Energy Solutions

1 Hitachi's Energy Solutions

The circumstances under which energy infrastructure operates are becoming more diverse at the national, regional, and environmental level.

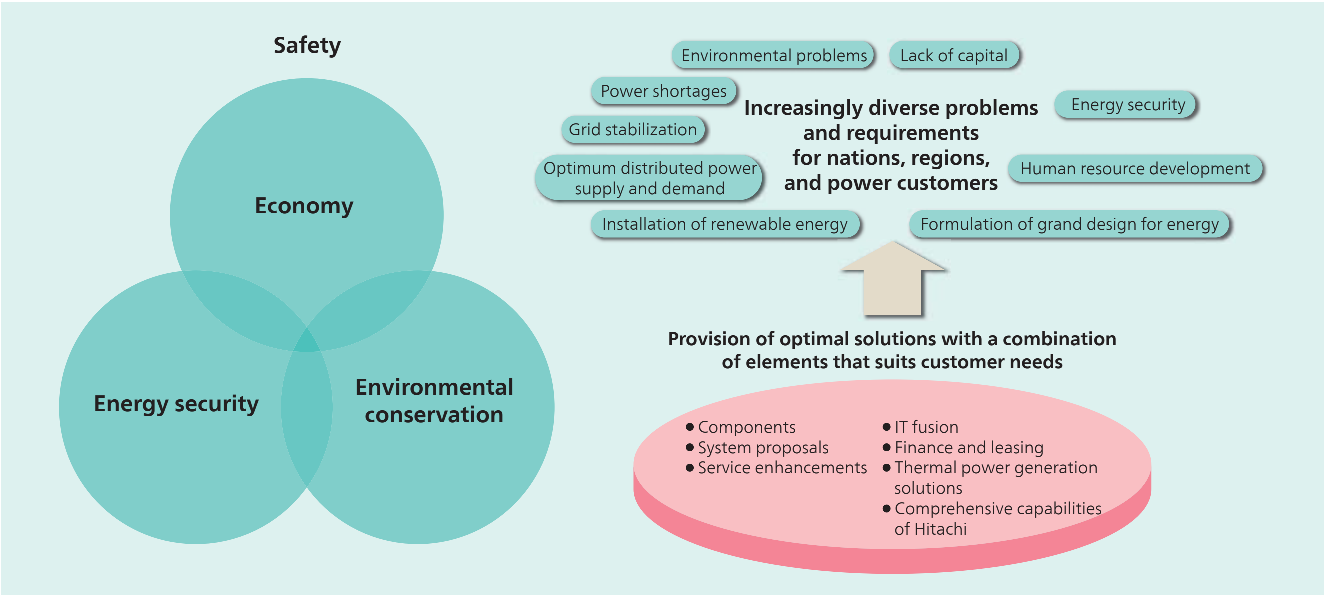
The major centers of demand for energy infrastructure are shifting from developed to emerging economies. Although growth in demand is anticipated, few emerging economies have established a grand design for their energy policies, and financial frameworks in many cases are weak. This means that proposals need to include financing. Furthermore, energy policies need to be formulated on a comprehensive basis, encompassing not only economics but also safety assurance and the environment. It is also essential to consider consistency with these energy policies when offering to supply infrastructure in the form of a solution. There is often more than one way of implementing energy policy, with a number of different solutions possible depending on which factors are prioritized. As it is anticipated that emerging economies will experience ongoing urbanization and the concentration of population, there is a need for efficient (smarter) operation of the energy infrastructure. In developed economies, meanwhile, there is a shift away from coal and toward gas turbine combined cycle (GTCC) and renewable energy in response to the shale gas revolution and growing interest in environmental protection. Also ongoing is a reorganization of power systems to achieve separation between generators and transmission businesses.

What is needed, then, is to look at power systems in terms of the "3Es + S," meaning not only economics but also energy security and environmental conservation (3Es), and also safety (S), the prerequisite for achieving these. In particular, an important aspect of achieving energy security is the establishment of an appropriate energy mix that does not rely on a single source of energy. Key aspects of improving environmental conservation, meanwhile, include compliance with restrictions on the emission of the carbon dioxide (CO_2) implicated in global warming, and the installation of renewable energy sources such as photovoltaic or wind power generation.

To resolve these complex issues that are closely tied up with increasingly diverse social needs, it is necessary to collaborate on identifying the issues faced by customers and other parts of society and to offer order-made solutions.

It is these needs that the energy solutions supplied by the Power Systems Company of Hitachi, Ltd. are intended to satisfy. In addition to enhancing components, systems, and services sourced from both inside and outside Hitachi, fusing these with information technology (IT), and offering leasing or other financing arrangements, Hitachi intends to propose comprehensive solutions that include the thermal power systems supplied by the new company formed through a business integration with Mitsubishi Heavy Industries, Ltd. that commenced operation in 2014.

Hitachi intends to accelerate its activities as a solution provider based around its comprehensive capabilities (which include IT, logistics, and finance) working flexibly in tandem with interested parties from outside the company, and by establishing dedicated teams to survey the problems faced by society and the wants and needs of customers, to plan and devise solutions, and to coordinate the providers of the different components.



1 Overview of "3E +S" (left) and energy solutions (right)

Power Generation Equipment and Systems

1 New Technology for Taking Maximum Advantage of Hydro Energy

Hitachi supplied the turbines (used to drive generators supplied from the UK) at the Bhakra Power Station in India that commenced operation in 1959. In January 2008, a new order was received for the large-scale refurbishment of the five Francis turbines, which by then were nearly 50 years old.

The overhaul of the first turbine (Unit 2) commenced in April 2010. Due to cumulative delays at the site, the turbine did not resume operation until July 2013, followed by a second turbine (Unit 5) in October 2013. The refurbished turbines are currently in full commercial operation. Refurbishment is also planned for the remaining turbines, with work on a third (Unit 4) already underway on site.

By updating the runners, which were produced for the refurbishment using optimal design and have a forward-swept blade configuration (in which the shroud end of the inlet side of the blade is forward of the crown end relative to the direction of rotation), and the guide vanes, Hitachi succeeded in significantly increasing turbine efficiency. Similarly, increasing the output of individual turbines by 16.6 MW, and total output by 83 MW, is expected to make a major contribution to the tight electric power supply situation in India. Also, whereas the old runners had been periodically repaired to fix cavitation damage, the significant improvement in cavitation bubble formation characteristics in the relevant locations means that the upgraded runners will have a longer operating life with less frequent repairs.

The specifications of the refurbished turbines are as follows.

Effective head: 134 m (normal)
Turbine output: 128 MW (max.)
Speed: 166.7 min^{-1} (rated)
(Hitachi Mitsubishi Hydro Corporation)

2 Latest Switchboard Upgrade Technology for Hydro Power Plants

Hitachi has developed the G-HIACS* and deployed it in plant upgrades such as the unit 1 automatic control system of the Numappara Power Plant of Electric Power Development Co., Ltd. and the supervisory control system of the Shin-Nariwagawa Power Station of The Chugoku Electric Power Co., Inc. After commencing on-site installation in October 2013, these projects have now completed commissioning and are in operation.

Compared to the previous HIACS* series, G-HIACS features enhancements to maintenance tools in particular. Its main features are as follows.

(1) Enhanced ability to analyze what is happening when faults occur in sequence operation due to an upgrade to the trend monitor to support recording of approximately 100 data points at the computational cycle time (100 ms), compared to 48 points at 1-s intervals previously.

(2) Enhanced quality through logic debugging and easier simulation of key equipment and control devices thanks to the addition

1 128-MW Francis turbine for Bhakra Power Station in India

2 Unit 1 automatic control system of the Numappara Power Plant of Electric Power Development Co., Ltd.

to logic simulator mode of a function for specifying the changes in analog signals and a one-shot function for digital signals.

The ND series of unit-type protection relays were used to upgrade the protection systems for the Unit 4 motor-generator at the Shin-Nariwagawa Power Station of The Chugoku Electric Power Co., Inc. These comply with the B-402 electric power standard and IEC 60255 international standard, with features that include the ability to enable or disable the relay elements, select wide-band frequency characteristics, and customize the protection interlock circuit.

(Hitachi Mitsubishi Hydro Corporation)

* HIACS and G-HIACS are trademarks of Hitachi, Ltd.

3 Characteristics Improvement through Use of CFD in Runner Upgrade

Hitachi Mitsubishi Hydro Corporation used computational fluid dynamics (CFD) analysis to develop a turbine runner that features improved efficiency and reduced wear due to sediment abrasion for the 23,300-kW Francis turbine at Unit 1 of the Himekawa No. 7 Power Station of The Tokyo Electric Generation Co., Inc. The plant commenced operation with the upgraded runner in March 2012. The upgrade used a runner that was developed using a shape design technique involving the use of a solid-liquid two-phase flow analysis that modeled the flow of sediment to assess those intricate parts of a runner that are difficult to protect from sediment abrasion using surface treatments such as thermal spraying. An inspection conducted after nine months of use in December 2012 found no sediment abrasion. The upgraded runner is scheduled to be installed on Unit 2 in February 2014.

The 35,000-kW Francis turbine at the Shin-Inotani Power Station of the Hokuriku Electric Power Company commenced in May 2013 after a runner upgrade to improve cavitation characteristics was undertaken using CFD analysis. The turbine uses a runner with forward-swept blades in which the blade shape twists three-dimensionally and has a shape that prevents the formation of the localized pressure drops associated with cavitation. Use of this runner shape has resulted in stable operation.

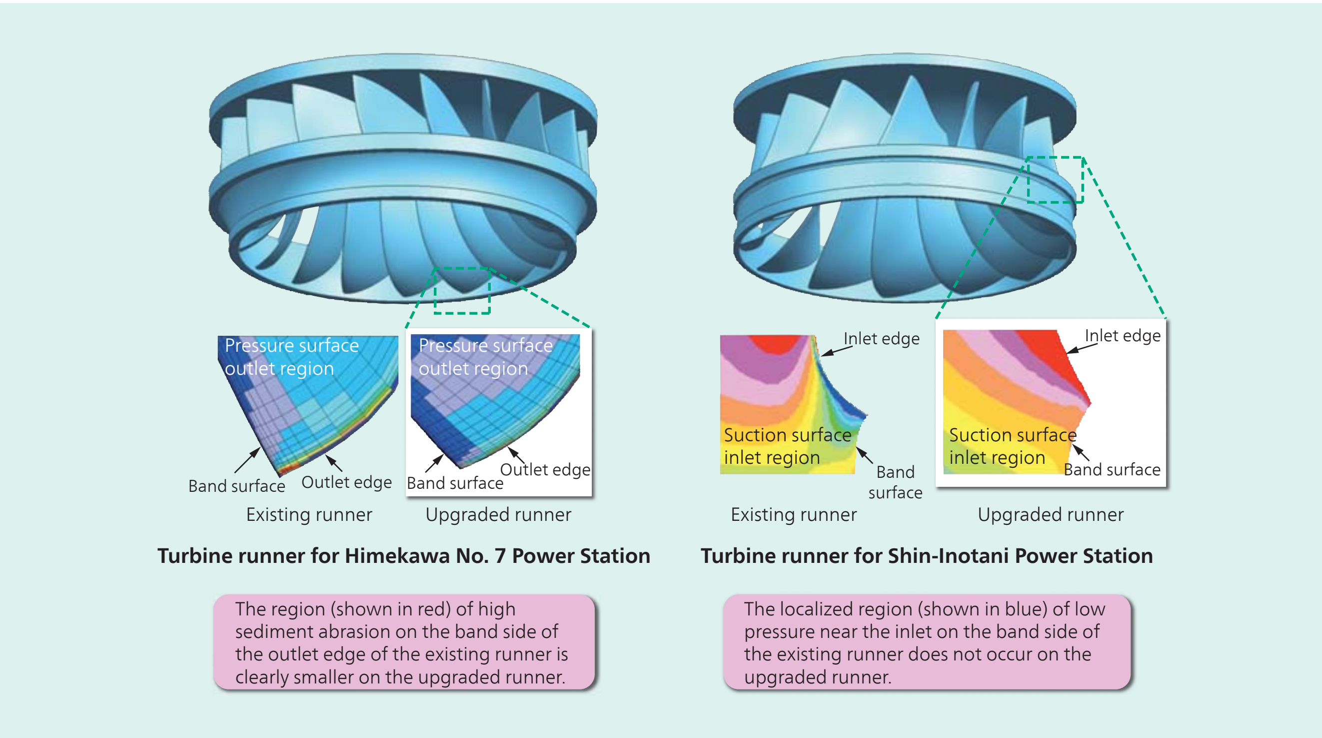
(Hitachi Mitsubishi Hydro Corporation)

4 Orders for Emergency Repair of Jebba Hydro Power Plant in Nigeria and Rehabilitation of Baluchaung No. 2 Hydro Power Plant in Myanmar

Although the Jebba Hydro Power Plant in the Federal Republic of Nigeria plays an important role, accounting for approximately 15% of the nation's generation capacity, it is currently operating at about half-capacity due to damage to the No. 4 generator incurred after an accident on the power grid in 2009. In December 2012, Hitachi Mitsubishi Hydro Corporation tendered for the emergency repair of the plant and was awarded a contract for the project based on its proposal to refurbish the plant's existing Hitachi, Ltd. equipment. The on-site refurbishment work is planned to take a minimum of eight months, from March to October 2014.

The Baluchaung No. 2 Hydro Power Plant in Republic of the Union of Myanmar accounts for approximately 10% of the nation's generation capacity, and thanks to its abundant water resources, operates as a reliable year-round, base-load generator. However, progressive aging and deterioration of the plant's equipment due to continuous operation since it entered service in 1960 means there is a need to repair and replace the equipment in the near future. Tendering for the rehabilitation project took place in June 2013, with Hitachi Mitsubishi Hydro Corporation being awarded the contract based on its proposal to refurbish the plant's existing Hitachi equipment. The plan is to perform on-site repairs and replaces to a total of six units from July 2014 to March 2016.

(Hitachi Mitsubishi Hydro Corporation)



3 Upgraded runner shape and improvements made through use of CFD

4 Interiors of the Jebba Hydro Power Plant in Nigeria (top) and the Baluchaung No. 2 Hydro Power Plant in Myanmar (bottom)

5 Sub-drain Water Purification System

There are three levels of contaminated water at the Fukushima Daiichi Nuclear Power Station; highly contaminated water in reactor buildings and turbine buildings, concentrated brine discharged from reverse osmosis (RO) desalination systems, and relatively low contaminated water that has been collected from sub-drains located around buildings. This water has various levels of contamination, and contains a variety of radioactive nuclides that include cesium (Cs-134 and Cs-137), strontium (Sr-89 and Sr-90), and antimony (Sb-125). To respond to this difficult situation, Hitachi-GE Nuclear Energy has developed a contaminated water treatment system specifically for treating sub-drain water.

The main features of the system are as follows.

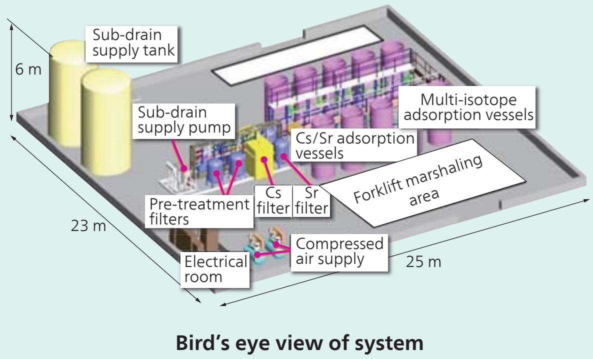
(1) Pre-treatment filters including not only conventional filters but also filters that can remove colloids

(2) Hitachi-GE Nuclear Energy's newly developed superior adsorbent to simultaneously remove Cs and Sr

(3) A flexible system with a sophisticated modular design to allow a combination of optimum adsorbents from all over the world when multi-nuclide removal is required

The new system will reduce the concentration of radioactive nuclides in sub-drain water to below discharge limits. By installing the system at the Fukushima Daiichi Nuclear Power Station, Hitachi is making a continuing contribution to the treatment of contaminated water.

(Hitachi-GE Nuclear Energy, Ltd.)



Features

- Daily treatment capacity of 1,200 m^3 (100% × two systems for high reliability)
- Compact system configuration covering area of 23 m × 25 m (planning stage)
- Adsorption vessels can be replaced using forklifts (does not require installation of a crane).
- Flexible configuration and quick site installation by modular design
- System produces its own compressed air.

5 Sub-drain water purification system

6 Project for Construction of New Nuclear Power Plants in UK

Even after the accident at Fukushima Daiichi Nuclear Power Station, the UK government has stuck to its policy of encouraging nuclear power and is proceeding with the introduction of a feed-in tariff scheme to guarantee the purchase price of nuclear power because of its status as low-carbon energy source. The laws relating to this electricity market reform were introduced into parliament in November 2012 and are scheduled to become law during 2014.

In November 2012, Hitachi purchased all issued stock in the UK nuclear power development company, Horizon Nuclear Power Limited.

Horizon Nuclear Power plans to construct two or three 1,300-MW-class advanced boiling water reactors (ABWRs) at each of its two sites (at Wylfa and Oldbury), with the first reactor scheduled to commence generation in the first half of the 2020s. To this end, the UK's Office for Nuclear Regulation and the Environment Agency embarked on a Generic Design Assessment process in April 2013. Hitachi is also expediting its activities aimed at advancing construction plans at the Wylfa site, including a plant design prepared to UK specifications and the establishment of supply chain management.

By adding a nuclear power business to its existing railway business in the UK, Hitachi believes it can contribute to advances in social infrastructure in the country, including employment.

6 Artist's impression of completed Wylfa Newydd Power Station

7 Power Conditioner for Megasolar Power Plants

With sunlight recognized as a form of renewable energy, the number of large photovoltaic power generation systems with capacities greater than 1 MW is growing rapidly. To improve the efficiency and reduce the installation costs for photovoltaic power generation systems, an increasing number of these systems are adopting a direct current (DC) voltage of 1,000 V, the standard outside Japan, in place of the 600 V used in the past.

In response, Hitachi has added the 660-kW power conditioning system (PCS), which can work with DC voltages in the 1,000-V range, to its line-up of PCSs for megasolar power plants. The inverter in the 660-kW PCS uses a three-level conversion circuit with high reverse conversion efficiency. It has a maximum efficiency of 98.8% (at 520 V DC), and is able to maintain high efficiency (98% or more) over alternating current (AC) outputs of between 5% and 90% (at 620 V DC). It also incorporates grid stabilization functions as standard features, including functions for suppressing voltage fluctuations and for adjusting reactive power, including a function for maintaining constant power factor. An outdoor package that includes three 660-kW PCSs has also been added to the product range. The ability to configure a 2-MW-class power generation system using a single outdoor package helps reduce the space requirements and cost of installation.

As it is forecast that photovoltaic power generation systems will switch to 1,000-V DC operation in the future, growth in demand is anticipated.

(Product release date: November 2013)

8 3.0-MW DF Converter for Wind Power Generation

Hitachi has participated in the Chinese market for wind power converters since 2008. Its products for this market have consisted to date of 1.5-MW and 2.0-MW converters for doubly fed (DF) generators and a 2.0-MW converter for permanent magnet generators (PMGs). (The 1.5-MW DF converter commenced operation in October 2010, the 2.0-MW DF converter in July 2013, and the 2.0-MW PMG converter in December 2012).

The newly developed 3.0-MW water-cooled DF converter provides greater capacity than the 2.0-MW air-cooled model, and is a response to demand from the Chinese market for higher capacity wind power generators.

Its main features are as follows.

(1) Suitable for sites with sudden changes in wind and at which turbines are frequently taken in and out of service

(2) Able to continue operating through short-duration spikes in the grid voltage (130% of rated voltage for 0.1 s)

(3) Able to continue operating through short-duration fluctuations in the grid frequency [rated frequency (50 Hz)±10 Hz for 0.5 s (+10 Hz) or 0.2 s (−10 Hz)]

(4) An independently operating converter connected to the grid can output reactive power.

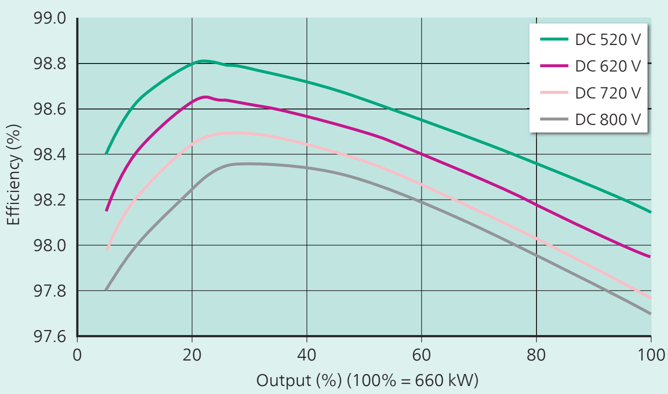
(5) 2,415 mm (W) × 600 mm (D) × 2,190 mm (H) (excluding protrusions), weight: 2,600 kg

(6) Capacity:volume ratio: 1.01 MW/m^3

(7) Water cooled: fully enclosed recirculated cooling

In the future, Hitachi intends to build its experience in the renewable energy sector by conducting verification tests of low-voltage ride through (LVRT), also available on the 1.5-MW and 2.0-MW DF models. Additional models are also planned along with deployment in Japan.

660-kW PCS
1,400 mm (W) × 1,000 mm (D) × 1,900 mm (H)



Example efficiency characteristics (typ.)

7 Power conditioner for megasolar

8 3.0-MW DF converter for wind power generation

9 Large 5-MW Offshore Wind Power Generation System

Demand for renewable energy has been on the rise in recent years, with growing interest in wind power as a source of domestic energy production in Japan. While most of the wind power generation systems currently operating in Japan are land-based, offshore sites typically have higher wind speeds and it is anticipated that they will become more common due to this and other advantages, including being less likely to cause difficulties due to noise or impact on scenery.

Compared to onshore sites, construction of offshore wind farms requires greater investment due to higher costs that include building foundations, installation, and laying undersea cables. Accordingly, using a smaller number of turbines with higher output is seen as a way of improving the profitability of wind farms, and this has led to demand for even larger wind power generation systems than systems in the 2-MW to 3-MW class that are large by the standards of onshore sites.

The 5-MW downwind turbine currently being developed for offshore use not only has a higher output than the previous 2-MW model, it also incorporates a medium-speed gear drive mechanism that combines permanent magnet synchronous generator with a speed-increasing gear with a ratio of approximately 1:40. The system will also help reduce wind farm construction costs thanks to a lighter and more compact nacelle that reduces the overturning moment of the downwind turbine and allows a more practical foundation design.

9 Large 5-MW offshore wind turbine

10 Megasolar System

Progress has been made in recent years on utilizing renewable forms of energy such as sunlight and wind. In Japan, a feed-in tariff scheme was introduced in 2012 following the passing of the "Act on Special Measures Concerning Procurement of Renewable Energy Sourced Electricity by Electric Utilities" in August 2011. This has led to a rapid expansion in plans for the installation of photovoltaic power generation systems and work is underway throughout Japan on the construction of large systems.

Hitachi has been involved in the development of high-capacity PCSs for large photovoltaic power plants and is anticipating the installation of several hundred megawatts of generation capacity, including a megasolar power plant at Ashikita that commenced operation at the end of 2013 and the 82-MW Oita Mega-solar Power Plant, Japan's largest class, which is scheduled to start generating power in the spring of 2014.

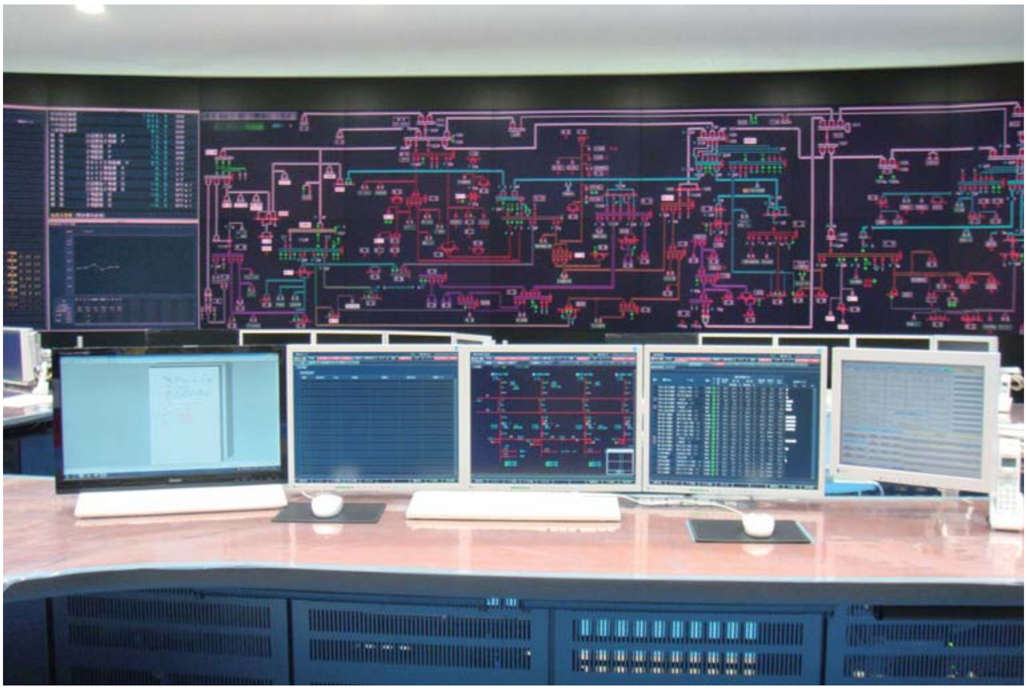
The Oita Mega-solar Power Plant being built in Oita City, Oita Prefecture to be operated by Oita Mega-solar Power Co., Ltd. will be the largest class such plant in Japan, with a 105-hectare site (1,050,000 m^2) and generation capacity of 82 MW. It is forecast to generate 87,000 MWh of electric power annually, enough for about 30,000 typical homes. If all of the solar panels in this very large system were laid in a line, they would stretch for approximately 500 km, roughly the distance from Tokyo to Osaka.

Meanwhile, vigorous efforts are being made to achieve further improvements in the efficiency of the PCS, a core component of photovoltaic power generation. In addition to the existing 500-kW model with a DC voltage of 600 V, Hitachi has also commenced sale of a 660-kW model that can operate at 1,000 V DC. This PCS uses a three-level inverter for a chopper-less design that delivers a world-leading level of conversion efficiency, with a maximum efficiency of 98.8%. Drawing on its past experience in engineering, procurement and construction (EPC), Hitachi is also enjoying strong sales for its package that bundles the main equipment needed for a medium-sized photovoltaic power generation system.

In the future, Hitachi intends to continue operating a broad-based photovoltaic power generation business that extends from medium to large systems, primarily in Japan, while also working aggressively to expand its business in overseas markets.

10 Power plant of SGET Ashikita Mega Solar LLC

Electric Power Transmission Equipment and Systems



1 Kumamoto Integrated Control Center of Kyushu Electric Power Co., Inc. (control room)

1 Kumamoto Integrated Control Center Kyushu Electric Power Co., Inc.

Kyushu Electric Power Co., Inc. is undertaking a full upgrade of its integrated control center systems, and is building the Kumamoto Integrated Control Center System under the supervision of Seiko Electric Co., Ltd. The upgrade will merge two existing integrated control centers, resulting in the new system being responsible for the monitoring and control of generation and substation facilities at approximately 200 sites. The system is currently undergoing final commissioning in preparation for commencing operation in April 2014.

The main features are as follows.

(1) Very high system reliability. The computer that underpins the online monitoring and control functions has a triply redundant configuration to allow for maintenance or faults, and the computer that handles operational support functions, such as issuing operating command sheets, has a doubly redundant configuration.

(2) A grid status panel that uses a projector-based display system and is designed to facilitate the effective sharing of information between the staff on duty. This includes grid information such as the constantly changing flow of electric power, and weather information such as thunderstorm warnings.

(3) Reduced workload for staff on duty. Functions include partial automation of grid reliability monitoring and the preparation of fault recovery procedures and operating orders.

2 Enhancements to Generator Protection Relay

In order to protect equipment by, for example, quickly disconnecting a generator from the grid and performing an emergency stop in the event of an internal electrical fault, the generator protection relays used in thermal, hydro, and other forms of power generation require high reliability and the selectivity to accurately detect the faults they are intended to catch. A new multi-function unit-type protection relay developed by Hitachi provides this selectivity and reliability as well as complying with the IEC 60255 international standard. It includes an English-language human interface and has the flexibility for use in a variety of different protection system applications.

The main features are as follows.

2 Unit-type protection relay

(1) Can be customized using engineering tools to perform protection, measurement, and control in ways that are specific to the application. This includes the ability to select the protection relay element and wide-band frequency characteristics, and to build protection sequence circuits.
(2) Designed for use with analysis tools that can perform measurement, oscillography, and event logging for the collection and analysis of grid data.
(3) Compact, swappable design in which the modules required for the protection relay are housed in a single unit case. It also features improved toughness, with temperature characteristics, electromagnetic compatibility (EMC), and seismic ratings that comply with the IEC 60255 international standard.

In the future, Hitachi intends to make the tools more efficient to use and extend the product range to expand the scope of applications.

3 Demonstration Smart Grid (Satsumasendai Area) Kyushu Electric Power Co., Inc.

Hitachi is conducting joint demonstrations with Kyushu Electric Power Co., Inc. on a demonstration smart grid built by the power company in Satsumasendai City, Kagoshima Prefecture, Japan that was completed in October 2013.

The demonstration smart grid includes photovoltaic power generation, lithium-ion batteries, a simulated power distribution system (simulated power lines, simulated loads, and voltage regulation equipment), and an energy management system that measures, monitors, and controls the output, voltages, currents, and other parameters of these systems. The total outputs of the photovoltaic power generation system and lithium-ion batteries are 278 kW and 118 kW respectively, and they provide both high-voltage and low-voltage grid connections.

The demonstration project involves using these systems to trial various ways of overcoming the supply and demand and voltage problems that are associated with the connection of large amounts of photovoltaic generation capacity. In the case of supply and demand, this consists of collecting data on parameters such as sunlight intensity and photovoltaic power generation, and battery charging, discharging, and state of charge, and using it to test methods for predicting the output of photovoltaic power generation and for optimizing control of the batteries. In the case of voltage, the project will test optimized voltage control methods by conducting experiments on the sort of voltage management problems that are likely to occur on future distribution systems, using the simulated load to generate fluctuations in the grid load, and then collecting and analyzing data on resulting power line voltages, currents, and other parameters.

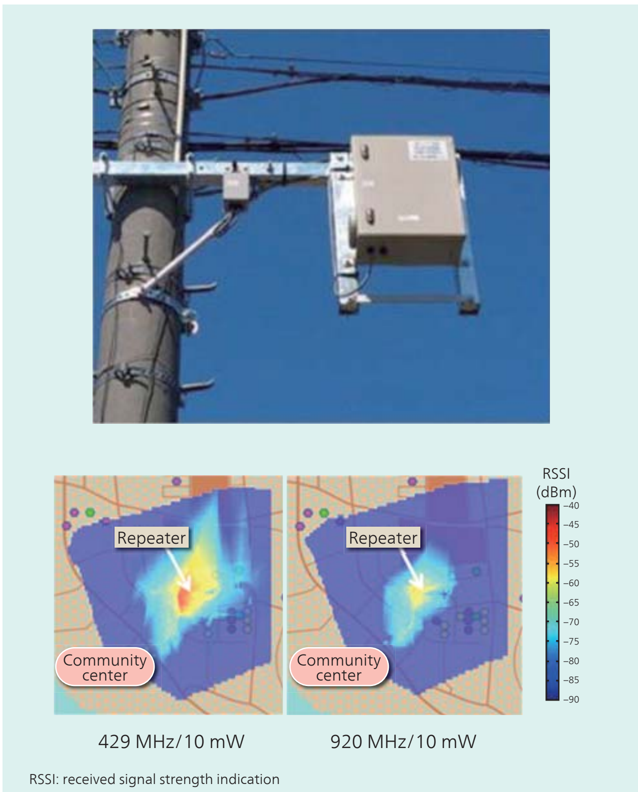
The demonstrations are scheduled to continue until March 2015.

3 Demonstration smart grid (Satsumasendai area) of Kyushu Electric Power Co., Inc.

4 Demonstration Project for Next-generation Output Control Using Two-way Communication

Since FY2011 Hitachi has been participating in the "Demonstration Projects for Next Generation Power Control Systems by Two-way Communications" funded by the Agency for Natural Resources and Energy of the Ministry of Economy, Trade and Industry, Japan. The objective of these demonstration projects is to investigate the stabilization of power grids that include extensive photovoltaic power generation. As part of this work, Hitachi is demonstrating the monitoring and control of a power conditioning system (PCS) at Rokkasho-mura in Aomori Prefecture and two other sites, which use a communications system to regulate power output.

Hitachi is trialing a two-way communication system that controls PCS output via specified low-power radio or Japan's various cellular phone networks. The tests conducted over four periods, starting in December 2012 and covering each of the four seasons, have achieved favorable communications in a variety of weather conditions. By measuring the radio transmission characteristics of the different communication methods, the tests succeeded in combining different forms of radio communication



4 Repeater (top) and radio transmission characteristics (bottom) for specified low power radio

to suit the local conditions.

Through these year-round, long-run trials, the demonstration project indicated that it is possible to implement a communication system that can perform detailed control of PCS output.

5 Japan-U.S. Island Grid Project

The island of Maui in Hawaii is by far the most oil-dependent part of the USA, with electricity tariffs three times higher than those on the mainland due to the rising price of oil. It is also a site of rapid progress on the introduction of renewable energy, with plans to replace 40% of total power generation on the island with renewable energy by 2030.

It is against this background that a project has been launched on Maui aimed at supporting the large-scale use of electric vehicles (EVs), maximizing use of renewable energy, and ensuring the security of electric power supply.

Together with the State of Hawaii, County of Maui, Hawaiian Electric Company, Inc., Maui Electric Company, Ltd., The University of Hawaii, and US national research laboratories, Hitachi has been contracted by the New Energy and Industrial Technology Development Organization (NEDO) to participate in its Japan-U.S. Island Grid Project in Maui (project name: JUMPSmartMaui).

Quick charging stations have been installed at five sites around the island, chosen based on an analysis that considered traffic flow and the distances to homes, office districts, and tourist sites. A further 15 stations are planned. In addition to encouraging the wider adoption of EVs by making them easier to use, the project will also establish an energy infrastructure for the island that is not dependent solely on fossil fuels by using the energy storage capacity of EVs for surplus power absorption and to stabilize renewable energy. There are also plans to expand it to include a virtual power plant (VPP) function that contributes to the energy supply and demand balance for the entire island through the integrated management of the decentralized energy resources.
(Commencement of operation: December 2013)

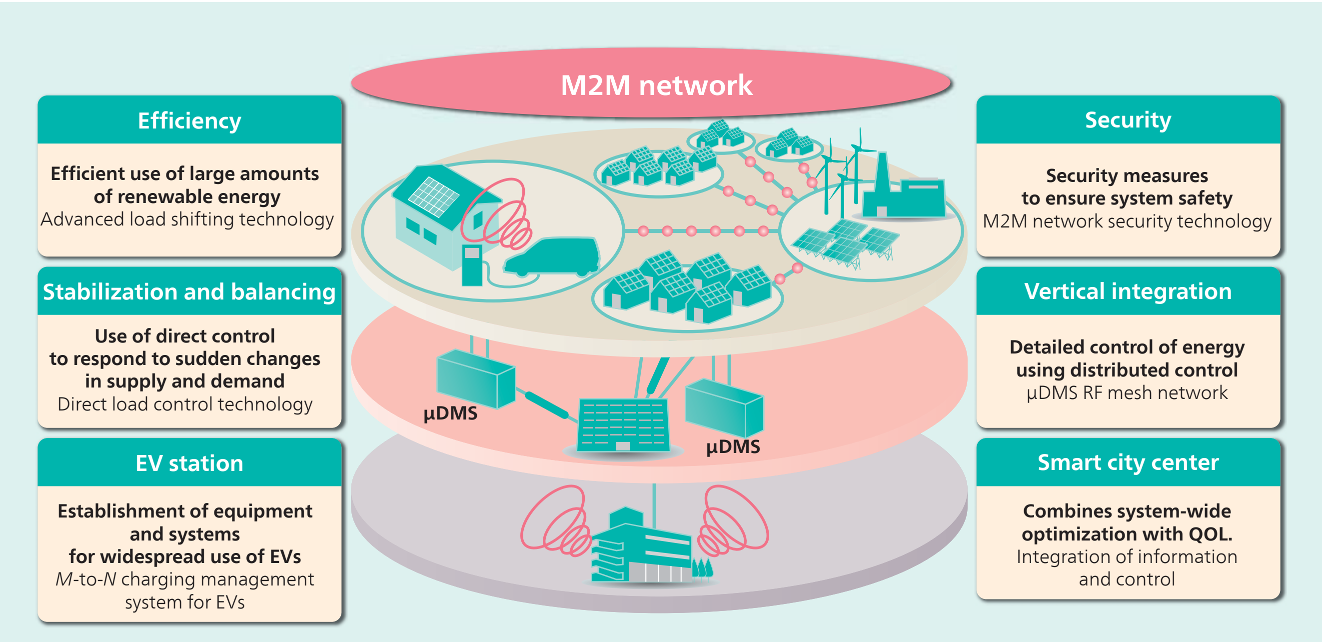
6 Kashiwa-no-ha Smart City Smart Grid Model Based on Grid Power Coordination

The Kashiwa-no-ha Smart City Project aims to achieve safe, secure, and sustainable urban development in the form of a city that provides a model for the future through a collaboration between the public, private, and academic sectors. Based around the central Gate Square district, it provides support for making significant reductions in carbon dioxide (CO_2) emissions and for the local community's business continuity plan (BCP), including the provision of backup lines of energy supply for the entire region and the effective use of renewable and unused sources of energy.

The project involves installing independent power lines within the district so that locally produced electric power from storage batteries installed at major facilities can be distributed to buildings that normally have secure and reliable supplies of grid power but experience peak demand at different times. This also provides a bare-minimum supply of domestic electric power to the surrounding neighborhood in the event of a grid power outage.

The equipment supplied to the project by Hitachi included one of Japan's largest stationery lithium-ion batteries (3,800 kWh), a system for the electric power interchange device between different parts of the city, distribution equipment, and also an area energy management system that not only monitors, controls, and operates these other systems, but also provides residents with information such as the mechanisms of energy use and guidance on their behavior.

In the future, Kashiwa-no-ha plans to construct a network that covers the entire city while also expanding the coverage area of its "Smart Grid Model Based on Grid Power Coordination" and adding additional functions.
(Scheduled commencement date: April 2014)



M2M: machine to machine, DMS: distribution management system, RF: radio-frequency, QOL: quality of life

5 Solutions supplied to demonstration project by Hitachi

Background image courtesy of Mitsui Fudosan Co., Ltd.

6 Kashiwa-no-ha Smart City

7 Ongoing Supply of 380-kV Transformers to Saudi Arabia

Since the 1970s, Hitachi has supplied a total of more than 40 large transformers to the Kingdom of Saudi Arabia. This has included a series of major orders since 2005 for large transformers of 500 MVA or more for use in power plants, with on-site installation currently in progress at the same time as work proceeds on design and fabrication for new orders.

Products for the Kingdom of Saudi Arabia require special specifications to deal with the harsh environmental conditions, including limits on temperature rise. In addition to giving full consideration to these requirements prior to design and fabrication, Hitachi also takes advantage of the ongoing orders to hold periodic technical consultations with customers to deepen the relationship of trust through the exchange of information about the reasons behind the specifications and other technical issues. In recent times, Hitachi has utilized these relationships to enter into discussions about future projects.

With numerous plans for power plant construction in Saudi Arabia in response to rising demand, Hitachi intends to draw on its past experience to meet the demand for large power plant transformers while also strengthening cooperation with the customers.

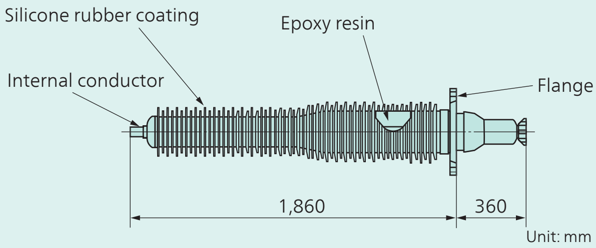
7 Factory testing of first 900-MVA-class power plant transformer (four transformers are to be supplied in total)

8 154-kV-class Earthquake-proof Transformer

The newly developed 154-kV-class earthquake-proof transformer uses 154-kV-class direct-molded bushings made by SWCC Showa Cable Systems Co., Ltd., which use new materials and feature light weight and small size, and also provides improved earthquake resistance due to a lower center of gravity for the completed transformer and greater rigidity in the bushing attachments.

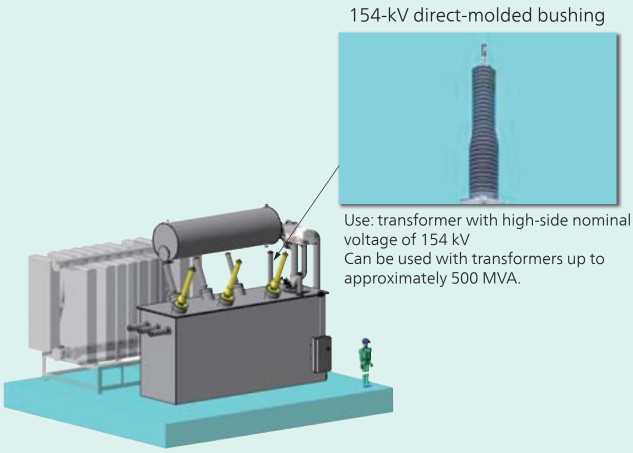
The transformer also has a function for instantaneous and automatic recovery if the pressure of sloshing transformer oil during an earthquake causes a relief valve to open.

Instead of using oil for insulation, the direct-molded bushings have an insulation design in which a coating of silicone rubber is laid directly over epoxy resin. In addition to eliminating the risk of oil leaks, this is also approximately 80% lighter and 40% smaller than the porcelain-insulated bushings used previously. This lighter weight and smaller size increases the natural frequency, thereby reducing the risk that resonance with the seismic



154-kV direct-molded bushing (154D-H)

Parameter	Porcelain (154-H)	Direct-molded (154D-M)
Mass	590 kg (approx.)	120 kg (approx.)
Maximum diameter	515 mm	310 mm
Total length exposed to air	2,970 mm	1,860 mm
Contamination rating	Up to 0.12 mg/cm^2	

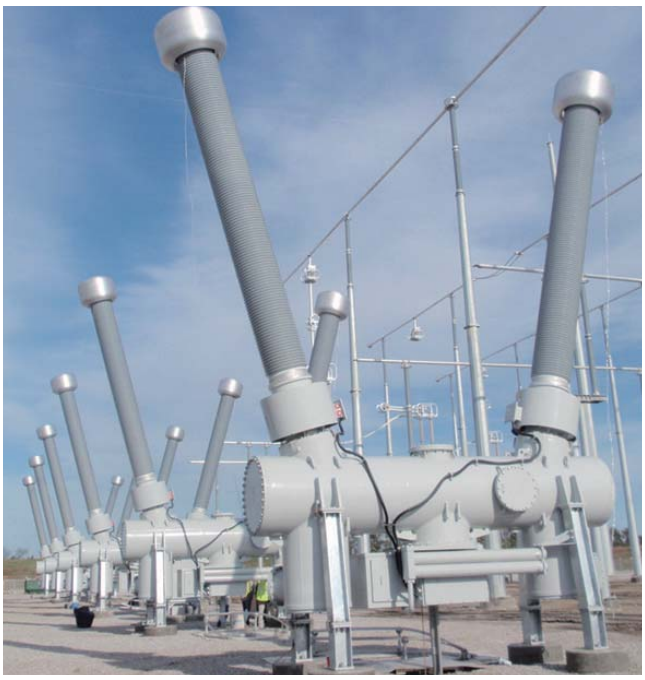


8 Design of 154-kV direct-molded bushings made of new materials (top) and overview of earthquake-proof transformer (bottom)

vibration will cause large stresses in the bushings. As restrictions on the angle of attachment of the bushings have also been eliminated, the new transformer provides more flexibility in layout design, making it suitable for a wider range of applications.

9 800-kV GCB for North American Market

A gas circuit breaker (GCB) is a grid protection device that can perform rapid switching of high voltages and heavy currents. Although Hitachi has already supplied about 40 800-kV GCBs (for the highest voltage level in North America) with double mechanisms per phase, there is demand for single-mechanism models for greater reliability and easier maintenance. Accordingly, Hitachi has developed a single-mechanism GCB with the high performance to comply with both the latest IEEE standards and customer specifications.


9 800-kV GCB developed and supplied by Hitachi (single-mechanism model)

The GCB is rated for 800 kV, 4,000 A, breaking current of 50 kA, and 60 Hz. Its main features are as follows.

(1) Easier maintenance and greater reliability from using a single mechanism to drive two contacts, reducing the operational variability inherent in the design compared with the dual-mechanism GCBs used in the past.

(2) Achieving duties complies with latest standards and customer specifications, thanks to mechanical systems that have been made lighter and faster through the fluid and strength analyses.

(3) Easier operation and lower failure rate achieved through lower component count and simplified design.

Hitachi's aim is to continue expanding its share of the North American GCB market.

10 Assembly Guidance System for Switchgear

Gas-insulated switchgear (GIS) and GCBs have an important role in the electrical conversion equipment used in the distribution of electric power. In operating its business globally, Hitachi demands high-quality products, not only from its Japanese facilities but also from production at overseas affiliates.

The newly developed Global (GIS, GCB) Kokubu (Kumitate) Instruction Training System (G-KITS) is a system for guiding workers through assembly work to ensure consistent quality. It incorporates operating procedures and automatic monitoring of work quality.

The main features are as follows.

(1) Clear and easy-to-understand work instructions using three-dimensional animations.

(2) Realtime data collection made possible by the use of digital approvals implemented through the adoption of information technology (IT) in the workplace to replace the paper- and rubber-stamp-based practices used for work records in the past.

(3) Uses digital torque wrenches to prevent problems such as bolts being missed or tightened with insufficient torque, and uses the associated work records to perform automatic monitoring.

10 Example G-KITS screen in Chinese

Kokubu Engineering & Product Division at Hitachi Works, Hitachi, Ltd. is designated by Hitachi as a “mother factory.” The division has set up a model production line using G-KITS to conduct verification testing, including actual assembly. After its initial use in the assembly of 145-kV GCBs, the system was subsequently adopted at Hitachi (Suzhou) EHV Switchgear Corporation, an overseas affiliate.

In the future, Hitachi intends to extend use of G-KITS to other standardized models and will consider adopting it at other overseas affiliates.

11 Substation for Floating Offshore Wind Power Facilities

This substation equipment for floating offshore wind power facilities was built by Hitachi as part of an FY2011 demonstration project run by the Agency for Natural Resources and Energy of the Ministry of Economy, Trade and Industry, Japan with the aim of developing technologies that will be required in future large wind farms.

The main challenges posed by the development, and the measures adopted to deal with them, are listed below.

(1) Development of techniques for dealing with swaying

To verify the robustness of the systems, vibration testing and tilt testing were conducted based on data on swaying provided by the manufacturer of the floating platform.

(2) Reliability and maintainability testing of equipment to be installed offshore

Compared with equipment intended for land-based installation, parts with tougher galvanizing or other surface coatings were selected.

(3) Testing of grid connection via long undersea cable

Analyses of both systems were conducted based on grid data supplied by Tohoku Electric Power Co., Inc. to confirm that the effect on the existing grid would be within permitted limits.

The substation systems were rated at 66 kV and 25 MVA, with the electric power from the turbines being stepped up from 22 kV to 66 kV for connection to the Tohoku Electric Power Co., Inc. grid. The floating platform on which the substation is installed is stationed approximately 20 km off the coast of Fukushima Prefecture.

In the future, Hitachi intends to perform comparison tests on the data acquired from the demonstration project and to use this in the development of key technologies.

Built by Japan Marine United Corporation

11 Floating offshore substation
[The electrical conversion equipment is installed on the superstructure (painted white).]