Technotalk

Construction of New Energy Systems Using Advanced Power Generation and Transmission Technology

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Numerous electric power generation and transmission facilities were significantly damaged by the Great East Japan Earthquake that struck on March 11, 2011, creating a crisis in energy supply. Despite this, a major crisis was averted and reconstruction is now in progress thanks to the efforts, primarily by electric power companies, to restore services quickly, and through industry and households working together to conserve power. Hitachi supports all aspects of the energy infrastructure and is contributing actively to the recovery and reconstruction following the earthquake. Hitachi intends to draw on its advanced technologies, its past accomplishments, and its many years of experience to respond to the expansion of global energy demand and the construction of new energy systems in the future.

Moving from Earthquake Reconstruction to the Next Stage

Nishino: One year and eight months have passed* since the Great East Japan Earthquake, and over that time Japan has come together, not only to work on the reconstruction of the affected areas, but also to cope with the shortage of electric power. Hitachi, meanwhile, has been doing all it can to help with the restoration of electric power infrastructure. To begin with, I would like you to tell me about what is being done to support the recovery, and the forward-looking measures that are being adopted.

Hoizumi: Major factories for Power Systems Company in Ibaraki suffered significant damage during the earthquake. Nevertheless, the entire group worked together and we quickly had production up and running again. Since then we have contributed the restoration of operation at 23 thermal power plants damaged by the earthquake or tsunami, with a total generation capacity of more than 10 GW.

We also responded to requests for the rapid delivery of

* at the time of the interview

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Since joining Hitachi, Ltd. in 1981, he has worked on instrumentation and control planning for nuclear power plants, and engaged in the decommissioning of the Fukushima Daiichi Nuclear Power Station. He is currently engaged in the UK project. Mr. Tanikawa is a member of the Atomic Energy Society of Japan.

gas turbines for use as emergency power supplies. An F6FA was delivered to Ohi Thermal Power Station of Tokyo Electric Power Co., Inc. in August 2011, an H-25 to the Niigata Thermal Power Station of Tohoku Electric Power Co., Inc. in January 2012, and an H-25 to the Himeji No. 2 Power Station of The Kansai Electric Power Co., Inc. in August 2012. In each case it took only about four months from the time of installation for these plants to commence operation, faster than had ever been achieved before.

Tanikawa: As you know, the earthquake and tsunami resulted in core meltdowns at Fukushima Daiichi Nuclear Power Station. Hitachi established a department dedicated to responding to the accident shortly after it occurred that is engaged in work on a daily basis at the Fukushima site, at the headquarters of Tokyo Electric Power Co., Inc., and at Hitachi Works. In particular, through activities that have included building a circulation cooling system, cooling the spent fuel pool, and the installation of a cover for the Unit 1 building, they have made a major contribution to minimizing emissions of radioactive material and achieving a cold shutdown. Preparations are currently underway for the removal of fuel from the Unit 4 spent fuel pool, and ongoing technical development is in progress aimed at removing fuel debris from the core.

Also, top priority has been given to improving safety at other plants, and Hitachi is proceeding with design work aimed at applying safety measures to existing plants based on the issues highlighted by the accident, including providing filter vent systems and a wider range of power supplies and cooling equipment.

Komiya: Kokubu Works is the main plant for Hitachi's electric power transmission distribution (T&D) business, and it also suffered damage in the Great East Japan Earthquake. The High Voltage & High Power Testing Laboratory, in particular, was severely damaged resulting in its being completely rebuilt, with completion in May 2012. As performance testing and other development work for T&D products was held up until the laboratory could be restored, it is currently operating 24 hours a day to work through the backlog.

The earthquake also reinforced the importance of T&D systems, and the importance of wide-area grid interconnections in particular. Japan has nine high-voltage direct current facilities in operation across six sites, including high-voltage direct current transmission, frequency converter stations, and back to back ties. Hitachi has supplied plant and equipment to all of these and aims to draw on this experience to support future growth in the T&D systems.

Achieving the Best Mix of Energy Supplies

Nishino: Since the time of the oil shock, Japan has adopted a "best mix" energy policy consisting of an appropriate balance of different sources of electric power, and this is acknowledged as one of the factors that helped us overcome the post-earthquake electric power crisis. However, this energy policy is also currently a subject of national debate.

Sakamoto: People speak of the "three Es" as being critical to this energy "best mix," namely economics, environment, and energy security. Japan's energy policy was formulated to satisfy these three criteria, and they remain just as important in the post-earthquake era as they were before. In terms of energy security, in particular, not relying too heavily on any one type of fuel is an important aspect of establishing a secure supply of energy.

Saeki: Renewable energy will play an important role in the future "best mix" of energy sources. A feed-in tariff scheme covering all production has been introduced in Japan and market interest is growing.

Hitachi has been active in the wind turbine business in collaboration with Fuji Heavy Industries Ltd. since 2005, and we acquired that company's wind turbine business in July 2012 to strengthen our involvement. A feature of our wind turbine is that it has a downwind configuration, meaning

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Naofumi Sakamoto

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Since joining Hitachi, Ltd. in 1992, he has worked in the Group Company Office, Global Business Division, and Business Development Office. He is currently engaged in researching policy and market trends in the energy, environment, and industrial sectors, and in the formulation of business strategy. Mr. Sakamoto is a Master of Business Administration (MBA).

that the rotor blades are downwind of the tower. Downwind turbines not only achieve highly efficient and reliable power generation in the sort of rough and mountainous terrain common in Japan, they are also suitable for offshore wind power generation.

Hitachi aims to play a role in the wider adoption of renewable energy through both photovoltaic and wind power generation, with activities in the field of photovoltaic power generation including a range of megasolar projects, as well as having already supplied a 13-MW system to the Ohgishima Solar Power Plant of Tokyo Electric Power Co., Inc.

Komiya: Proceeding with a "best mix" of energy that includes renewable energy makes power system stabilization systems even more important. To supply users with high-quality electric power, Hitachi is embarking on a variety of demonstrations around the world involving advanced distribution management systems (DMSs). These are a new generation of automatic systems for electric power generation. For example, experimental trials are being conducted on static synchronous compensators for distribution networks (D-STATCOMs) used to reduce voltage fluctuations on distribution networks. Hitachi is also working on development and experimental trials of microgrid technology that uses information technology (IT) to achieve stable control of frequency and voltage at a regional level.

Development of large battery systems that provide an effective way of performing load smoothing is also in progress, with the intention that this will facilitate comprehensive power system stabilization by adding effective functions to measures from both the demand side and the wide-area power system.

Kobayashi: On the generation side, we are taking two different approaches to power system stabilization. One is the use of batteries that can be charged and discharged to minimize fluctuations in the output of renewable energy, as described by Mr. Komiya.

The other is to combine these with other power sources to absorb fluctuations, our objective being to improve the performance of coal-fired power plants, gas turbines, and other generation methods to expand their range of operation and shorten their startup times. This will allow them to respond quickly to changes in load.

Development of Technology to Meet Global Needs

Nishino: It is anticipated that improvements in equipment energy efficiency and elsewhere will mean that future increases in demand for electric power in Japan will be small. Meanwhile, the International Energy Agency estimates that global energy demand will have increased to about 1.7 times 2008 levels in 2030. Responding to this global demand for energy will be important in the future.

Sakamoto: When considering global needs in the energy sector, the "three Es" mentioned earlier will also be important background factors. For all nations, what will be essential will be the maintenance of energy security and environmental measures for reducing carbon dioxide (CO_2) emissions.

Also, while frugal engineering and cost-saving and economical engineering have become topical subjects, global deployment requires that economics be considered at the system level rather than at the level of individual products, in accordance with the situation in each market. Delivering systems at an appropriate price and quality is important for satisfying global needs.

Hoizumi: Against a background of demand for higher efficiency, gas turbines and gas combined cycle plants are becoming the mainstream technology around the world for gas-fired thermal power generation, and it is anticipated that this trend will continue in the future. Hitachi is conducting ongoing research and development aimed at improving gas turbine efficiency, and we are responding to demand for greater efficiency by enlarging the gas turbine capacity, using

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Since joining Hitachi, Ltd. in 1982, he has worked on the development of low-NO*x* burners for coal-fired power plants. He is currently engaged in the development of equipment and systems for thermal, nuclear, and renewable power generation.

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the proven technology of the 30-MW-class H-25 gas turbine as a base for developing the 100-MW-class H-80. More than 150 H-25 gas turbines have been sold throughout the world.

For coal-fired power generation, our strategy is to focus primarily on India, Southeast Asia, and Eastern Europe where demand is strong, and we are seeking to take advantage of Hitachi's strength in coordinating entire plants, with an involvement in key equipment including boilers, steam turbines, generators, and air quality control systems.

Although coal varies widely in quality, from high-grade bituminous coal to low-grade lignite, Hitachi has combustion technologies for many different grades of coal, and we can supply a variety of different types of power plant to suit a wide range of different requirements in different countries. To comply with environmental regulations, we are also directing our efforts at flue gas treatment technologies and products to reduce the impurities in flue gas such as nitrogen oxides (NO_x), sulfur oxides (SO_x), and particulate matters.

Kobayashi: Hitachi Research Laboratory is working on improving gas turbine efficiency from a variety of different angles. It is also working on using the shapes of the compressor, turbine, and other components to reduce fluid losses, techniques for improving the efficiency of the gas turbine itself, techniques for increasing the combustion temperature of combined cycle systems to improve their efficiency, and improvements in environmental performance to reduce the generation of NO_x.

Hitachi is also striving to boost efficiency through innovations to the system itself. A good example of this is Hitachi's proprietary advanced humid air turbine (AHAT) technology. Unlike a conventional combined cycle system, AHAT is a next-generation gas turbine power generation system that does not use a steam turbine. It achieves efficiency that is equal to or better than that of combined cycle power generation at low cost through the use of humid air. Demonstrations aimed at commercialization are currently in progress.

In the field of coal-fired power generation, we are working on improving the efficiency of power generation from lignite across the total system, using technology for removing the high moisture content of lignite as a base. Hitachi Power Europe GmbH is taking a central role in the development of this technology.

Tanikawa: In global terms, nuclear power generation provides a low-cost means of generating large amounts of electric power reliably without emitting CO_2, and its use is anticipated to grow in emerging economies in particular. The advanced boiling water reactor (ABWR) is a third-generation boiling water reactor that has demonstrated a track record of reliable operation since being installed at Units 6 and 7 of the Kashiwazaki-Kariwa Nuclear Power Station of Tokyo Electric Power Co., Inc. This success has attracted attention from overseas, and the installation of ABWRs is currently under consideration in the Socialist Republic of Viet Nam, Republic of Lithuania, and UK. With the aim of supplying highly reliable ABWR plants to overseas countries, Hitachi is working on ABWR designs that incorporate additional safety enhancements based on experience from the Fukushima accident.

Komiya: The global market for T&D is also predicted to grow strongly. The factors underlying this include vigorous investment in electric power and the expansion of grids in emerging economies, and there is a growing need for strengthening wide-area interconnections through the use of long-distance and high-voltage direct current power transmission. In China, a 1,000-kV-class alternating current grid that uses Hitachi ultra-high-voltage (UHV) switchgear has entered commercial operation. In developed economies, meanwhile, demand is expected from the upgrading of aging substation equipment that was supplied around 1970.

Other expectations for the future include the growing adoption of smart grids and enhancements to transmission networks to cope with the introduction of renewable energy. In the T&D business, our aim is to respond to global needs

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by supplying solutions that fuse IT with T&D systems through the installation of "strong and smart grids."

New Energy Technologies that Open up Future Possibilities

Nishino: Along with initiatives aimed at the near future, the energy sector also demands a long-term outlook. What do you think Hitachi should be doing in terms of looking to the future?

Sakamoto: Whether it be for reasons of economics or the environment, the pursuit of higher efficiency is a long-term priority. While restrictions on CO_2 emissions have stalled somewhat due to political factors in different countries, I believe that there remains great potential for technological solutions achieved through innovation, such as the way the world's energy situation has been transformed by the ability to extract shale gas at low cost, for example.

In Japan, electric power systems reform, including the separation of generation and transmission, is currently under consideration, while, from a technical perspective, there is a need to work on technologies for improving the energy efficiency of the power system itself as well as the mechanisms of electric power distribution.

Hoizumi: Two means of enhancing efficiency that we are focusing on in particular are advanced ultra-supercritical (A-USC) and integrated coal gasification combined cycle (IGCC) technology. Whereas the current leading-edge ultra-supercritical (USC) technology operates with a steam temperature of 620°C, we are participating in a national project that is developing A-USC with a steam temperature in the 700°C range.

IGCC is a technology for producing more electric power from the same amount of coal by converting the solid coal into a gas that can be used to fuel a gas turbine and generate electric power using a combined cycle process. Hitachi is participating in the Coal Energy Application for Gas, Liquid and Electricity (EAGLE) technology development project, and is using the results of this research as the basis for the design and fabrication of a large 170-MW demonstration plant for Osaki CoolGen Corporation that is intended to commence operation in 2017.

In the field of environmental technology, we are working on carbon capture and storage (CCS). We have developed an absorption liquid that can capture CO_2 from boiler flue gas with high efficiency, and are currently planning a test facility in partnership with the Saskatchewan Power Corporation in Canada. Our aim is to utilize these technologies to achieve coal-fired power generation that is both economically viable and places a low load on the environment.

Kobayashi: One of the important technologies that underpins this innovation is that of materials. We are developing metals that can withstand temperatures as high as 800°C for use in A-USC. Use of materials with superior heat tolerance helps reduce plant costs by allowing important equipment to use thinner structures.

For CCS, we are developing CO_2 capture technology that uses a solid adsorption agent and delivers better plant efficiency than the chemical solvent method. As we work toward commercialization, we are now approaching the end of the material development phase.

Tanikawa: In the field of nuclear power, we are proceeding with the development of next-generation reactors with world-leading levels of safety and economics. Looking further ahead, our intention is to develop technology for reactors with intrinsic safety in which fuel melting cannot occur.

Saeki: While renewable energy currently supplies about 10% of Japan's electric power, hydroelectric power accounts for most of this, with photovoltaic and wind representing less than 1%. There is no doubt that there are significant challenges in the way of achieving the target of raising this proportion to 30% by 2030. If photovoltaic power were to provide 10% of our power needs, for example, this would require an installed capacity of 97 GW (at a utilization of 12%), equivalent to 97 standard nuclear power plants. In addition to the acquisition of land and cutting the cost of generation, achieving this will also require technology for reducing the load it will place on the grid as a system.

Similarly, an installed capacity of 46 GW (at a utilization of 25%) would be required for wind to provide 10% of our power needs. As finding space for this on land will be difficult, it is likely that offshore wind power generation will play a valuable role. Having already supplied wind turbines with capacity of 2,000 kW, we also need to contribute to achieving the target by developing technology for floating turbines as well as using larger sizes to improve economics.

Komiya: In T&D systems, it is power system stabilization technologies that hold the key to the future. We are focusing our efforts on developing smart next-generation T&D systems based around Hitachi's technologies for more robust grids that combine renewable energy, batteries, and IT.

Nishino: The Great East Japan Earthquake has highlighted numerous issues in the energy sector. The earthquake has added an "S," safety, to the "three Es" mentioned by Mr. Sakamoto. I hope that we can contribute to building new energy systems that learn from the experience of the earthquake, and that use technology to underpin the "three Es + one S" by bringing together the diverse capabilities of Hitachi.