Power

1 Changhua Offshore Wind Power Project of Taiwan Power Company 5.2-MW Wind Power Generation Systems

Taiwan has announced a four-year plan for the promotion of wind power generation that is aimed at accelerating the introduction of renewable energy. The goal under this plan is to introduce offshore wind power facilities with a cumulative total generation capacity of 5.5 GW by 2025. In response, to increase production Taiwan Power Company, the nation's electricity utility, has launched a plan to construct an offshore wind farm off the coast of Changhua County, having set a target of 1 GW of installed capacity for offshore wind power generation by 2025, rising to 1.8 GW by 2030.

Hitachi has signed a contract with Taiwan Power Company to supply the Changhua Offshore Wind Power Project with 21 5.2-MW wind turbines (109.2 MW in total), the scope of which extends from system construction to installation and a five-year operation and maintenance (O&M) contract. The turbines will be installed offshore of Fangyuan Township in Changhua County. The work being undertaken by Hitachi accounts for roughly one-third of the total project value of 25 billion New Taiwan dollars (approximately 94 billion yen).

The large HTW5.2-127 wind power generation systems to be supplied to the Changhua Offshore Wind Power Project have a blade length of 127 m and a rated power of 5,200 kW, and are designed to cope with earthquakes and tsunamis as well as typhoons and other strong gusts. The systems will be manufactured during 2019 and early 2020, with commissioning to take place from the summer of 2020 for completion by the end of December.

1 5.2-MW wind turbine for Changhua Offshore Wind Power Project and cutaway drawing of nacelle interior

2 Completion of First Turbine in Project to Use AGP to Improve Output and Efficiency at Ohgishima Power Station

Hitachi has won a contract to use Advanced Gas Path* (AGP) to improve output and efficiency at Ohgishima Power Station (natural gas, 1220 MW), which is jointly owned by Tokyo Gas Co., Ltd. and Showa Shell Sekiyu K.K.

The work involves the incorporation of high-performance, high-temperature components into three gas turbines to improve their thermal efficiency. This also has the potential to reduce nitrogen oxide (NOx) emissions through the use of a low-NOx combustor and to expand the combustion range.

Improving the thermal efficiency of a power station increases its output and efficiency, reducing its fuel use and improving its economics. Another benefit from the incorporation of high-temperature components is that it can significantly lengthen the time between inspections.

The work on the project was conducted during inspections, with on-site staff, including those engaged in design and commissioning, working together to complete the work on Unit 2 in June 2018, on schedule and without any accidents or damage. (The other units are Units 1 and 3, with work on the next unit planned for 2019.)

Hitachi is currently planning the work on the next unit to ensure that it, too, is undertaken without any accidents or damage.

* Advanced Gas Path is a service supplied by General Electric Company (GE) that utilizes the latest technology for gas turbines.

2 Advanced Gas Path (AGP) upgrade work at Ohgishima Power Station

3 Supply of 1,008-MVA Transformer for Unit 3 of Paiton Power Station in Indonesia with Short Delivery Time

Paiton Power Station is a coal-fired power plant located in East Java in Indonesia. Unit 3 at the plant plays an important role in the electricity grid on the island of Java, having the largest capacity of any generator in Indonesia. Accordingly, the requirements for the new transformer included not only high quality, but also that its installation be moved forward drastically so that generation would be able to commence at as early a date as possible. Hitachi's large transformers typically require 12 months for design, parts procurement, manufacturing, and delivery, with a further month or more being needed for installation. In this case, however, to satisfy the customer's requirements, the delivery time for this contract was unprecedentedly short, with delivery in five and a half months and only 28 days for installation.

To accommodate this short delivery time, Hitachi drew on the comprehensive capabilities of "One Hitachi" to fulfill its promise to the customer, shortening the delivery and installation times by one week and six days respectively. Along with establishing a project management team that encompassed sales, operations, and manufacturing, Hitachi put a strong emphasis on managing the project in a way that would ensure smooth communications with the customer and achieve the best overall result. This effort also included working with suppliers to prioritize quick delivery; taking steps at the manufacturing facility to work double shifts, allow for holidays, and reassign staff across different departments; and engaging in collaborative creation with Hitachi's Indonesia subsidiary, PT. Hitachi Asia Indonesia, to shorten the installation schedule.

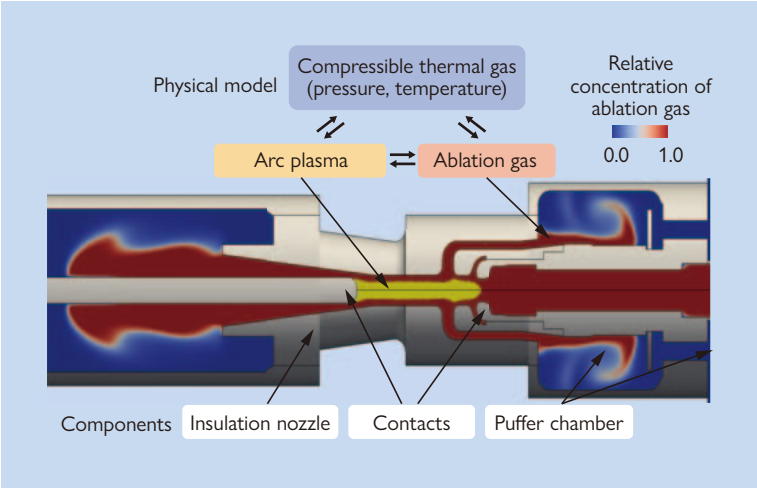
Hitachi intends to continue supplying reliable products with high quality by drawing on the experience gained from this work in future projects.

3 Transformer in operation

4 Improved Accuracy for Thermal Gas Flow Analysis of Gas Circuit Breakers

Gas circuit breakers play an important role in protecting power transmission networks from short circuit currents such as those resulting from lightning strikes. To shut off the current on detection of an abnormal condition, a high-speed mechanism inside the circuit breaker mechanically separates the contacts, and arc-extinguishing gas is blasted to cool the arc plasma that is generated between the contacts as they disconnect. This means that understanding the behavior of the gas inside the circuit breaker, including the arc plasma, is important for improving circuit breaking performance and equipment reliability.

In response, Hitachi has developed a technique for thermal gas flow analysis with enhanced models of various phenomena, including the emission of heat and light by the arc plasma generated between the contacts, ablation of the insulation nozzle, and the behavior of compressible thermal fluids. The technique provides more accurate assessments of the interactions between these different phenomena and of the spatial distributions and temporal variations in the temperatures and pressures of the high-temperature gas heated by the arc plasma. Hitachi intends to utilize the technique to develop smaller and more reliable gas circuit breakers with lower switching energy, and through the resulting products to contribute to the reliable supply of electric power.



4 Distribution of ablation gas in gas circuit breaker obtained by thermal gas flow analysis

5 Installation of Circuit Breakers with Closing Resistor for Transmission Lines with Phase Shifters

The total transmission capacity of electricity grids in which electric power can be transmitted via more than one route is sometimes limited by imbalances between the power flows along different transmission lines. Accordingly, it is possible to improve overall grid utilization and operate more efficiently by installing phase shifters to balance the power flows across different transmission lines. Unfortunately, phase shifters have a very high impedance, raising concerns about the consequences of this for transmission lines: (1) circuit breaking failure due to the current zero delay phenomena during an earth fault, and (2) bus bar voltage drop caused by the inrush current of the phase shifters.

When installing phase shifters, Tohoku Electric Power Co., Inc. in Japan took steps to deal with these issues, using analysis to demonstrate that the problems can be avoided by using circuit breakers with a closing resistor (such that, when the circuit breaker closes, it does so with a series resistance) to suppress the direct current (DC) component of closing current after single phase auto-reclosing and the inrush current during phase shifter energization. Moreover, the circuit breakers that were manufactured, delivered, and installed had effective resistance values and pre-insertion times obtained from the results of this analysis.

5 Phase shifter and circuit breaker with closing resistor

6 Manufacturing and Delivery of ZC-MMC type VSC

Hitachi manufactured and delivered a highly efficient 20-MW-class frequency converter using a zero-sequence canceling modular multi-level converter (ZC-MMC) as part of the replacement of a frequency converter type line commutated converter (LCC) used to transfer electric power between the 50-Hz and 60-Hz power systems at a customer site*.

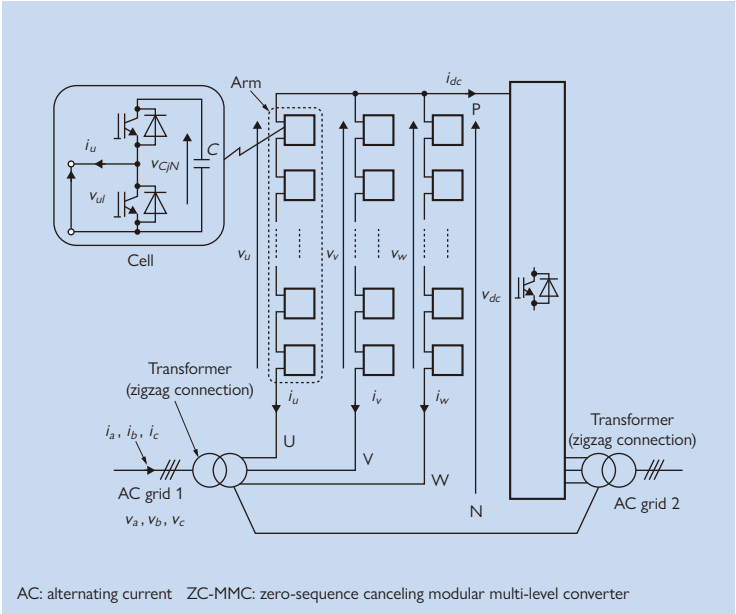
The converter is a world-first product, using a ZC-MMC and with the main circuit having 21 chopper cells in series (including one redundant cell). The control system performs individual control of each cell and has a standby backup system for high reliability. The upgrade was intended to deliver the following operational benefits.

(1) A wider operating range that allows unconstrained and uninterrupted operation, even when reversing power flow direction.

(2) Reduced harmonics [due to the multi-level converter type voltage source converter (VSC)] means there is no need for a harmonic filter.

(3) Reduced voltage fluctuations (through use of the converter type VSC to control reactive power) enables control of voltage fluctuations in the on-site distribution system and power factor with respect to the grid connection.

* This converter commenced operation in December 2016.



AC: alternating current ZC-MMC: zero-sequence canceling modular multi-level converter

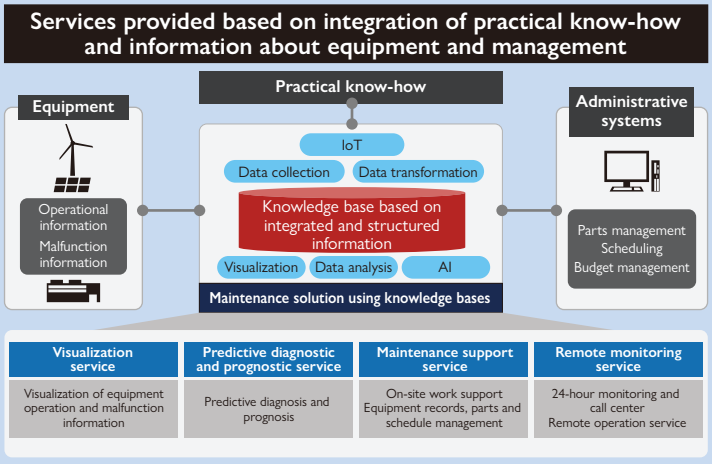
6 ZC-MMC circuit diagram

7 Site Remix Solution Supporting Use of Knowledge Base for Maintenance

Hitachi Power Solutions Co., Ltd. is establishing a knowledge base by using structured identifier management technology (SIMT) which assigns identifiers that give structure to various distributed information sources, linking information about equipment and management to practical know-how built up in the form of operational technology (OT) for the optimal control and operation of customer equipment. The company also supplies the Site Remix solution using knowledge bases for maintenance that helps users achieve timely decision making by providing the necessary information for maintenance when needed.

Site Remix provides a range of services, including visualization, pre-emptive and predictive diagnosis, maintenance support, and remote monitoring.

This solution can provide information about root cause analysis and next actions to take based on factors such as past similar problems, when a



AI: artificial intelligence IoT: Internet of Things

7 Block diagram of Site Remix solution using knowledge bases for maintenance

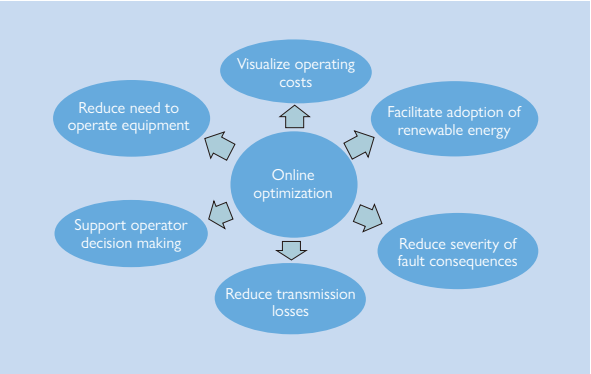
potential problem is detected, while also helping to improve the level of on-site maintenance by enabling information sharing between supervisor and field personnel.
(Hitachi Power Solutions Co., Ltd.)

8 Trials of Grid Stabilization Solutions in Japan and Elsewhere

There is rising demand for solutions that can make the electric power infrastructure more flexible and robust, including by facilitating the adoption of renewable energy, coping with frequently occurring natural disasters, and introducing market mechanisms to reduce the cost to society. Also in demand are enhancements to multi-faceted management systems for administering, operating, and maintaining electric power infrastructure in response to the shrinking workforce, a consequence of the aging population.

As a first step toward satisfying these diverse requirements, Hitachi has analyzed the utility of core technologies for online optimization. In particular, Hitachi is involved in a feasibility study as part of a project (P11013) by Japan's New Energy and Technology Development Organization (NEDO) in which Hitachi joint venture subsidiary THE Power Grid Solution Ltd. is playing a central role. The study is looking at ways of using systems to obtain benefits such as lower transmission losses by achieving an optimal voltage profile.

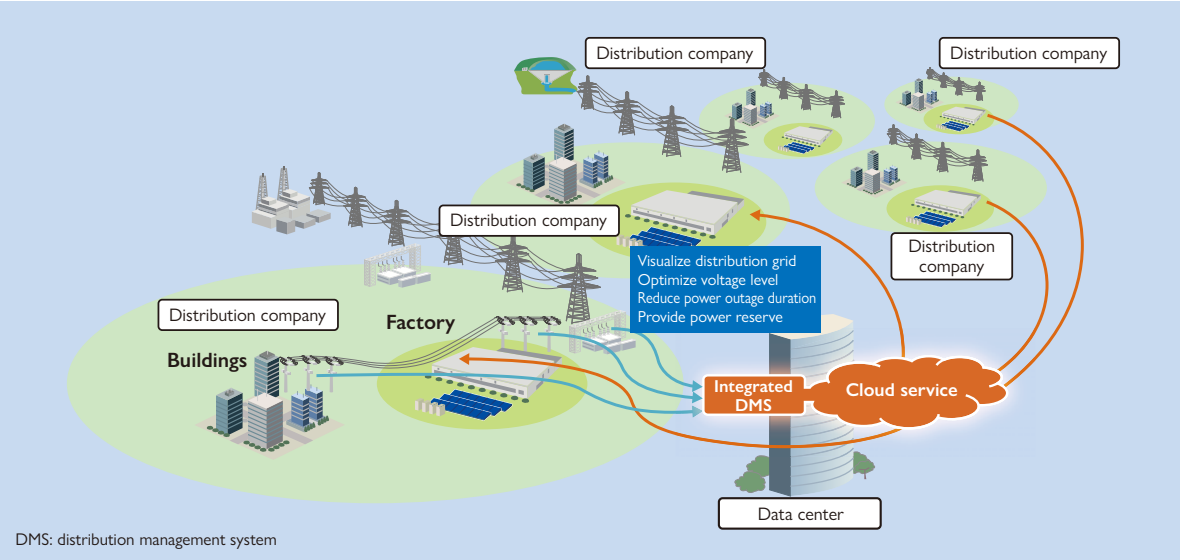
Hitachi also aims to supply even more effective solutions by taking on the associated issues from a variety of different perspectives, including trialing battery management systems and enhancing the functions of electric power distribution systems to that optimization and other sophisticated computing techniques can be used as part of the system.



8 Utility of online optimization

9 Trial of Integrated Cloud-based DMS for Electricity Distributor in Slovenia

Based on European Union (EU) directives that include reductions in the emission of greenhouse gases, the Republic of Slovenia has set targets for producing 25% of its total energy from renewable sources and for improving energy efficiency by 20%, both by 2020.



9 Installation of integrated cloud-based DMS

Meanwhile, given the aging distribution network infrastructure and the increasing demand for electric power due to economic growth, it is anticipated that capital investment in the distribution network will increase. Similarly, the likely impact on the distribution network of the installation of large amounts of renewable energy is also creating a need for technology that can provide sophisticated distribution network management.

To overcome these challenges, Hitachi together with NEDO has supplied Slovenia with an integrated cloud-based distribution management system (DMS) that can minimize the capital investment needed to provide voltage optimization and distribution network monitoring by utilizing advanced Japanese technologies in the field of power distribution and information and communication technology (ICT), with benefits that include measures for dealing with the installation of renewable energy. The system commenced operation in October 2018. The next step will be to verify its effectiveness in practice.

10 Demonstration Project of Large Hybrid Battery System on Izu Oshima

To encourage the adoption of renewable energy and reduce fuel costs, an issue of particular importance to offshore islands, and with the aim of delivering a solution that will lead to the resolution of these problems, Hitachi is working on developing and implementing a hybrid battery system that combines lead-acid batteries with lithium-ion capacitors to provide a safe and low-cost energy storage system.

A demonstration project of the technology on Izu Oshima island that was launched with support from NEDO has since 2015 been in a phase of joint research with TEPCO Power Grid, Inc. This involves evaluating the monitoring control system and building up operational know-how on the use of an energy storage system to balance supply and demand in an electric power system subject to variable renewable energy, with lithium-ion capacitors being used to smooth short-term fluctuations in renewable energy output and lead-acid batteries to cover the longer-term fluctuations over the course of a day.

Hitachi aims to commercialize the system to contribute to stabilizing the supply of power for island regions.

10 LL-G lead-acid batteries installed on Izu Oshima