Power

1 Nacelle durability testing

1 Durability Testing of Nacelle for 5.2-MW Wind Turbine Generator

Wind power is both a promising and a realistic source of renewable energy. Hitachi has developed a wind turbine generator system with a rated output of 5.2 MW. The first unit was built in 2015 and the second installed as floating wind turbine generation system off the coast of Fukushima in 2016. While the rated output of wind turbine generator systems continues to increase as their deployment expands from land to sea, the increased risk of accident or fault means that ensuring reliability is essential.

Accordingly, Hitachi manufactured a test version of the nacelle for the 5.2-MW wind turbine generator and conducted durability testing to verify its reliability of the main wind turbine components. The testing was conducted over a period of about six months at the National Renewable Energy Center (CENER: Centro Nacional de Energías Renovables) in the region of Navarra in the Kingdom of Spain. The nacelle was subjected to a variety of test loads that were equivalent to a 20-year fatigue load. The testing found that the propagation of load to key structural components agreed with the results of preliminary and dynamic analyses, and that the durability of the nacelle was adequate.

Hitachi intends to utilize the test data as feedback for the design of its production models so that they will be better equipped to serve as more reliable wind turbine generation systems.

2 Construction of Nojimaokawa Power Plant

The Nojimaokawa Power Plant (rated output of photovoltaic modules: 9,865.4 kW, rated output of power conditioner: 7,920 kW) of AWJ Godo Kaisha, a company jointly held by Banpu Power Public Company Limited and Prime Road Capital Company Limited, commenced operation in May 2017. This was the first time

2 Nojimaokawa Power Plant

Hitachi has been involved in a photovoltaic power construction project on Awaji Island. The Awaji Wind Power Plant (of Kanden Energy Solution Co., Inc.) that uses Hitachi wind turbines is located at a nearby site.

As power cables from the wind turbines pass across the Nojimaokawa Power Plant, the installation work needed to take care not to interfere with these. The grid interconnection is located about 240 m away and connects to three power pylons. As the site lacks any wired communication links and has poor wireless network coverage, a survey of wireless coverage was conducted for three carriers and the carrier who offered the best radio reception was chosen. A repeater was also installed to boost signal strength and enable remote monitoring of the power plant.

3 550kV-GISs for EGAT Chaiyaphum 2 and Bangkok Noi Substations

In the Kingdom of Thailand, reliability improvement and the strengthening of electricity transmission and distribution networks are needed to keep up with the rising demand for electric power that has accompanied rapid economic growth. The Electricity Generating Authority of Thailand (EGAT) that has responsibility for the supply of electric power has, since 2014, been constructing 550-kV transmission substations around the country, the highest voltage substations in use in Thailand. As part of a consortium with local companies, Hitachi received an order for transmission substations (four new substations and one substation upgrade) for the first

3 550kV-GIS for EGAT Chaiyaphum 2 substation

time in around two decades since it supplied the first 550-kV gas-insulated switchgear (GIS) for Thailand's first 550-kV substation in 1999. The Chaiyaphum 2 and Bangkok Noi substations were commissioned in 2017.

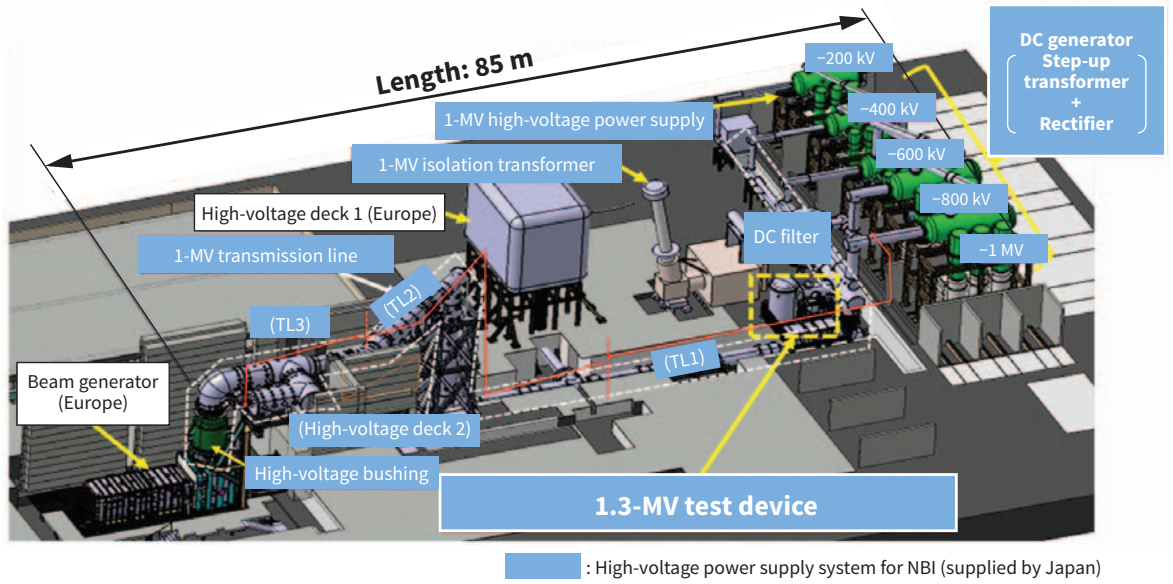
Hitachi was recognized by EGAT for its technical capabilities that made these the first to be completed of a number of new substations that commenced construction at around the same time. In the future, Hitachi plans to contribute to the infrastructure development business in Thailand by winning a greater number of turn-key orders for substations in collaboration with local companies and others.

4 Ultra-high Voltage Power Supply for ITER/NBTF NBI

ITER is an international project working on an experimental nuclear fusion reactor. The neutral beam injector (NBI) used at ITER for plasma heating uses a 1-MV ultra-high voltage direct current (DC) power supply to accelerate H^- and D^- ions and produce a 1 MeV/40 A negative ion beam.

To verify the beam acceleration technology, a neutral beam test facility (NBTF) is currently under construction at Consorzio RFX situated in Padua in the Italian Republic. Japan has responsibility for key high-voltage equipment, including the DC generator and high-voltage transmission line.

Hitachi received an order for this equipment in 2012 from what is now the National



4 Ultra-high voltage power supply for ITER/NBTF NBI

Institutes for Quantum and Radiological Science and Technology (QST) [formerly part of the Japan Atomic Energy Agency (JAEA)] and has proceeded with their manufacture. The equipment has achieved world-leading performance* for an NBI high voltage power supply, including the use of sulfur hexafluoride (SF_6) gas to deliver an insulation performance (1 MV) that is significantly higher than achieved in the past despite its small size, and the ability to operate for the long periods of time (60 minutes) needed to sustain a stable nuclear fusion plasma. The various items of equipment were transported to Italy as they finished manufacturing, with dispatch of the final large items, which included transmission line 3 (TL3), being completed in August 2017.

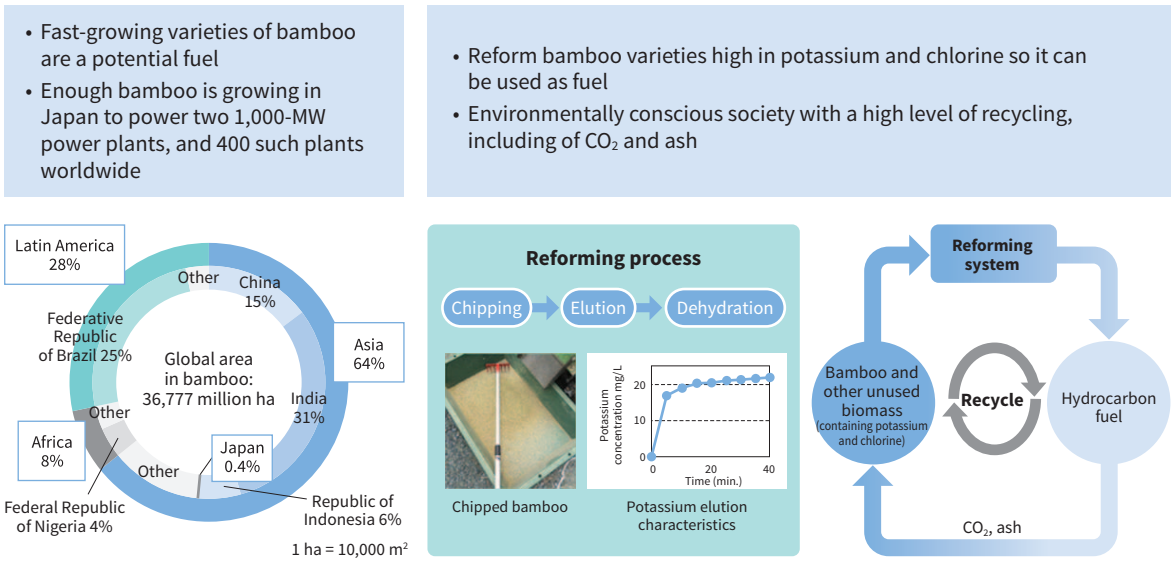
Installation work has been ongoing at the RFX since December 2015, with Hitachi sending installation technical advisors to the site. Along with contributing to NBIs for ITER as well as future prototype nuclear fusion reactors, it is anticipated that the technology developed for this equipment will also be applicable to accelerators used in a variety of other fields.

* As of December 2017 (based on research by Hitachi)

5 Reforming Technique for Unused Biomass

Although bamboo grows rapidly and is found in the vicinity of cities, it is not used as a biomass fuel because of its high potassium and chlorine content. Potassium lowers the temperature of ash softening, causing adhesion to the interior of boiler combustion chambers that reduces heat transfer and impedes the flow of exhaust gases. Chlorine not only damages refractory material and tends to result in the corrosion of heat transfer tubes, it also leads to the emission of harmful dioxins. A consequence of this is that local governments are unable to deal with wilding bamboo that causes problems such as forest encroachment and fallen bamboo.

In response, Hitachi has developed a reforming technique that chips the bamboo into 6-mm-diameter fragments and uses elution treatment to reduce potassium and chlorine to levels similar to those found in woody biomass fuel. The technique can be applied to a variety of unused biomass, including the bamboo and bamboo grass that grow in Japan as well as weeds, Japanese cedar bark, and non-Japanese varieties of bamboo. Bamboo grows to maturity in three years. If it could be used as a fuel, it has the potential to contribute to creating a sustainable society with a high level of recycling



CO_2: carbon dioxide

5 Reforming technique for unused biomass that helps mitigate global warming

achieved through the use of renewable energy, generating electric power equivalent to two 1,000-MW thermal power plants in Japan, or 400 such plants worldwide where the total bamboo resource is 200 times that in Japan*.

* This development was conducted over two years through a project funded by the Forestry Agency for developing systems for processing and utilizing woody biomass.

6 Upgrade to GT at Unit 3 of Kawagoe Thermal Power Plant of Chubu Electric Power

Gas turbine (GT) 7 at Unit 3 of Kawagoe Thermal Power Plant of Chubu Electric Power Co., Inc. completed its routine inspection in February 2017, marking the completion of upgrades to all seven GTs in Unit 3. Supplied by Hitachi in the 1990s, the combined-cycle generation GTs were at the leading edge for their time. They have now been upgraded to the latest GTs and control equipment to restore their output during summer months and increase thermal efficiency.

The main features are as follows.

(1) The GTs were upgraded to the latest technology to restore their output and increase thermal efficiency.

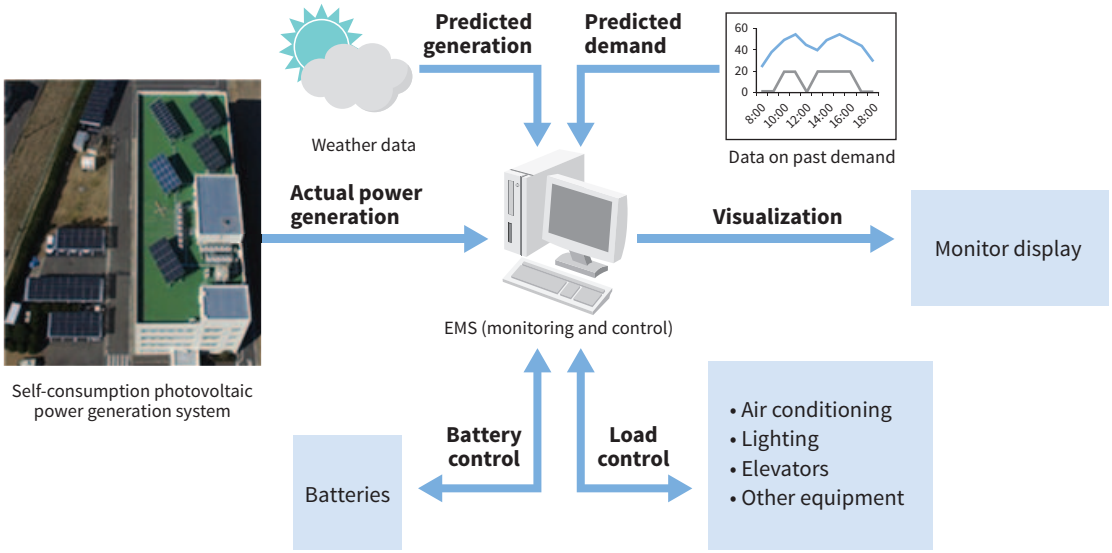
(2) The latest model-based control technology has been adopted to provide optimal control of operation.

These upgrades were well received by the customer, having restored output of 6,400 kW for each GT at an air temperature of 15°C, improved thermal efficiency by approximately 2.8%, and significantly reduced nitrogen oxides (NO_x) emissions. With rising demand for GT upgrades throughout Japan, Hitachi intends to draw on this experience and continue to apply its engineering capabilities to a variety of refurbishment and replacement projects in the future.

6 On-site delivery of GT

7 Highly Efficient Self-consumption Photovoltaic Power Generation System Solutions

Hitachi Power Solutions Co., Ltd. supplies photovoltaic power generation systems that also helps cut power bills as well as comply with



7 Self-consumption photovoltaic power generation system installed for demonstration use

the Act on Rationalizing Energy Use (Energy Conservation Act) by enabling photovoltaic power to be consumed entirely on site. Hitachi Power Solutions has already installed such a system at its Omika annex facility, where it has demonstrated the potential for cutting power consumption by about 30%. The system is made up of 103 kW of photovoltaic capacity, 50 kWh of batteries, and an energy management system (EMS).

In addition to building a demand model for the EMS that predicts electric power demand and photovoltaic generation, Hitachi Power Solutions has also developed a function for charging and discharging control that makes the most of the available batteries and functions for automatic control of air conditioning and other loads.

In the future, Hitachi Power Solutions aims to strengthen and expand its business by undertaking new installations and upgrades of existing photovoltaic power generation for customers such as factories, office buildings, and other commercial facilities able to install 50 kW or more of photovoltaics as a response to the challenges of reducing power bills, compliance with the Energy Saving Law, implementing business continuity planning (BCP), and how to make use of unused space on site.

(Hitachi Power Solutions Co., Ltd.)