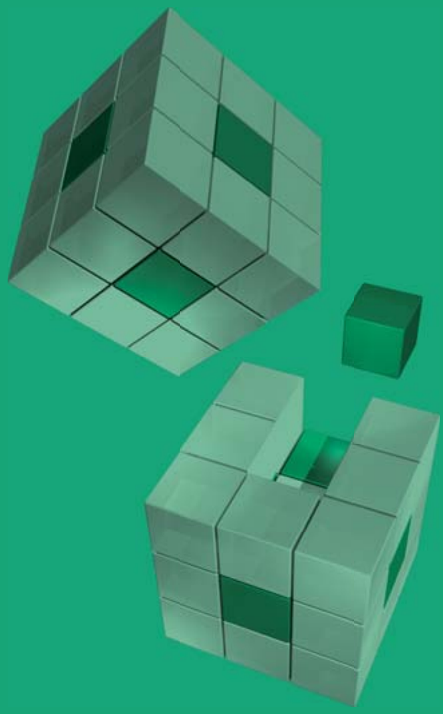


Power Systems

Thermal Power

■

Hydraulic Power

■

Nuclear Power

■

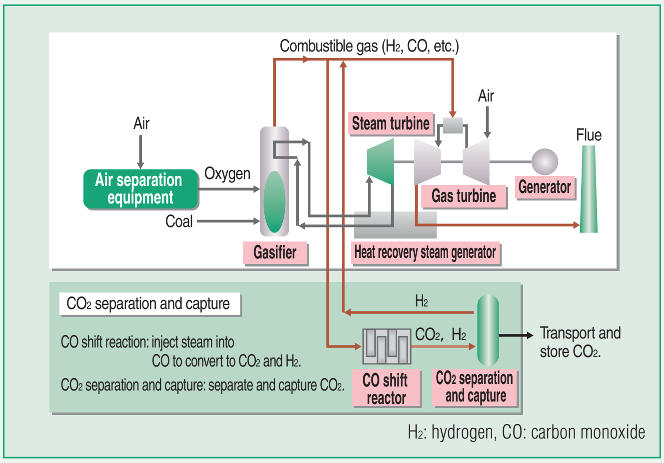
New Energy

■

Electric Power Distribution

Oxygen-blown IGCC Power Generation Demonstration "Osaki CoolGen Project"

Hitachi has received orders from the Osaki CoolGen project for key equipment intended for a large, 170-MW-class, oxygen-blown, IGCC demonstration plant. The order consists of a coal gasifier and combined-cycle generation system. In addition to demonstrating the operation of highly efficient oxygen-blown IGCC, the project also intends to trial an integrated system that incorporates CO_2 separation and capture and fuel cell technologies. With construction scheduled to commence during 2013, we spoke to engineers who are currently involved in the peak period of the design phase.



IGCC system configuration

Interest in Highly Reliable and Economical Coal-fired Power Generation

Coal's excellent economics and security of supply gives it a major role as the mainstream fuel for electric power generation in the world. However, because coal also emits large amounts of carbon dioxide (CO_2), Hitachi has long had an interest in integrated coal gasification combined-cycle (IGCC) power generation because of its high efficiency and suitability for CO_2 capture. This has included development of the associated technology.

Hitachi has participated in the Coal Energy Application for Gas, Liquid and Electricity (EAGLE) project run by the New Energy and Industrial Technology Development Organization and Electric Power Development Co., Ltd., including supplying a complete plant and supporting experimental operation. Drawing on the results of this work, Hitachi has received orders for key equipment for the Osaki CoolGen project, a large demonstration plant for testing oxygen-blown IGCC and CO_2 separation and capture technologies that is based on the Japanese government's CoolGen clean coal policy. In addition to supplying technology at each stage of the project, Hitachi is responsible for overall plant management in its role as technical leader.

Oxygen-blown IGCC Capable of High Generation Efficiency and Low Environmental Load

IGCC is a combined-cycle electric power generation system that uses a gasifier operating at high temperature and pressure to convert coal into combustible gas that is then used to fuel a gas turbine and generate electric power. Heat recovery is also used to recover the exhaust heat from the gas turbine and the reaction heat from the gasifier, using it to produce steam and generate electric power in a steam turbine. Oxygen-blown IGCC is an effective technique for boosting the efficiency of combined-cycle electric power generation by using oxygen in the coal gasification process.

Babcock-Hitachi K.K. is responsible for the coal gasifier required by the process. Its features include use of single-chamber, two-stage, spiral-flow gasification for efficient gasification of coal using a low volume of oxygen and suitability for use with a wide range of coal grades.

In addition to the gasifier and other coal gasification equipment, Hitachi has also received orders for combined-cycle electric power generation equipment, including the gas turbine, steam turbine, heat recovery steam generator, and generator. In supplying this equipment, Hitachi will draw on knowledge and technologies gained from the EAGLE project.

Contribution to Low-carbon Society through Cleaner Coal-fired Electric Power Generation

Construction of the Osaki CoolGen project will get underway during 2013, with experimental trials due to commence in 2017. As well as improving the basic performance, operating characteristics, and economics of the IGCC system, Hitachi is also currently working on developing technologies for the future.

Technologies for reducing CO_2 emissions while continuing to use coal will likely be essential to future energy development. The power generation efficiency of IGCC can be significantly improved through the use of larger gas turbines operating at higher temperatures, and the technology has the potential to perform CO_2 separation and capture with low energy using compact equipment. Even greater efficiencies can be achieved if IGCC is combined with fuel cells.

With this project, Hitachi is not only speeding up the commercialization of oxygen-blown IGCC, it is also contributing to the realization of a low-carbon society through cleaner and more advanced coal-fired electric power generation.

Nobuo Nagasaki (left), Chief Project Manager, IGCC Project Marketing & Management Division, Thermal Power Systems Division, Power Systems Company, Hitachi, Ltd.; Kengo Uematsu (right), Chief Project Manager, Coal Gasification System Center, Plant Engineering Division, Kure Division, Babcock-Hitachi K.K.

Commencement of CCS Demonstration Project with SaskPower in Canada

In March 2012, Hitachi signed an agreement with Saskatchewan Power Corporation (SaskPower), an electric utility in Saskatchewan, Canada, and embarked on a project to construct a carbon capture test facility (CCTF) to demonstrate Hitachi carbon capture technology.

The site of the trials is SaskPower's Shand Power Station, a 298-MW coal-fired power plant near the town of Estevan in Saskatchewan. Located in Canada's mid-west, the plant has for some time been a leading center for the development of carbon capture and storage (CCS) technology, including trials of carbon dioxide (CO_2) sequestration and the use of CO_2 for enhanced oil recovery. The aims of the project are for the two companies to work together to combine technologies and know-how for CO_2 capture, and to conduct comprehensive trials and evaluations of the reliability, economics, and other aspects of the complete system with a view to future full-scale commercial facilities. The demonstration project will use Hitachi's H3-1 solvent, which features excellent absorption and energy efficiency characteristics. With a view toward future up-scaling to a commercial facility, the test facility will be designed to process 120 t/d of CO_2 with a capture rate of 90%. Trials are scheduled to commence in mid-2014.

Planned carbon capture test facility

Commencement of Commercial Operation of Stage II Repowering Project for Senoko Power Station in Singapore

The stage II repowering project (two units) for the Senoko Power Station supplied to Senoko Energy Pte Ltd. in the Republic of Singapore commenced commercial operation in August 2012.

The contract for this project was let in September 2008 to a consortium made up of Hitachi Asia Ltd. (HAS), Mitsubishi Heavy Industries, Ltd., and Mitsubishi Corporation. Hitachi, Ltd. supplied the boilers, steam turbines, and generators, and handled the repowering of three existing 250-MW oil-fired power plants that commenced operation in 1979 with two large, combined cycle power plants (431-MW generator output) (units 6 and 7). Acting as a sub-contractor to HAS, Hitachi, Ltd.'s role included civil engineering, removal of existing plant, refurbishment of reused existing plant, rehabilitation work, supply and installation of new equipment (including heat recovery steam generators), and commissioning.


Overview of stage II repowering project for Senoko Power Station of Senoko Energy Pte Ltd.

This was the first overseas repowering project to be undertaken by Hitachi in the form of an engineering, procurement and construction (EPC) contract covering removal and rehabilitation of existing plant and refurbishment. The project was completed successfully thanks to careful process planning and coordination that paid close attention to integration with existing customer equipment and handling of reused plant.

The main specifications are as follows.

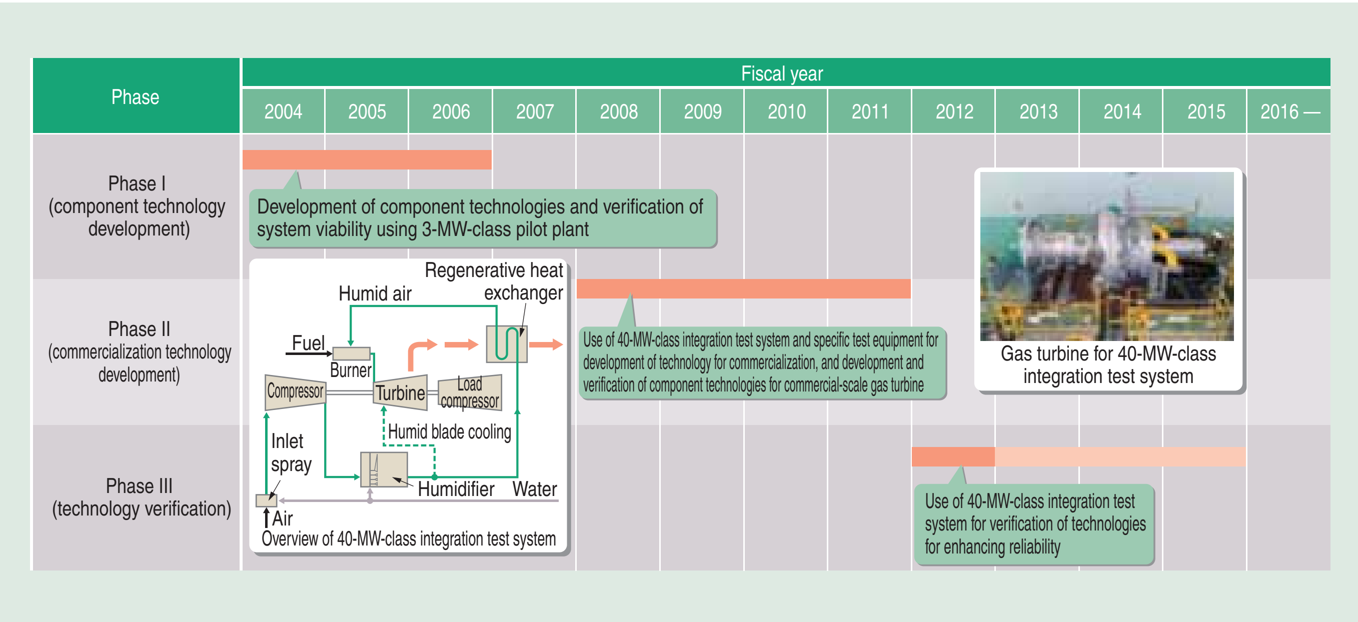
Generator output: 431,000 kW (at an ambient temperature of 32°C) (gas turbine: 279,000 kW×1, steam turbine: 152,000 kW×1)
Steam: 12.5 MPa-550°C/550°C
Gas turbine: M701F4 (supplied by Mitsubishi Heavy Industries, Ltd.)
Steam turbine: TCDF-26
Heat recovery steam generator: heat recovery, triple-pressure, naturally circulated, horizontal boiler

Completion of the Development Phase II of AHAT, New Gas Turbine Generation System

The advanced humid air turbine (AHAT) has attracted attention as a small to mid-range (up to 200-MW class) gas turbine with high efficiency and excellent operating characteristics. In work sponsored by the Ministry of Economy, Trade and Industry, Hitachi is collaborating with the Central Research Institute of Electric Power Industry and Sumitomo Precision Products Co., Ltd. on technology development aimed at commercializing the AHAT.

Phase I, which ran for three years commencing in 2004, involved the development of component technologies and verifying the viability of the system using a 3-MW-class pilot plant. Phase II, which ran for four years from 2008, included the development of 40-MW-class equipment for testing specific technologies required for commercialization as well as testing the interoperation of the heavy-duty gas turbine, inlet spray cooling, humidifier, and regenerative heat exchanger under conditions of high pressure and humidity.

Phase III (technology verification) has now commenced and is scheduled to run for four years from 2012. With the aim of bringing the technology into practical use in the near future, Phase III will include the development of technologies for enhancing reliability and for scaling up in preparation for a demonstration plant, and the use of test equipment to verify data so that the results can be incorporated into the demonstration plant.



Technology development process for AHAT commercialization

Construction of SCR Catalyst Works in China

SCR catalyst plant in China

As environmental regulations have been tightened, demand has increased in China for selective catalytic reduction (SCR) catalysts to minimize nitrogen oxide (NO*x*) emissions from power plants. Babcock-Hitachi K.K. and Hitachi (China) Ltd. jointly established Babcock-Hitachi (Hangzhou) Environmental Equipment Co., Ltd. to manufacture SCR catalysts. Production commenced in June 2012.

The features of the SCR catalyst manufactured by the new company include a plate type that resists plugging with the dust contained in flue gas. It is also recognized for its low pressure loss, high erosion resistance, long-life, and high activity with respect to NO*x*. Through the active involvement of the company in the market, Hitachi intends to continue contributing to environmental protection in China.

Commencement of Commercial Operation of 525-MVA/464-MW Unit 2 Motor-generator at Kannagawa Hydroelectric Power Station of Tokyo Electric Power Co., Inc.

The 525-MVA/464-MW Unit 2 motor-generator supplied to the Kannagawa Hydroelectric Power Station of Tokyo Electric Power Co., Inc. commenced commercial operation in June 2012 (after on-site work was shortened by approximately one month). This was the first motor-generator to be released by Hitachi Mitsubishi Hydro Corporation since its formation in October 2011.

The new unit has the same specifications as the Unit 1 motor-generator (supplied by Hitachi, Ltd.) that commenced operation in 2005, making it one of the world's largest in terms of individual motor-generator capacity. Motor-generators for pumped storage power generation have the potential to help maintain a stable supply of electric power by acting as power storage devices, first storing energy by operating as a motor to pump water uphill, and then operating as a generator to supply electric power to the grid during times of high demand.


Unit 2 motor-generator at Kannagawa Hydroelectric Power Station of Tokyo Electric Power Co., Inc. (operating in pumped storage mode)

Prior to commencing commercial operation, the two motor-generators, which are among the largest in the world, underwent combination tests (simultaneous emergency stop of both units*1 and a synchronized startup*2 test) to confirm that they delivered the required performance.
(Hitachi Mitsubishi Hydro Corporation)

*1 Simultaneous emergency stops (load rejection) were triggered on both motor-generators while operating at full load to confirm that they shut down safely.
*2 A method for starting pumped storage operation by increasing speed from zero up to rated speed in which one unit acts as a generator and drives the other unit (unit being started in pumping mode) via an electrical connection between the two.

Water-lubricated Resin Bearing with Low Impact on Environment

Hitachi has developed a water-lubricated resin bearing that is used to replace oil-lubricated white metal bearings in hydraulic turbines. Since their initial use in a Kaplan turbine in March 2006, the new bearings have been used in a total of 13 turbines across nine hydro power plants. These installations include both Kaplan and vertical-shaft Francis turbines. Previous water-lubricated resin bearings have been static-pressure bearings that required a feed pump for supplying pressurized water. The new bearing is a dynamic-pressure bearing that does not require a feed pump and only requires the replenishment of water lost by evaporation.

(1) Specifications
- Polyphenylene sulfide (PPS) resin
- Bearing peripheral speed: 5 m/s or more
- Bearing pressure: 1.5 MPa or less

(2) Use of water lubrication means that any discharge into waterways is non-polluting, consisting of water only.
(3) The low viscosity of water compared to oil minimizes bearing loss.
(4) The low absorption of water by the PPS resin minimizes variation in the gap between the bearing pads and shaft.
(5) No pump or other auxiliary equipment is required.
(Hitachi Mitsubishi Hydro Corporation)



Water-lubricated resin bearing in Kaplan turbine (left) and black PPS bearing pads (right)

Global Operations of Hitachi's Nuclear Power Business

While the environment for nuclear power generation has changed significantly around the world since the accident at the Fukushima Daiichi Nuclear Power Station of Tokyo Electric Power Co., Inc., many countries are continuing to look into nuclear power or proceed with new projects driven by considerations such as global environmental problems and energy security.

Based around its alliance with General Electric Company (GE), Hitachi is working with partners (including collaboration with utility companies that have skills in operation and maintenance, construction companies familiar with conditions in their respective countries, and financial partners) to establish the capability to provide services over the entire life cycle of nuclear power plants, including licensing, design, fabrication, procurement, construction, operation, and maintenance.

In the UK, the government has stuck to its nuclear strategy even after the accident at Fukushima Daiichi Nuclear Power Station, recognizing nuclear power as a low-carbon source of electric power and proceeding with the establishment of a "Feed-in Tariff with Contract for Difference" scheme as part of its electricity market reforms. In November 2012, Hitachi purchased all issued shares in Horizon Nuclear Power Limited, a nuclear power business development company in the UK, and has plans to build two or three advanced boiling water reactor (ABWR) plants at each of Horizon's two sites (at Wylfa and Oldbury). The 1,300-MW-class plants will include enhanced safety features that incorporate the lessons from Fukushima, and the first reactors are expected to commence operation in the first half of the 2020s. To this end, Hitachi has commenced preliminary engineering work, and has already started the Generic Design Assessment process, having signed a contract for this purpose in April 2013 with the Office for Nuclear Regulation and the Environment Agency.

In July 2011, Hitachi was selected as a strategic investor in the Visaginas Nuclear Power Plant Project in the Republic of Lithuania, giving it preferred bidder status in the negotiations for a formal contract. In March 2012, the concession agreement was agreed between the Lithuanian government and Hitachi. In January 2013, the Lithuanian Government established a Governmental Working Group (GWG) to prepare a comprehensive energy strategy, including a statement of its position on the Visaginas Project. In April, the government accepted the GWG's report, which stated that the Visaginas Project would be continued subject to several conditions. Meanwhile, Hitachi is holding ongoing discussions with Visagino Atomine Elektrine (VAE) and regional partners on how best to proceed with the project.

Hitachi has also been actively promoting its ABWR design technologies in the Socialist Republic of Viet Nam following an agreement in October 2010 between the Vietnamese and Japanese governments on the construction of the Ninh Thuan 2 Nuclear Power Plant. A series of seminars on reactor designs jointly sponsored by Japan's Ministry of Economy, Trade and Industry and the Vietnamese Ministry of Industry and Trade got underway in March 2013 with a seminar on the ABWR. In collaboration with other companies, Hitachi plans to continue to contribute to Vietnam through further promotional work based around its technologies and accumulated experience. This will include emphasizing the safety, advanced design, and proven performance of the ABWR, including measures adopted in response to Fukushima, with the aim of having this design selected for the new plant.

This article has reviewed three recent projects. Based around its alliance with GE, Hitachi plans to work with a range of partners to provide the best possible solutions for the construction of new nuclear power plants in countries around the world.
(Hitachi-GE Nuclear Energy, Ltd.)

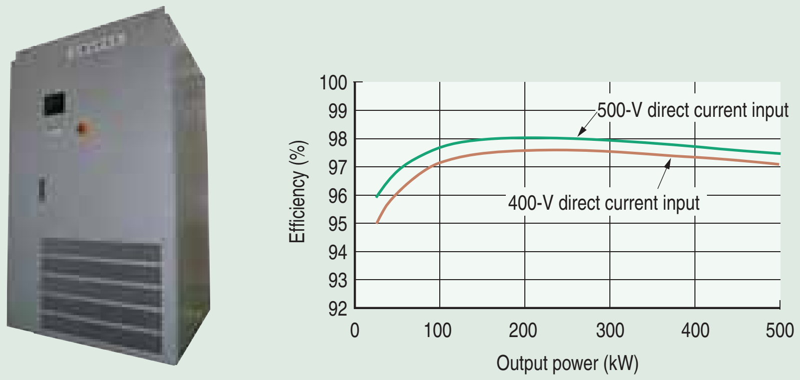
Acquisition of Horizon (November 2011) (upper), impression of completed Visaginas Nuclear Power Plant (lower left), and impression of completed Ninh Thuan 2 Nuclear Power Plant (lower right)

Highly Efficient, Three-level PCS for Photovoltaic Power Generation

Hitachi has commenced deliveries of a highly efficient, three-level, 500-kW power conditioning system (PCS) for photovoltaic power generation systems.

Photovoltaic power generation only operates at its rated output for a certain period during the day, with a lower output at other times. Accordingly, the PCS needs to maintain a high conversion efficiency even during times of low output. Use of a three-level converter circuit and the optimized design of the filter circuit allow this PCS to achieve a conversion efficiency of 97% over a wide range (100 to 500 kW) (PCS efficiency for a 500-V direct current input and 200-kW alternating current output is 98%). This PCS is also equipped with standard grid stabilization functions for suppressing voltage fluctuations and fault ride through. Hitachi has also improved the ease-of-production of the three-level PCS by adopting a standard unit-based design, building a cell-based production line, and upgrading inspection equipment.

Significant increases in demand are anticipated in the future due to the introduction in Japan of a feed in tariff scheme for renewable energy in July 2012.



525-kVA/500-kW PCS
(1,200 mm wide × 1,000 mm deep × 1,900 mm high)

Three-level PCS unit and efficiency characteristics (example of measured values)

Power Converter for 2-MW Doubly-fed Wind Turbine Generator

Hitachi entered the Chinese market for wind power converters in 2008. Products already released include a power converter for 1.5-MW doubly-fed wind turbine generator and 2-MW permanent magnet wind turbine generator.

Along with these products, Hitachi has now developed a power converter for 2-MW doubly-fed wind turbine generator in response to the demand from the Chinese market for higher capacity.

The main features are as follows.

(1) 18% increase in power density (compared to Hitachi's power converter for 1.5-MW doubly-fed wind turbine generator)

(2) Suitable for wind farm with extreme fluctuation in wind speed and frequent interruptions to operation

(3) Able to continue operating through short-duration rises in grid voltage (rated voltage × 130%, 0.1 s)

(4) Able to continue operating through short-duration variations in grid frequency [50-Hz rated frequency ±10 Hz (0.5 s for +10 Hz, 0.2 s for −10 Hz)]

(5) Able to output reactive power while operating as standalone converter connected to grid

(6) 2,325 mm wide × 640 mm deep × 2,340 mm high (excluding protruding parts), mass: 2,000 kg

As for the 1.5-MW secondary-excited wind power converter, the new converter will undergo low voltage ride-through (LVRT) certification testing with the aim of having it widely adopted in the renewable energy field.

Power converter for 2-MW doubly-fed wind turbine generator

Megasolar System

The 21st century has seen an acceleration of various moves aimed at preventing global warming, with the expectation that use of renewable energy sources that do not emit carbon dioxide (CO_2) will form a major part of these initiatives. Hitachi has been involved in the development of large power conditioning systems (PCSs) for major photovoltaic power plants from an early stage, and has built up considerable experience and success in this field, including taking responsibility for all aspects of megasolar power plants (plants with capacities in excess of 10 MW) from design through to construction.

Plans for large photovoltaic power plants have grown since Japan introduced a feed in tariff scheme in July 2012, with increasing participation in the power generation business by companies from outside the industry. Against this background, not only are large megasolar power plants in the 100-MW class being planned, but there is also a trend toward plans for relatively compact plants in the 1- to 2-MW range.

Based on its experience as a systems integrator, Hitachi has started marketing megasolar kits that package together the key components. Photovoltaic power systems are characterized by long periods operating under partial load, and the photovoltaic power generation equipment provided by these kits includes a new PCS featuring significantly improved conversion efficiency at low loads and an amorphous transformer with low losses under no load. This configuration can increase the amount of power generated from photovoltaic power systems.

New PCS (left) and amorphous transformer (right)

Nagano Region Integrated Stability Control System for Chubu Electric Power Co., Inc.

Hitachi has supplied an advanced special protection system for Chubu Electric Power Co., Inc. (CEPCO). The system, called the Integrated Stability Control (ISC) system, maintains power network stability to prevent wide area black-outs. Since 1995, Hitachi has been supplying centralized protection systems that prevent transient instability even if severe faults occur on the power network. Hitachi has enhanced this system and developed the ISC with 10 analysis engines to handle both voltage and transient stability issues because it was assumed that a newly planned power plant located very far away from demand areas would cause new instability problems.

The main features of the ISC are:

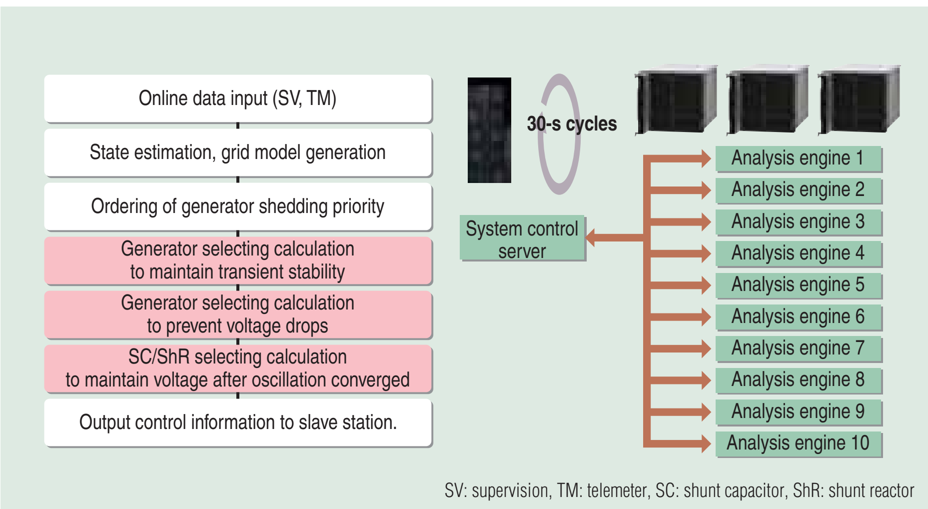
(1) The ISC executes stability analysis against contingency cases and generates countermeasures every 30 seconds.

(2) 10 reliable high-speed blade servers are used as analysis engines.

(3) When a real fault occurs, the ISC identifies the corresponding contingency case and controls the appropriate power system equipment based on the generated countermeasures.

The ISC enables CEPCO to deliver power from the new power plant stably without new power transmission lines.

(Commencement of operation: May 2012)

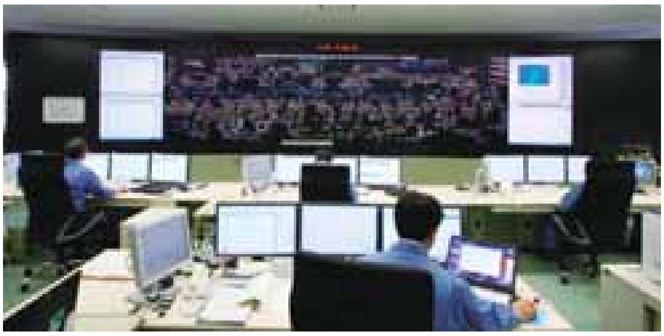


Processing flow and system configuration of central processing unit of Chubu Electric Power Co., Inc.'s integrated stability control system for the Nagano region

New EMS/SCADA System for Niigata Regional Load Dispatching Center

The new control center system [energy management system/supervisory control and data acquisition (EMS/SCADA)] for the Niigata Regional Load Dispatching Center of Tohoku Electric Power Co., Inc. has been developed. This system supervises high- and medium-voltage transmission network of the Niigata area and supports load dispatching instruction operation.

This system has the following features in addition to general EMS/SCADA functions.



Niigata Regional Load Dispatching Center system for Tohoku Electric Power Co., Inc.

(1) Fault detection

A network fault and its location can be identified from circuit breaker tripping information and protection relay operation information derived from substations.

(2) Switching order generation

Switching plan with operation steps can be generated and executed.

(3) Network security assessment

Risks for the current network condition are periodically evaluated by the contingency analysis.

(4) Information management

Network operation results such as online data, alarm/event messages and diagrams are stored into relational database management system (RDBMS). This function provides an interface to personal computer (PC)-based office application software that allows for quick and easy analysis of the network operation.

Hitachi's advanced blade server was selected for its high reliability, long-term maintenance, energy-efficiency and space-saving.

It is anticipated that the new system will contribute to further efficiency gains and more advanced operation.

(This system was put in commercial operation in January 2013)

Communication Network for Protection Relay Systems that Support Realtime Process Bus

The role of protection relay systems is to maintain the continuity of the power supply by identifying and isolating faulty sections of the power system promptly when a lightning strike or other grid fault occurs. Accordingly, these systems require a communication network that can support the bidirectional transmission of large amounts of information and ensure that the data handled by the system is kept synchronized.

Hitachi has now developed a new range of power system protection with versatile process-level communication suitable for mission critical protection applications. This is the first commercial product of its type to use this technology in Japan. The new network not only retains the flexibility and scalability of previous systems, it can also be used to build wide-area, distributed protection relay systems for smart grids that connect large quantities of photovoltaic or wind power generation capacity.

Protection relays that support the realtime process bus have the following features.

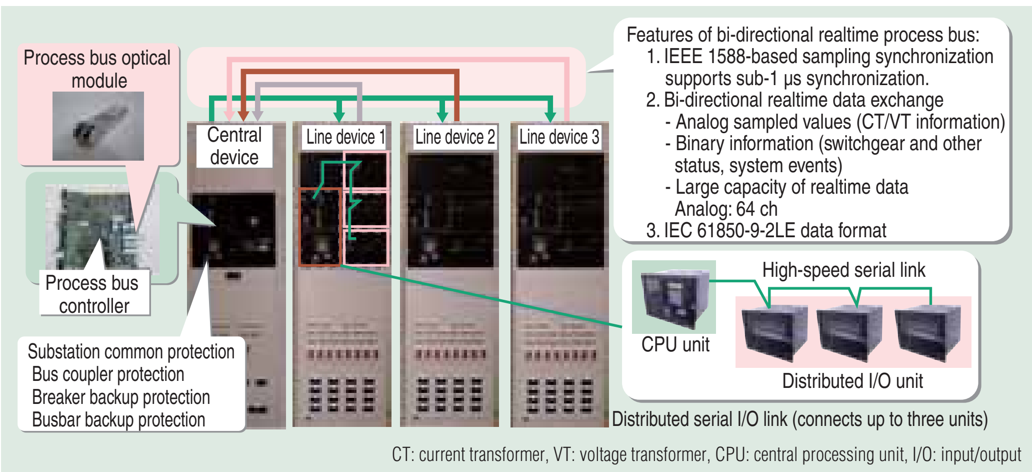
(1) Unit-based distributed functionality supports a wide range of different system configurations.

(2) Complex systems can be standardized as units to allow for future unit upgrades.

(3) Cabling requirements are minimized by using fiber optic communications to consolidate high-volume and high-speed signaling between units and other equipment.

(4) Support for integration of new protection systems that require high-volume data communications between substations.

In the future, Hitachi intends to expand its range of products that support the realtime process bus.



Digital protection relay using realtime process bus technology

Development and Future Plans for 1,100-kV/63-kA GCB for Chinese Market

Gas-insulated circuit breakers (GCBs) are an important category of substation equipment whose role is to disconnect fault currents. Globally, increasing demand for electric power is driving growing interest in ultra-high-voltage conversion techniques for use in long-distance and high-capacity transmission. China, for example, embarked on a 1,100-kV project in 2007.

To gain entry to this market, Hitachi developed a 1,100-kV GCB that it supplied to the Nanyang Substation, one of three substations in a pilot 1,100-kV alternating current (AC) transmission grid, which commenced commercial operation in December 2011. Based on an existing 1,100-kV GCB developed for use in Japan (in the 1990s), the new GCB incorporates the latest technology to optimize the insulation spacing, and is only about half the weight and volume of its predecessor. The design of the circuit breaker itself was also partially updated with the result that it is able to cope with cut-off currents of 63 kA, a very rigorous standard for this class of device.

1,100-kV grid supplied to Nanyang Substation was the first of its type in the world to enter commercial operation. In supplying the GCB, Hitachi was making a major contribution to the progress of this class of substation technology, and with China's 1,100-kV AC transmission grid scheduled for future expansion, the supply of further units is anticipated.

1,100-kV/63-kA GCB supplied to Nanyang Substation in China

High-power Testing Facility with State-of-the-art Equipment

A major upgrade to the high-power test equipment at Hitachi's high voltage & high power testing laboratory was undertaken in FY2011, and the facility has been using its new state-of-the-art equipment to perform breaking and other high-power tests since May 2012. In particular, the all-weather voltage source has been upgraded in order to conduct synthetic breaking tests of high-voltage circuit breakers. The equipment includes a main capacitor bank with a rated voltage of 1,200 kV and total capacitance of 8.3 μF, and a capacitor bank for adjusting the transient recovery voltage with a rated voltage of 1,650 kV and total capacitance of 1.64 μF. These are used for testing of circuit breakers and switchgears from medium-voltage to ultra-high-voltage class transmission systems. In addition to utilizing the latest technologies for high reliability in the design and manufacture of each unit to ensure that it suited its intended purpose, Hitachi also took note of the relevant standards such as JEAG5003 and IEEE 693 for seismic capacity to ensure that the equipment would be capable of withstanding a 0.5-G resonant vibration in the event of an earthquake.

High-power testing facility

The testing laboratory is certified under the ISO/IEC 17025 standard. It is also a member of the Japan Short-Circuit Testing Committee (JSTC), which in turn is a full member of the Short-Circuit Testing Liaison (STL). This means the facility can provide its customers with an independent and objective testing service for certifying compliance with circuit breaker and other related standards set by standards bodies such as the International Electrotechnical Commission (IEC). The facility is also able to issue certificates for type tests.

Development of Transformer for Floating Offshore Wind Farms

The Agency for Natural Resources and Energy of the Ministry of Economy, Trade and Industry is conducting experimental research into floating offshore wind farms, and Hitachi has developed a 66-kV/25-MVA transformer for use in prototype systems that is the first in the world to be designed to cope with the pitch and roll of a floating structure. Hitachi was assigned the task of producing the transformer based on the expertise in the manufacture of environmentally compatible and fire-resistant silicone-oil-filled transformers that Hitachi has built up over time. The equipment for the floating offshore power plant was completed at the end of March 2013, followed by delivery and on-site installation with a target of commencing operation in September 2013.

Use of floating offshore wind farms is appropriate for Japan's ocean floor topography that offers few offshore sites with shallow water. To ensure that equipment will maintain performance despite the pitching and rolling that occurs in a floating structure, Hitachi verified performance under these conditions by conducting the following testing that simulated the pitch and roll of an actual floating system.

(1) Transformer tilting test: Tests reliability when the transformer is tilted at an angle

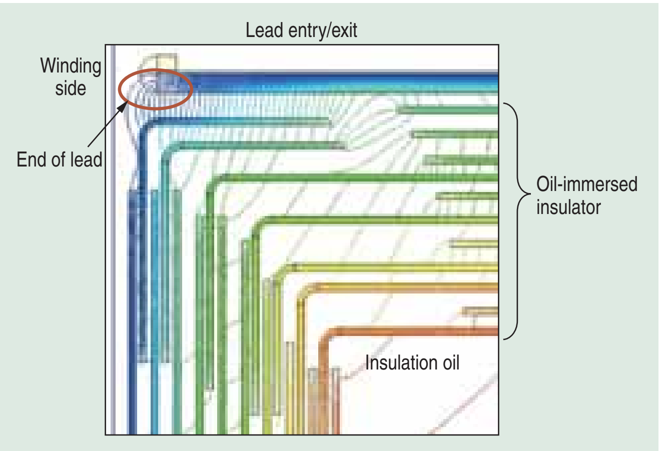
(2) Vibration testing of key components: Vibration durability testing in accordance with the JIS F8006:1979 standard ("general requirements for vibration test of electrical apparatus for marine use")

It is anticipated that the technologies developed and established through the manufacture of this transformer will be increasingly applied in floating offshore substations around the world in the future.

Transformer tilting test

Reliability Assurance for DC Isolation Transformers

Hitachi has undertaken direct current (DC) electric field analyses of the oil-paper insulation in transformers under steady state conditions and also under transient conditions that consider how the distribution of potential varies with time. This is intended for use in insulation design to ensure the reliability of the increasingly high-voltage equipment to which DC voltages are applied, including converter transformers, DC reactors, and other equipment used in DC power transmission.



Results of anisotropic, non-linear DC electric field analysis of the regions where the transformer winding leads enter and exit

Conductivity influences the distribution of potential, and under a DC electric field, the behavior of this conductivity is non-linear due to the field's influence. Similarly, the conductivity of laminated, oil-immersed insulating material is anisotropic due to the effect of material orientation (the conductivities in the cross and through directions are different). Accordingly, it is necessary to calculate the behavior of this anisotropic, non-linear DC electric field. Also, the distribution of potential is obtained by considering the charge distribution due to the imbalance in current flow inside the insulating material resulting from connection of the DC voltage under transient conditions.

In addition to performing an anisotropic, non-linear DC electric field analysis under steady state conditions of the regions where the transformer winding leads enter and exit, a transient field analysis was also performed to assess the cross-direction insulation of the oil-immersed paper for the end regions of the oil-immersed insulating material.

These analyses succeeded in obtaining a detailed assessment of the electric field in the oil-paper insulating material. In the future, Hitachi intends to perform insulation design with high reliability, including for equipment operating at even higher DC voltages.