Overview

Future of Solution Business for Electric Power and Energy Sectors

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INCREASINGLY DIVERSE REQUIREMENTS OF ELECTRIC POWER INFRASTRUCTURE

THE requirements for the electric power infrastructure are becoming increasingly diverse, including global environmental problems, the concentration of the population in cities, growing use of renewable energy, and the aging of infrastructure, particularly in developed nations. Dealing with this requires not just equipment reliability but also the combination of different information and other advanced technologies. This article draws on the trends in electricity markets to explain these increasingly diverse requirements and the measures needed to satisfy them, and describes Hitachi's solution businesses for the electric power and energy sectors.

TRENDS IN ELECTRICITY MARKETS

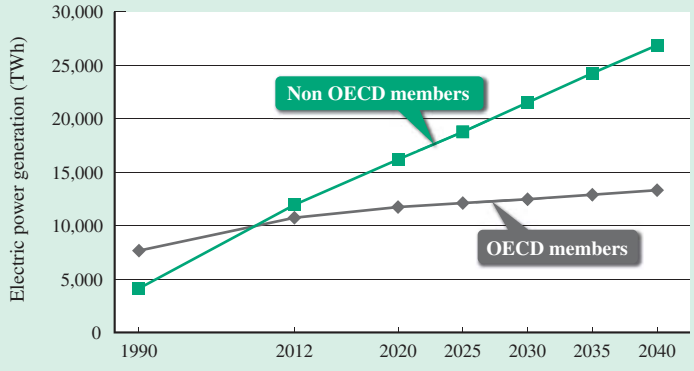
The situations facing electric power infrastructure are becoming increasingly diverse geographically. This article divides these into developed nations that are experiencing flat growth in demand for electric power, emerging nations where growth is strong (see Fig. 1), and Japan, which is in the process of implementing electricity market reforms.

Electricity Market Trends in Developed Nations

The following are some of the problems faced by developed nations that have a high level of existing infrastructure.

(1) Dealing with global warming

At the 21st Conference of Parties (COP21) of the United Nations Framework Convention on Climate Change held in November and December 2015, the participating nations sought to agree on targets for reducing emissions of greenhouse gases. In anticipation of this, nations presented ambitious reduction targets in August 2015, conveying a sense of their commitment to dealing with global warming. To give some examples, the USA presented a target of reducing greenhouse gases emissions by 26 to 28% relative to 2005 by 2025, the European Union (EU) presented a target of a reduction within its territory of at least 40% relative to 1990 by 2030, and China presented a target of reaching



OECD: Organisation for Economic Co-operation and Development

Fig. 1—Electric Power Demand Forecast.
While demand is forecast to remain flat in the developed nations of the OECD, rapid growth is forecast for non-member emerging nations.

its peak carbon dioxide (CO_2) emissions around 2030, with emissions per unit of gross domestic product (GDP) to fall by 60 to 65% relative to 2005 by 2030. Japan set a target of reducing its greenhouse gases emissions by at least 32% relative to 2010 by 2030.

(2) Grid stabilization

While the installation of wind, photovoltaic, and other renewable energy is progressing, prompted by this rising environmental awareness, these power sources differ from thermal and other forms of generation in that their output varies due to factors such as the weather. However, electric power grids need to maintain a continuous balance between the supply and consumption of electric power, and this becomes more difficult the greater the proportion of variable power sources. Normally supply and demand are kept in balance by control of thermal power plants such as diesel generators or gas turbines that have a rapid response, meaning that in some cases the capacity of these adjustable forms of electric power set a limit on how much renewable energy can be utilized. This presents an obstacle to implementing the measures for dealing with global warming described above.

(3) Aging of equipment

The bulk of social infrastructure in developed nations, including electric power and energy equipment, has been in place for a long time. The many faults in aging equipment that occur as a result of this are a recognized problem. For example, a document published by the New York Independent System Operator (NYISO), a grid operator in the USA, states that more than 80% of the transmission infrastructure in that state is more than 30 years old, and that dealing with aging equipment has become a challenge.

(4) Introduction of market principles

To enable transmission system operators[(a)] (TSOs) to maintain grid stability while minimizing capital investment, there is a trend toward some developed nations opening up electricity services to the market. This includes moves to open up the ancillary services market for balancing the supply and demand for electric power to third party suppliers in places such as Germany and by some US TSOs. The term "ancillary services" refers to services for balancing supply and demand so as to minimize fluctuations in frequency, voltage, and other power quality parameters. By opening up this business to parties other than the TSO, the market provides the spare capacity needed for maintaining grid stability while keeping investment by the TSO to a minimum.

(a) TSO
Abbreviation of "transmission system operator," a company that owns and operates the ultra-high-voltage grid in a particular region.

Electricity Market Trends in Emerging Nations

Fig. 1 shows how recent years have seen a notable rise in the demand for electric power from emerging nations, which are not members of the Organisation for Economic Co-operation and Development (OECD). This is an example of a market trend in emerging nations. The trend is expected to continue, driven by such factors as rising populations, economic growth, and the movement of people from rural to urban living.

Meanwhile, island nations and nations with large land areas have concerns about the size of their investment in grid infrastructure. As many of these nations use small power plants with low efficiency that cost a lot to fuel, there is potential for using renewable energy to reduce fuel costs.

Electricity Market Trends in Japan

This section looks at the trends in the Japanese electricity market in terms of the long-term energy mix and the progress of the electricity reforms.

(1) Long-term outlook for energy supply and demand

Electric power and energy needs to be considered not only in economic terms, but from the "3E+S" perspective of energy security, economic efficiency, the environment, and safety. Accordingly, the Long-term Energy Supply and Demand Outlook published by the Ministry of Economy, Trade and Industry (METI) in July 2015 considered the mix of electric power sources in 2030 Japan shown in Fig. 2. Along with keeping demand for electric power equal to the level in FY2013 through comprehensive energy efficiency measures, achieving this and raising the level of energy self-reliance will require use of nuclear energy to provide base-load power equivalent to about 20% of the total, and an increase in renewable energy to between 13% and 15%, including the aggressive expansion in the use of geothermal, hydro, and biomass energy, which are reliable forms of power generation.

(2) Electricity market reforms

To facilitate progress in things like living standards and economic growth, post-war Japan placed top priority on the security of the electric power supply. This led to the establishment of an electricity market based on vertically integrated regional monopolies. This provided a steady return on investment in large power plants and served as a foundation for security of supply and economic growth.

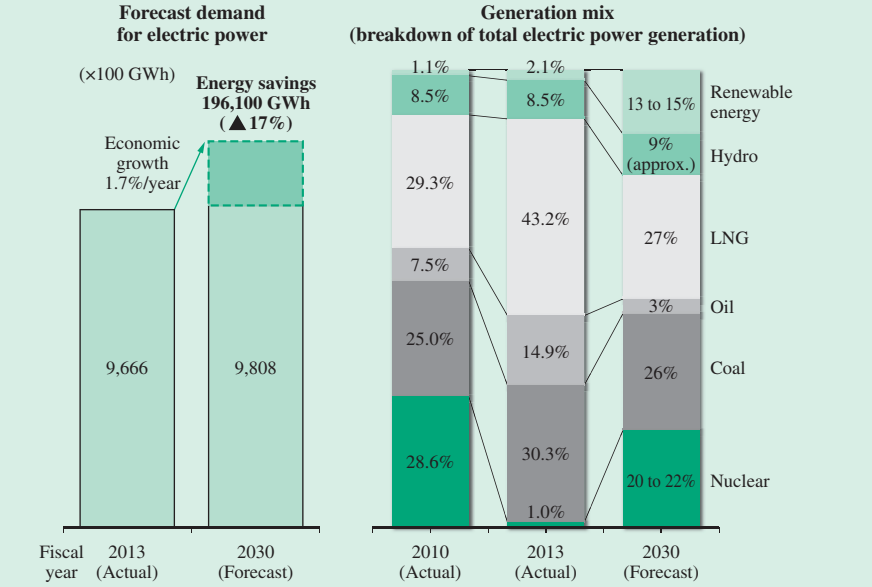


Fig. 2—Long-term Energy Supply and Demand Outlook. Achieving these targets will require comprehensive measures for energy efficiency as well as a better ratio of energy supply and demand using nuclear and renewable energy.

Reflecting an international trend toward deregulation, however, the 1990s saw growing calls for liberalization from within Japan. The trend toward deregulation, which began in the 1990s with the freeing up of "special high-voltage electric power" retailing, still continues. Subsequent developments include the establishment of the Organization for Cross-regional Coordination of Transmission Operators, JAPAN (OCCTO) in 2015 to expand interconnection between regional grids, full liberalization of electricity retailing, including small consumers in 2016, and the planned legal separation of transmission network operators and abolition of retail price controls in 2020. These measures are being undertaken with aims that include ensuring security of supply, minimizing electricity prices, expanding options or use of electric power, and creating new business opportunities for companies.

In the future, this will accelerate entry into the electric power business by companies from other industries, not just the existing electric power companies, with participation being considered by, for example, gas companies and retailers as well as Internet, mobile phone, and other telecommunication companies. Along with the intensification of competition, this is expected to open up new business opportunities.

PLANS FOR HITACHI'S SOLUTION BUSINESS

Hitachi is a one-stop supplier of optimal solutions to the market for electric power systems, which is subject to the ongoing reforms described above. These solutions extend from generation to distribution and consumer systems. Hitachi is contributing to the establishment of reliable electricity systems by drawing on its accumulated technologies and knowledge to supply best solutions to power companies and new entrants to the electricity markets (known as power producers and suppliers), consumers, and various other stakeholders through collaborative creation with customers that encompasses the implementation and operation of transmission, distribution, and interconnection systems, renewable energy, management services for consumers, and systems for the full liberalization of electricity retailing (see Fig. 3).

SOLUTIONS FOR MARKET NEEDS

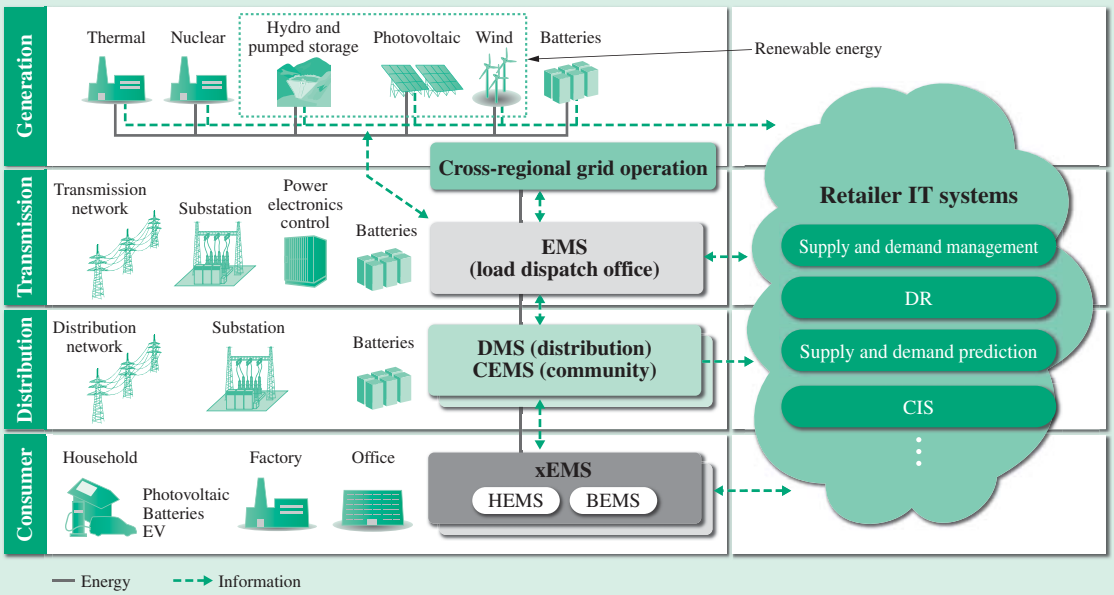
Because customer needs are becoming more diverse, as described above, there is a need for flexibility in the supply of solutions to these needs.

The following are some of the solutions supplied by Hitachi.

Ensuring Reliable Power Sources

As noted above, there is demand for increasing the supply of electric power, particularly in emerging nations.

It is anticipated that thermal power will remain the main form of generation. In this sector, Hitachi, Ltd. and Mitsubishi Heavy Industries, Ltd. established



EMS: energy management system DMS: distribution management system CEMS: community energy management system
HEMS: home energy management system BEMS: building energy management system EV: electric vehicle IT: information technology
DR: demand response CIS: customer information system

Fig. 3—Hitachi Electric Power and Energy Solutions.
Hitachi supplies total solutions that extend from generation to transmission, distribution, and retailer IT systems.

Mitsubishi Hitachi Power Systems, Ltd. as a joint venture in February 2014 with the aim of becoming a leading international supplier of thermal power plants, including by offering a wide range of gas turbine products, for example, that extends from the highly efficient large models that have been the focus of Mitsubishi Heavy Industries in the past to the small and medium-sized models in which Hitachi has specialized.

Similarly, in the nuclear power sector, Hitachi combined its commercial resources with US company General Electric Company (GE) in July 2007 to form Hitachi-GE Nuclear Energy, Ltd. As one of the few specialist nuclear power manufacturers in the world, Hitachi-GE Nuclear Energy builds nuclear power plants and supplies maintenance and services.

Reduction in Emission of Greenhouse Gases

Having been a subject of debate at international bodies, measures for dealing with global warming are in the process of becoming national obligations. In particular, reducing carbon emissions by forms of electric power generation that emit large amounts of greenhouse gases is a very significant problem for society. Hitachi is able to supply equipment for the generation of renewable energy that includes wind and photovoltaic power plants.

In the case of megasolar projects (large photovoltaic power plants), Hitachi handles engineering, procurement, and construction (EPC). Hitachi has an extensive involvement in a wide range of important equipment used in megasolar power generation systems, including operation monitoring and instrumentation systems as well as highly efficient power conditioning systems[(b)] (PCS) and amorphous transformers that consume low levels of electric power in standby mode.

Hitachi also produces wind turbines with a downwind configuration, meaning that the nacelle is on the upwind side of the blade. A feature of downwind rotors is that they can yaw freely during strong winds (the nacelle is not locked to prevent yaw rotation), meaning the nacelle will naturally orient itself into the wind and move in response to cross winds (which pose the greatest risk to wind turbines). As Japan has a lot of mountainous regions, wind turbines are often located on undulating ground such as hillsides where they are subject to the updrafts caused by the wind blowing across this uneven terrain. However, because the rotor plane of a downwind rotor is oriented downwards

(b) PCS
Abbreviation of "power conditioning system," meaning a device that converts the direct current (DC) power generated by a photovoltaic power system to the alternating current (AC) conventionally used by households and other consumers. PCSs are also used to convert the DC power from fuel cells and batteries.

relative to the upwind direction, they are able to deal with updrafts efficiently and can achieve higher generation efficiency than an upwind configuration.

Hitachi has a model with a maximum output of 2 MW for land and offshore sites, and a 5-MW model primarily for offshore use. The first 5-MW model was completed in March 2015 and Hitachi hopes to expand this business in the future.

Nuclear power is another form of generation that does not emit a large amount of greenhouse gases. The UK government in particular is pushing ahead with nuclear power with the aim of creating a low-carbon society, with Horizon Nuclear Power Limited being established in 2009 with the aim of constructing new nuclear power plants. Hitachi acquired Horizon in November 2012 and plans to build nuclear power plants in the 5,400-MW class or larger at Wylfa on the island of Anglesey, and Oldbury-on-Severn in South Gloucestershire. The intention is to construct the plants using technology from the advanced boiling water reactor (ABWR), the only third-generation nuclear reactor to enter commercial operation.

The construction project is currently at the stage of obtaining approvals from the UK government. One of the main approvals is the generic design assessment (GDA). The project has already completed the third of four steps in the GDA approval process, with the fourth step currently in progress. The nuclear power plant construction project will get underway once all approvals have been obtained.

Response to Electricity Reform and Retail Liberalization

The electricity reforms require a neutral agency that can operate the grid at a cross-regional level over and above the traditional electric power company territories. In Japan, this agency is the OCCTO, and Hitachi is currently working on the cross-regional operation system for which it was awarded the contract. The OCCTO handles the supply and demand monitoring required for electric power suppliers to operate across regional boundaries, and is responsible for issuing supply orders and other tasks associated with cross-regional coordination at times of tight supply such as during disasters. Hitachi will contribute to the reliable operation of cross-regional grids by drawing on its experience with systems for grid monitoring, grid stabilization, and power trading built up through its past work on supplying load dispatch offices (command centers), the power trading system for the Japan Electric Power Exchange, and other infrastructure.

Preliminary applications for registration as an electricity retailer (a requirement for participation in the electricity retail business) have already opened in anticipation of the full liberalization of electricity retailing in 2016. With a total of 40 companies having registered as of October 26, 2015, a large number of new entrants to the electricity retailing market are anticipated. As these new entrants require a variety of information technology (IT) systems, such as those for managing customer information, contracts, meter data, and supply and demand, this has the potential to pose a significant barrier to entry. Hitachi Systems Power Services, Ltd., a Hitachi group company, supplies IT systems able to be used under full liberalization of electricity retailing in the form of a cloud service. Use of a cloud-based service enables businesses to get up and running quickly with a smaller investment, while also providing flexible operation in accordance with factors such as the number of retail customers and the size of the operation.

Grid Stabilization Solutions

The rising environmental awareness referred to earlier has led to increasing use of wind, photovoltaic, and other forms of renewable energy. Unlike thermal power generation, the output of these forms of generation fluctuates due to factors outside human control, such as the weather. Electric power grids need to maintain a continuous balance between the supply and consumption of electric power, and the greater the proportion of variable power sources the more essential it is that this balance be maintained. One way to achieve this is through the use of batteries for energy storage.

Hitachi has developed the CrystEna container-type energy storage system shown in Fig. 4 and is participating in a demonstration project in the US market for frequency regulation.

PJM(c), the largest independent grid operator in the USA, operates a market for frequency regulation to provide short-term adjustments to the balance of supply and demand to deal with factors such as the widespread use of variable power sources. The market for frequency regulation in the region managed by PJM is open to participants with batteries or other energy storage systems who submit bids for supply and demand balancing. CrystEna combines lithium

(c) PJM
A regional transmission organization that covers 13 states in the US central east coast and mid-west. The name “PJM” stands for Pennsylvania, New Jersey, and Maryland.

Fig. 4—CrystEna.
Providing an all-in-one package that includes the batteries, PCS, controller, and air conditioning minimizes the time and work required for installation.

ion batteries with a PCS, battery management system, cooling, and firefighting system in a 12-m container. Utilizing CrystEna in the demonstration project for the PJM frequency regulation market allows Hitachi to collect operational data and verify the performance of the battery system and its efficacy for grid stabilization.

Meanwhile, factors such as the installation of large amounts of renewable energy and the progress of the electricity reforms have led to a rising need for the cross-regional balancing of supply and demand. In Japan in particular, there is a growing demand for high-voltage direct current (HVDC) transmission systems due to factors such as the different frequencies used in the east and west of the country and the installation of large amounts of renewable energy.

Having participated in all previous HVDC projects in Japan, Hitachi established a joint venture in October 2015 with ABB, an international electrical and automation company, to work on HVDC projects in Japan. Through this joint venture, Hitachi intends to contribute to cross-regional grid interconnection in Japan by combining the project management capabilities and quality assurance it has built up through experience in Japan with the leading-edge HVDC technology of ABB.

Microgrids and Smart Energy Solutions

As already noted, factors such as the installation of large amounts of renewable energy capacity on the grid make its operation difficult. Two advanced measures for dealing with this are microgrids and smart energy practices.

Microgrids are small sub-grids that balance their own supply and demand for electric power without relying on the main grid, and either are not connected to the grid or are able to disconnect and continue operating in the event of an emergency. Hitachi can supply microgrids of many different types using power sources, energy management systems (EMSs), and other component parts.

The balancing of supply and demand is commonly done by controlling the power supply (generation). While it is easier for grid operators to only have to control a small number of generators, the large number of consumers makes it difficult to control demand. Accordingly, conventional grid operation keeps supply and demand in balance through control of thermal power plants with a rapid response, such as diesel generators or gas turbines.

However, advances in IT mean it is now possible to use demand-side control to balance supply and demand. The systems used for this purpose are called demand-side management (DSM) systems. DSM systems may be incentive-based, whereby consumers are paid incentives in accordance with the amount by which they reduce demand at such times as when grid operators find it difficult to balance supply and demand, or time-of-day pricing schemes that are designed to encourage consumers to reduce their peak demand voluntarily.

These smart energy solutions rely on equipment (such as power sources and distribution infrastructure) and on knowledge and expertise in both IT and control technology. By consolidating knowledge in these fields built up over many years, Hitachi intends to build and supply to customers a wide variety of smart energy solutions.

ADOPTION OF SOLUTION-BASED BUSINESS MODELS

To respond to the increasing diversity of societal needs resulting from changing trends in the electricity market, it is essential to establish solution-based business models that can adapt flexibly to customer requirements. Hitachi intends to combine IT with equipment manufacturing know-how built up over time to adopt solution-based business models and contribute to overcoming the challenges faced by society and customers.

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