extra notes

Renewable Energy

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The adoption of renewable energy on a large scale is an international trend. Hitachi is working on core technologies for maintaining and improving the reliability and competitiveness of photovoltaic and wind power generation. Hitachi is also conducting research and development of future forms of renewable energy, including in particular gas turbine systems that utilize solar heat. Internationally, Hitachi is also marketing new energy and smart grid systems designed for conditions in different countries such as the Russia.

LARGE-SCALE PHOTOVOLTAIC POWER GENERATION

HITACHI has received turnkey orders [engineering, procurement, and construction (EPC) contracts] for a large number of megasolar power plants, including an 82-MW megasolar power plant for Oita Solar Power Corporation. It also supplies its Megakit photovoltaic power generation system packages and ancillary equipment, particularly power conditioning systems (PCSs) that help increase power generation. Overseas activities include a 1.2-MW megasolar project for Mitsubishi Corporation in Brunei, and the supply of PCSs to the Thailand.

Hitachi initially supplied highly efficient PCSs in Japan and overseas that used two-level pulse width modulation (PWM) inverters and were designed for small size and high efficiency. Hitachi then went on to develop and commercialize PCSs designed for even greater efficiency that used three-level PWM inverters. In addition to its current HIVERTER-NP203i model, which has a maximum input voltage of 660 V, Hitachi has released the new HIVERTER-NP213i model with a maximum input voltage of 1,000 V and a maximum conversion efficiency of 98.8%, which represents world-leading performance for a PCS in its class* (see Fig. 2).

Fig. 1—82-MW Megasolar Power Plant for Oita Solar Power Corporation.
This megasolar power plant scheduled to commence operation in 2014 will be Japan's largest.

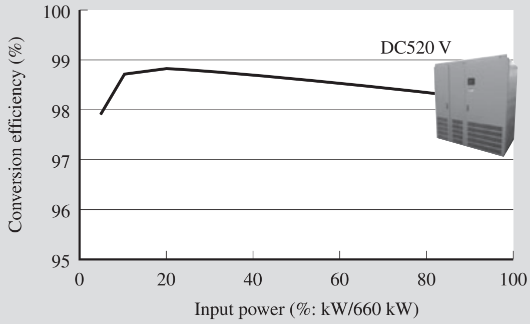

Fig. 2—PCS Conversion Efficiency Characteristics (HIVERTER-NP213i).
Hitachi is helping maximize the amount of power generated by providing high conversion efficiencies in the actual operating ranges used for photovoltaic power generation.

WIND POWER GENERATION

The downwind configuration of the 2-MW-class HTW2.0-80 wind turbine means that the rotor is located on the downwind side of the tower. The downwind configuration applied to 2MW HTW2.0-80 locates the rotor downwind of tower. This

* PCSs for large photovoltaic power generation systems in the 500-kW class. Based on Hitachi research as of October 2012.

Fig. 3—Wind Power Generation System with Downwind Configuration.
This wind power generation system is used by the Fukushima Floating Offshore Wind Farm Demonstration Project (Fukushima Forward). (Photograph courtesy of Fukushima Offshore Wind Consortium)

configuration, which lowers wind load, can simplify foundation work and reduce its cost, and can improve generating efficiency in hilly areas where updraft wind generally blows.

This model also features a high level of tolerance for lightning to withstand intense winter thunderstorms that occur in Japan.

Because the benefits of a downwind configuration are particularly applicable to offshore sites, Hitachi is also working on the development of a 5-MW-class downwind offshore wind power generation system. To facilitate progress on this work, a HTW2.0-80 turbine has been installed off the coast of Fukushima by the Fukushima Floating Offshore Wind Farm Demonstration Project (Fukushima Forward) funded by the Ministry of Economy, Trade and Industry (see Fig. 3). Trial operation of this system together with an offshore substation also supplied by Hitachi has already commenced. Trial operation of a HTW2.0-80 wind turbine has also commenced off the Goto Islands in Nagasaki Prefecture in a Floating Offshore Wind Turbine Demonstration Project run by the Ministry of the Environment (the first such project in Japan on a commercial scale).

RAPID ENGINEERING TOOLS

Extracting maximum performance from large-scale photovoltaic and wind power generation requires advanced core technologies that can be used in the associated engineering work. Hitachi has developed rapid engineering tools for both photovoltaic and wind power.

Fig. 4 shows a rapid engineering tool for large photovoltaic power generation systems. This megasolar design tool is used for the processes from project planning to estimation. By combining and linking programs that perform calculations for such things as power output and mounting structures, the tool reduces the time required for data input, automates the generation of drawings for submission to the customer during each process, and allows these drawings to be managed in a standardized format.

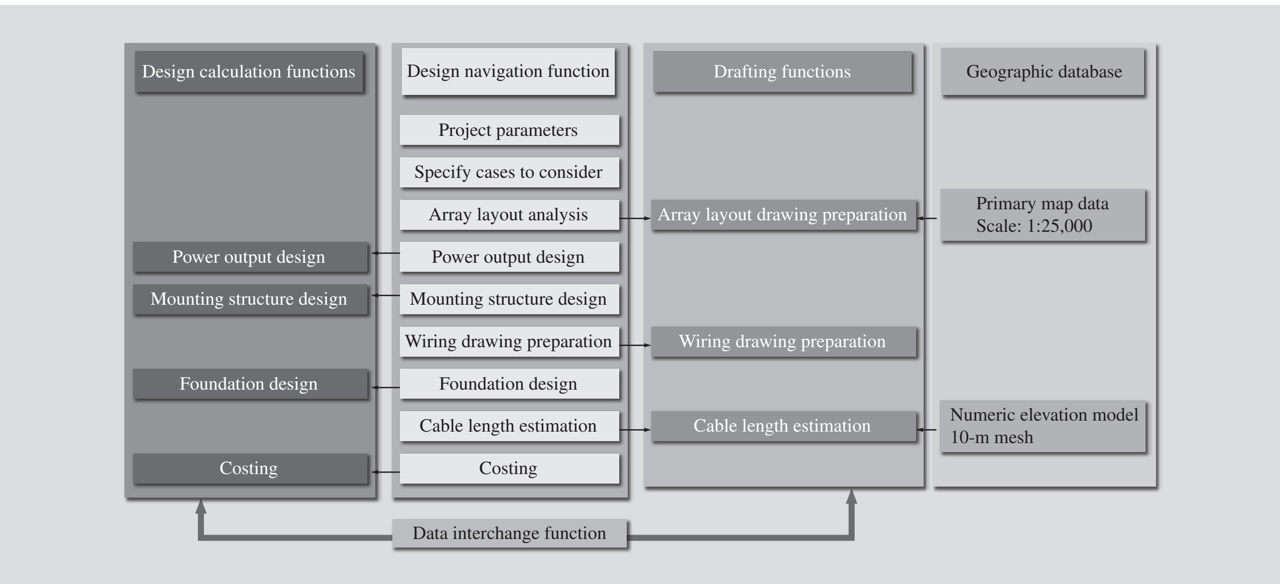

Fig. 4—Configuration of Rapid Engineering Design System for Megasolar Projects.
The interchange of data between design tools avoids data entry errors and saves time by reducing the volume of manual data entry.

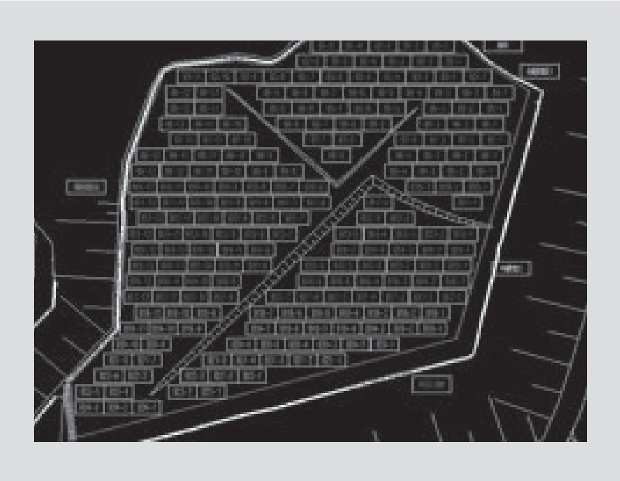

Fig. 5—Automatic Generation of Array Layout.
The system uses map data to determine the layout of the photovoltaic panels automatically. This layout can then be used to evaluate the cable routing.

The tool can automatically estimate annual power generation using a database of sunlight levels around Japan that was published by the New Energy and Industrial Technology Development Organization (NEDO), use map data to determine how to arrange the photovoltaic panels to maximize their number, determine the optimal mounting structures for the photovoltaic panels, and determine the shortest cabling layout (see Fig. 5).

Advanced numerical analysis techniques are essential for the development of wind turbines, which require a high level of reliability. A downwind turbine configuration means that each rotor blade passes through the tower wake at each rotation. Accordingly, Hitachi has developed its own numerical analysis model that considers the tower shadow effect caused by aerodynamic interference between the tower wake and rotor (see Fig. 6). Numerical analysis techniques are also utilized for development tasks such as estimation of blade and tower strength and multi-objective optimization of blade shape.

DEVELOPMENT OF SYSTEM USING SOLAR HEAT

A new system for exploiting renewable energy is a gas turbine system that uses solar heat. Once the thermal energy is collected, solar thermal power generation can use the same technology as conventional thermal power generation. It can also achieve higher generation efficiencies than photovoltaic power generation. The main limitations are weather conditions and the large area of land required for the solar collectors that generate the high-temperature steam.

Hitachi has developed a new gas turbine system that uses solar heat and that reduces the land area required per unit output for solar collectors to one-tenth or less that of previous solar thermal power generation methods (see Fig. 7).

A characteristic of gas turbines is that their output falls during the summer, for example, because the lower air density when air temperatures are high reduces the mass flow of air drawn into the compressor. A technique that has been implemented to overcome this is to spray water into the gas turbine intake to cool the incoming air. Unfortunately, this technique has failed to mitigate the drop in output sufficiently because of the potential, if the spray droplets are large, for it to cause erosion of the compressor blades. This limits the amount of sprayed water to no more than

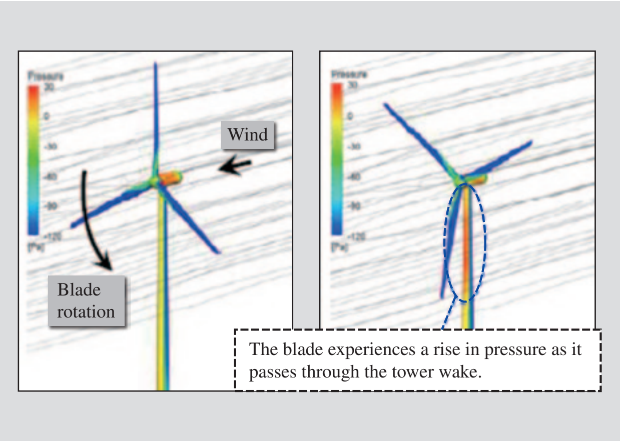

Fig. 6—Calculation of Tower Shadow.
This analysis considers the pressure fluctuations that result from the tower wake that is a feature of downwind turbines.

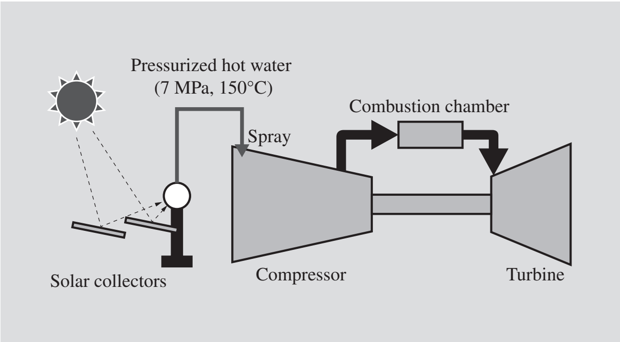

Fig. 7—Concept of Gas Turbine System Utilizing Solar Heat.
Solar heat is used to produce pressurized hot water that is then sprayed into the gas turbine intake. When the water flash boils on exposure to atmospheric pressure, it takes latent heat from the intake air, thereby cooling the air.

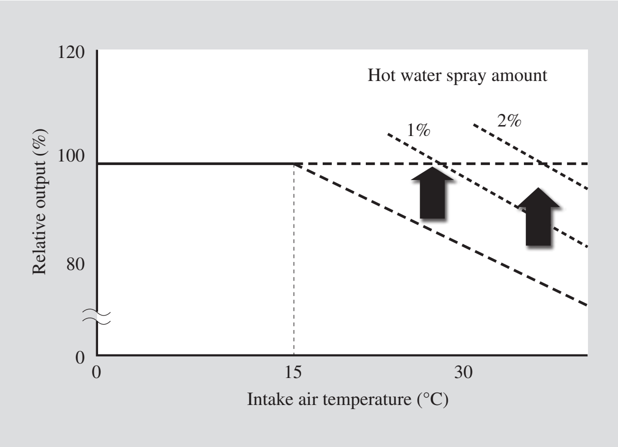

Fig. 8—Predicted Restoration of Gas Turbine Output through Spraying Pressurized Hot Water.
At an air temperature of 35°C, a gas turbine can be restored to its rated output by spraying water equivalent to 2% of the intake air by mass.

about 0.5% of the intake air by mass.

Hitachi has now developed a new system that operates with a water spray pressure of 7 MPa and uses solar heat to raise the water temperature to 150°C (conditions under which water is still a liquid). This pressurized hot water is sprayed into the intake where it instantaneously flash boils (vaporizes) on exposure to atmospheric pressure. At the same time, the droplet size also shrinks due to internal boiling. The heat of vaporization is taken from the surrounding air, efficiently cooling it, and the technique also prevents erosion of the compressor blades by water droplets. It is seen as providing an effective way of using solar heat during summer when the loss of gas turbine output is at its most severe (see Fig. 8).

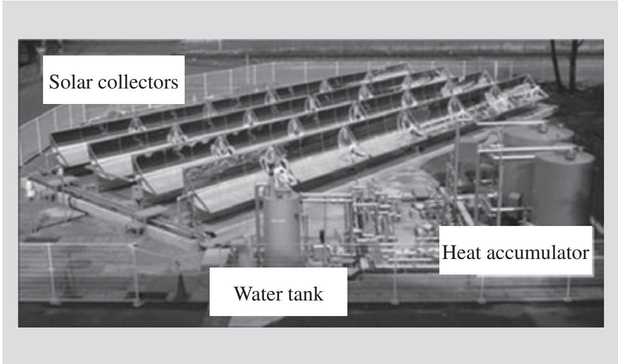

Fig. 9—Experimental System at Hitachi.
Trough-shaped solar collectors are used to collect solar heat.

The viability of this principle has been verified on an experimental system installed at Hitachi (see Fig. 9), with demonstration trials on actual gas turbines planned in the future.

OVERSEAS PARTNERSHIPS

Because the renewable energy business is influenced by different national policies, it is essential to establish partnerships with overseas institutions and customers. Hitachi has established such partnerships in the fields of renewable energy and smart grids from an early stage. Currently, this includes initiating approaches to public and private power companies in the Russian Federation and elsewhere with the aim of proceeding through win-win collaborations.

ABOUT THE AUTHORS

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