The Electric Power Industry in Japan 2020

JEPIC

JAPAN ELECTRIC POWER INFORMATION CENTER, INC.

JEPIC

Japan Electric Power Information Center, Inc. (JEPIC) marked the 60th anniversary of our founding in May 2018. Established in 1958 as a non-profit association of Japan's electric utility industry, our primary purpose is to meet the increasing need for systematic and sustained exchange of information with electric utility industries around the world. In response to government policy, JEPIC also initiated technical cooperation programs for developing countries in the field of electric power soon after our founding. These programs remain one of our main activities today.

Research and Information Activities

JEPIC conducts research on the electric power industry in foreign countries in light of situations and issues faced by the industry in Japan today. We provide information from those studies in various ways to contribute to the industry worldwide. JEPIC also works to enhance cooperation with foreign electric utilities and other related organizations.

Exchange and Cooperation Activities

JEPIC is promoting information exchanges with the foreign electric utilities and organizations in the electric utility industry by holding regular meetings, and taking part in international conferences and symposia.

International Cooperation

With the support of the member companies, JEPIC promotes integrated international cooperation programs for developing countries, mainly in Asia, for the purpose of improving power infrastructure and nuclear power safety in those countries and sharing of general information. These programs include human resource development efforts such as seminars that JEPIC coordinates. JEPIC both receives the participants of these seminars to Japan and dispatches experts to their countries. Including these seminar programs, JEPIC carries out the following tasks:

- Cooperation with electric utilities in ASEAN countries
- Technical cooperation under ODA programs
- Technical cooperation for nuclear power safety

Contents

Utility category	Utility name
Electricity transmission utilities	J-POWER
Electricity generation utilities	J-POWER Japan Atomic Power Co. New entrants Former general electricity utilities
General electricity transmission and distribution utilities	Former general electricity utilities
Electricity retailers	Former general electricity utilities New entrants

Former general electricity utilities:

- Hokkaido Electric Power Co.
- Tohoku Electric Power Co.
- Tokyo Electric Power Company Holdings
- Chubu Electric Power Co.
- Hokuriku Electric Power Co.
- Kansai Electric Power Co.
- Chugoku Electric Power Co.
- Shikoku Electric Power Co.
- Kyushu Electric Power Co.
- Okinawa Electric Power Co.

Executive Summary

I. Structure of the Electric Power Industry

- Liberalization of entry to the power generation sector commenced in 1995 at a time when generation and transmission were integrated along regional lines under 10 general electric utilities. Liberalization of the retail supply of electricity to all except low-voltage customers was then implemented in stages between 2000 and 2005.

- Policy on reform of the electricity system was adopted in April 2013, and in the first phase of reform, the Organization for Cross-regional Coordination of Transmission Operators (OCCTO) was established in April 2015. In the second phase, the Electricity Market Surveillance Commission (now called the Electricity and Gas Market Surveillance Commission) was established in September 2015 to strengthen oversight of the liberalized electric power market. Liberalization of the electric power retailing and generation sectors was completed in April 2016. In the third phase, legal separation of transmission and distribution from vertically integrated businesses is scheduled to be implemented in April 2020. Meanwhile, plans to abolish regulated electricity rates in April 2020 have been put on the back burner.

II. Energy Policy

- Under the philosophy of 3E+S (energy security, economic efficiency, and environment plus safety), the electricity sector aims to achieve a more balanced power generation mix by improving the efficiency of thermal power plants, reducing dependence on nuclear power, and expanding use of renewables.

- As of the end of August 2019, 15 nuclear reactors have been declared compliant with the new regulatory standards and granted permission to have their installation licenses amended accordingly. Nine of these have already reentered commercial service. The remaining six reactors that have been confirmed compliant and a further 21 reactors that are currently shut down or under construction are expected to eventually start or restart operation. Japan's remaining 24 reactors have been earmarked for decommissioning, including the reactors involved in the accident at Fukushima Daiichi Power Plant.

- Installed capacity of renewables (especially solar) increased as the result of a feed-in tariff (FIT) scheme. The government is considering completely overhauling the FIT scheme by the end of fiscal 2020. Meanwhile, competition for customers is hotting up as electricity retailers respond to the progressive termination of purchase periods from November 2019 by offering a variety of purchase price plans.

- In June 2019, the Japanese government submitted a long-term strategy for reducing emissions to the UN Secretariat, setting a concrete target of achieving an 80% reduction in greenhouse gas emissions by 2050. It calls for innovation coupled with a virtuous circle of environmental and economic growth to solve environmental issues.

III. Supply and Demand

- In fiscal 2017, electricity demand in Japan was 977 TWh and peak national demand came to 156 GW.

- In fiscal 2017, electric power generated in Japan came to 1,007 TWh, of which 16 TWh was generated by solar power and 6 TWh by wind power.

IV. Supply Structure

- Total generating capacity in Japan came to 306 GW at the end of fiscal 2018. This consisted of 161 GW of thermal power, 49 GW of hydro power, 57 GW of renewables (excluding hydro), and 38 GW of nuclear power. Development of 33 GW of generating capacity is planned from fiscal 2018 to fiscal 2028. This consists of 16 GW of thermal power, 7 GW of renewables (excluding hydro), and 10 GW of nuclear power.

- As of the end of March 2018, the former general electricity utilities had provided 49% of low-voltage customers with smart meters. All customers are expected to have smart meters by the end of March 2025.

- Tohoku Electric Power Co. and Hokkaido Electric Power Co. are now connected via two interconnection routes providing a total of 900 MW. The second route (300 MW) entered service in March 2019.

- Traditionally, grid facilities have been boosted according to power source grid capacity. However, a new approach is being taken now to make effective use of existing facilities by adopting the "connect and manage" model already used in the United Kingdom and elsewhere.

V. Retail Business and Trading Markets

- As of the end of February 2019, 9.44 million low-voltage customers (including households) have switched suppliers, accounting for 15% of the total number of low-voltage customers. With the market now fully liberalized, electricity retailers are offering a variety of rate plans tailored to customers' needs and lifestyles.

- The volume of trades on the JEPX spot market has been on the rise, reaching 209 TWh in fiscal 2018. This is more than a three-fold increase in year-on-year terms and means that about one quarter of all electricity sold in Japan is sold through JEPX. The average system price has hovered around the 8-9 yen/kWh mark and stood at 9.76 yen/kWh in fiscal 2018

- A baseload trading market was created, and the first baseload trades of fiscal 2020 took place in August 2019. The system prices were 12.47 yen/kWh in the Hokkaido area, 9.77 yen/kWh in the Tohoku/Tokyo area, and 8.70 yen/kWh in the West Japan area. Trade volumes came to 13 MW in the Hokkaido area, 88 MW in the Tohoku/ Tokyo area, 83 MW in the West Japan area, and 184 MW in the three areas combined.

- The creation of a capacity market and a balancing market is now under consideration, with a view to launching these markets in or after fiscal 2020.

I. Structure of the Electric Power Industry

1. History of the Electric Power Industry in Japan

(1) Establishment of a System Comprising 10 Electric Utilities

Japan's electric power industry came into being in 1886 with the commencement of operations by the Tokyo Electric Light Company, which was formed with private capital. Numerous electric utilities were subsequently established around Japan to serve growing demand for electricity driven by increasing industrialization. By the early 1930s there were more than 800 utilities. However, fierce competition engendered by the prolonged depression led to a series of mergers and acquisitions, and Japan's electric power industry ultimately coalesced around five utilities.

As Japan headed into World War II, the electric utilities came under the control of the government. In 1939, the government established the Japan Electric Generation and Transmission Company and electricity generation and transmission facilities came under centralized control. The government also consolidated the electricity distribution business into nine separate blocks. Following World War II, the Japan Electric Generation and Transmission Company was dissolved in May 1951 and the company's facilities and functions were transferred to nine privately-owned electricity distribution utilities. As a result, a regime of regional monopolies was established based on integrated systems of electricity generation and transmission in nine regions. The number of utilities then increased to 10 with the establishment of Okinawa Electric Power Co. following the reversion of Okinawa to Japanese control in 1972.

These electric utilities systematically invested in power supply facilities to meet a growing demand for electricity driven by Japan's rapid economic growth. As private enterprises, they simultaneously sought to deliver affordable, stable supplies of electricity while continuing to make management efforts to maximize shareholder equity. As a result, they contributed significantly to Japan's rapid economic growth in the 1950s and 1960s by providing high quality, affordable electricity with a minimum of outages. Although these utilities introduced electricity rate hikes in the wake of the global oil crises of the 1970s, they lowered rates several times between the 1980s and 2000s, successfully providing the power that supported the development of Japan's economy.

(2) Increasing Liberalization of the Electricity Market

Following the trend toward deregulation in the electric power industry in Western countries, the liberalization of entry into the electricity generation sector started in 1995 in Japan, followed by retail supply liberalization for customers receiving extra high-voltage (20 kV or above) in 2000. The scope of deregulation was expanded further in stages thereafter: to high-voltage (6 kV) customers with contracted demand of 500 kW or above, in principle, in April 2004, and to all customers in the high-voltage category (those with a contracted demand of 50 kW or above) in April 2005.

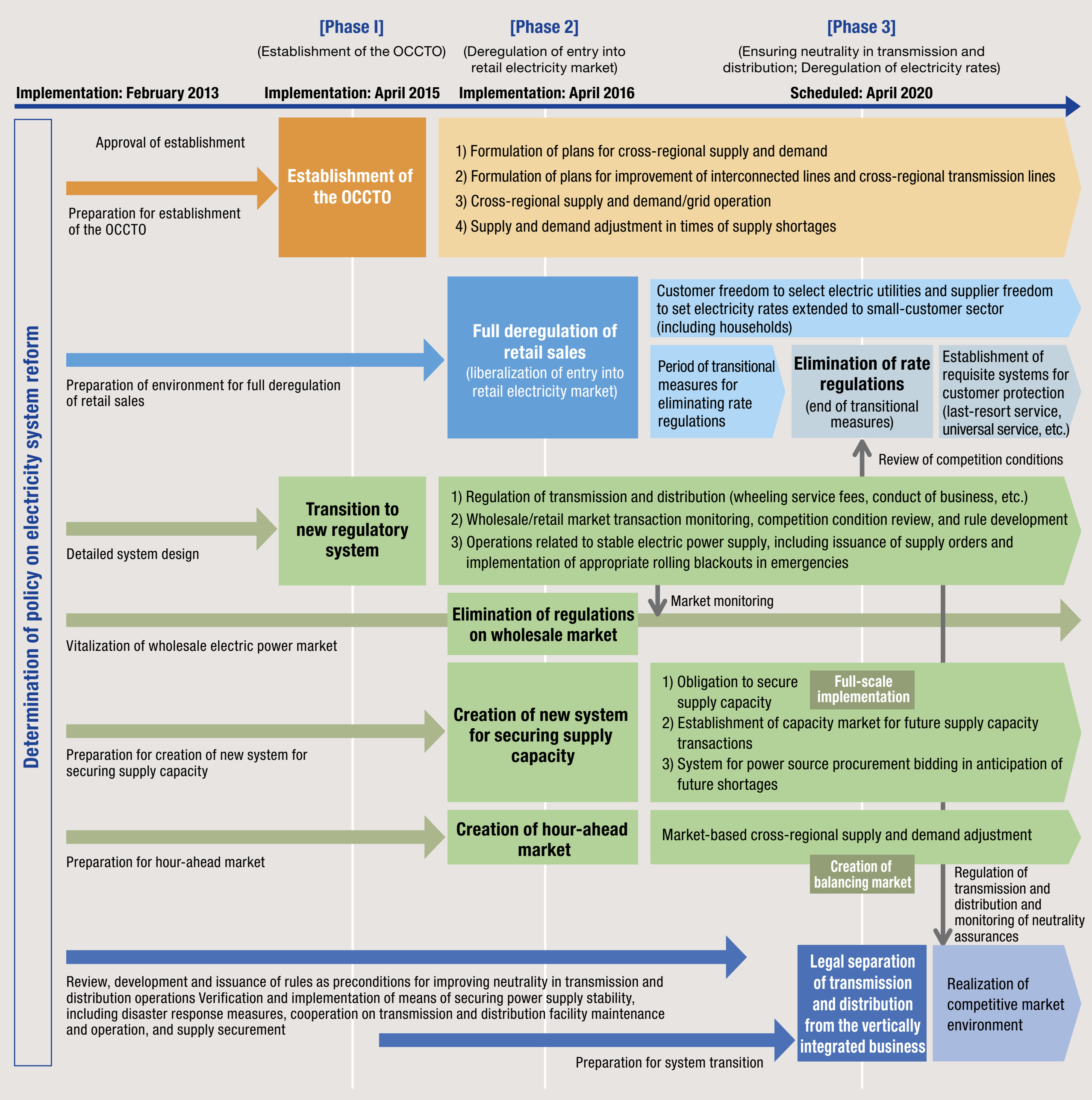
However, power shortages and other issues caused by the 2011 Great East Japan Earthquake prompted discussion of the ideal configuration of the nation's electric power system and its reform. Based on this discussion, reform of the electricity supply system has been pursued in three stages since 2015.

(3) Electricity System Reform

The Policy on Electricity System Reform describing the overall shape of reform was approved by the Cabinet in April 2013. This policy divided the reform process into three phases: 1) establishment by 2015 of an Organization for Cross-regional Coordination of Transmission Operators (OCCTO) to act as a command center responsible for managing supply and demand spanning different service areas; 2) full liberalization of entry into the retail electricity market by 2016; and 3) the legal separation of transmission and distribution from vertically integrated businesses, and elimination of regulated retail rates by 2020.

Roadmap to Electricity System Reform

Figure 1.1



Source: Adapted from the Report of the Expert Committee on Electricity Systems Reform (February 2013)

Based on this policy, a new entity called the Organization for Cross-regional Coordination of Transmission Operators (OCCTO) was established in April 2015 with the aim of enhancing the capacity to adjust supply and demand nationwide in both normal and emergency situations. In preparation for the second phase of liberalization of the retail market, another entity, the Electricity Market Surveillance Commission (now called the Electricity and Gas Market Surveillance Commission) was established in September 2015 to strengthen oversight of the liberalized electric power market. A licensing system was then launched in April 2016 and liberalization of the electric power retailing and generation sectors was completed. Preparations are now underway as shown in Figure 1.1 for the third phase of liberalization planned for April 2020, namely legal separation of transmission and distribution from vertically integrated businesses.

The necessary legal groundwork for the third phase of electricity system reform was completed with the enactment of revisions to the Electricity Business Act in November 2013, June 2014, and June 2015. Plans to eliminate regulated rates in 2020 have been put on the back burner (see "Electricity Rates" in Section 1, Chapter V).

(4) Updated System Design

The Ministry of Economy, Trade and Industry (METI) emphasized the need to increase economic efficiency by fostering further competition in the electric power sector, while addressing a number of issues that could not be resolved solely by relying on the market alone. These issues include ensuring safety, supply stability, and environmental acceptability including the promotion of renewable energies. METI also indicated that in order to solve these issues, steps should be taken to make existing markets more liquid and to actualize new forms of value by creating completely new markets, such as a capacity market and a non-fossil value trading market.

Based on these guidelines, a number of new types of market are being considered, including (1) a baseload power market, (2) a capacity market, (3) a balancing market, and (4) a non-fossil value trading market (see "Trading Markets" in Section 3, Chapter V).

2. Current Electricity Supply System

(1) Classification of Electricity Utilities

Japan's electricity utilities had been divided into the following five categories: general electricity utilities, wholesale electricity utilities, wholesale suppliers, specified electricity utilities, and specified-scale electricity suppliers (new entrants). Subsequently, with the implementation of full liberalization of the retail market, these classifications were reviewed and a new system of issuing licenses to business operators was introduced in April 2016. At present, the licenses define three main categories of electricity generation, transmission and distribution, and retailing, and the Agency for Natural Resources and Energy imposes necessary regulations for each sector. The 10 general electricity utilities that have historically been engaged in power supply since the end of World War II are now called "former general electricity utilities."

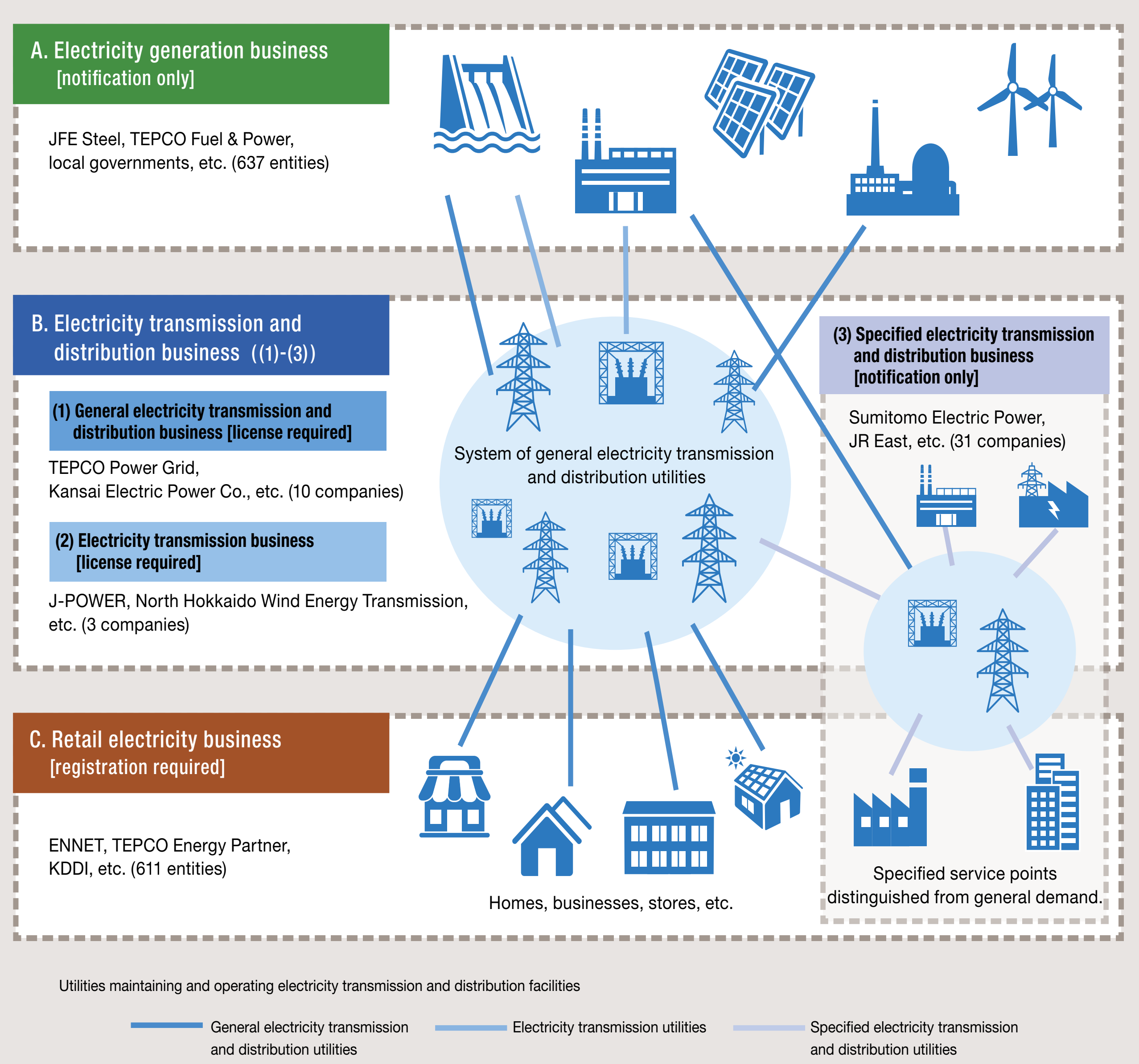
Data shows that 637 entities had obtained power generation licenses in the electricity generation sector and peak output was equivalent to 269 GW by May 2019. The group of former general electricity utilities, J-POWER and The Japan Atomic Power Co. accounted for 80% of the peak output. The main entrants other than former general electricity utilities include firms from paper manufacturing, steel manufacturing, and the gas and petroleum industries. Some local governments have also entered the power generation business, albeit on a small scale.

In the transmission and distribution sector, utilities spun out from the 9 former general electricity utilities will be required to conduct business as general electricity transmission and distribution utilities from April 2020.

In the retail sector, data released by METI's Agency for Natural Resources and Energy show that a total of 611 businesses (including the retail arms of former general electricity utilities) had obtained retail licenses (as of September 9, 2019). In addition to the 10 former general electricity utilities, PPSs (new entrants to the electricity retail sector) include telecommunications carriers, trading companies, gas and petroleum companies, steel manufacturers, and subsidiaries of former general electricity utilities. Net system energy demand in fiscal 2018 came

Electricity Supply System after Introduction of Licensing

Figure 1.2



Source: Compiled from Agency for Natural Resources and Energy, "(Reference) Electricity Power Supply Structure (from April 2016)" to 853 TWh, of which former general electricity utilities accounted for about 86%.

(2) Regulatory Organizations

a. Agency for Natural Resources and Energy

The Agency for Natural Resources and Energy is an external organ of METI. It is responsible for policies regarding energy conservation, new energies, and securing a stable, efficient supply of energy from oil, electricity, gas, and other sources. With regard to the electric power industry, the agency is responsible for developing the electricity market and electricity sources, adjusting electricity market supply and demand, and planning, devising, and promoting policies relating to nuclear power, renewables and smart communities to ensure a stable and efficient supply of electricity. The agency is given the role of supervising electric utilities.

b. Electricity and Gas Market Surveillance Commission

The Electricity and Gas Market Surveillance Commission was established in September 2015—as a separate entity from the Agency for Natural Resources and Energy in METI—in advance of the liberalization of electricity, gas, and heating supply, with the aim of further strengthening monitoring of the energy markets and related functions and encouraging sound competition. The Commission's powers include the ability to conduct on-site inspections of utilities, recommend business improvements, act as an arbitrator/mediator, approve wheeling service charges, and carry out reviews of retailer registrations. It also has the power to monitor the fairness of transactions and regulate business conduct to safeguard the neutrality of the electricity and gas network sectors.

(3) Organization for Cross-regional Coordination of Transmission Operators (OCCTO)

OCCTO was established in April 2015 as a government-authorized organization that all electricity utilities are required to join. Its objectives are to promote development of the transmission and distribution networks required to make cross-regional use of generating sources, and to strengthen the industry's capacity to adjust supply and demand nationwide in both normal and emergency situations. OCCTO is operated as a public organization authorized under the Electricity Business Act.

OCCTO's main functions include:

- To coordinate supply-demand plans and grid plans, boost the transmission infrastructure (including the capacity of frequency converters and interregional interconnections), and facilitate nationwide grid operation spanning different areas.
- To coordinate cross-regional supply-demand balancing and frequency adjustment by the transmission operators in each area under normal conditions.
- To adjust supply and demand by instructing that output be increased and power shared in the case of power shortages due to a disaster or other emergency.
- To perform, in an unbiased manner, functions relating to the acceptance of connections from new power sources and disclosure of grid data.
- To provide guidance and recommendations to electric power suppliers, handle complaints from electric power suppliers, and resolve disputes.
- To study the introduction of a supply and demand balancing market, and study and operate a capacity market as part of moves to secure supply and balancing capacity.
- To study the efficient use of electricity transmission and distribution facilities ("connect and manage").

II. Energy Policy

1. Strategic Energy Plan

The government formulated its first Strategic Energy Plan in October 2003, in accordance with the Basic Act on Energy Policy's requirement for a Basic Energy Plan to map out the basic direction of energy policy. The plan subsequently underwent several revisions, and the Fifth Strategic Energy Plan was adopted by the cabinet in July 2018 to reflect the entry into effect of the Paris Agreement.

The basic concept of the fifth plan is to achieve what are referred to as the "3E+S"—energy security, economic efficiency, and environment plus safety—given Japan's lack of domestic energy resources.

Guided by this 3E+S philosophy, the government formulated the fifth plan based on the following two key premises: firstly, that in the wake of the accident at the Fukushima Daiichi Nuclear Power Plant (Fukushima Daiichi accident), Japan should pursue the adoption of renewable energy resources and minimize its dependence on nuclear, giving top priority to its safety; and secondly, that in view of its lack of fossil fuel resources, Japan should treat its energy technologies as scarce resources and play a leading role in the development of decarbonized energy.

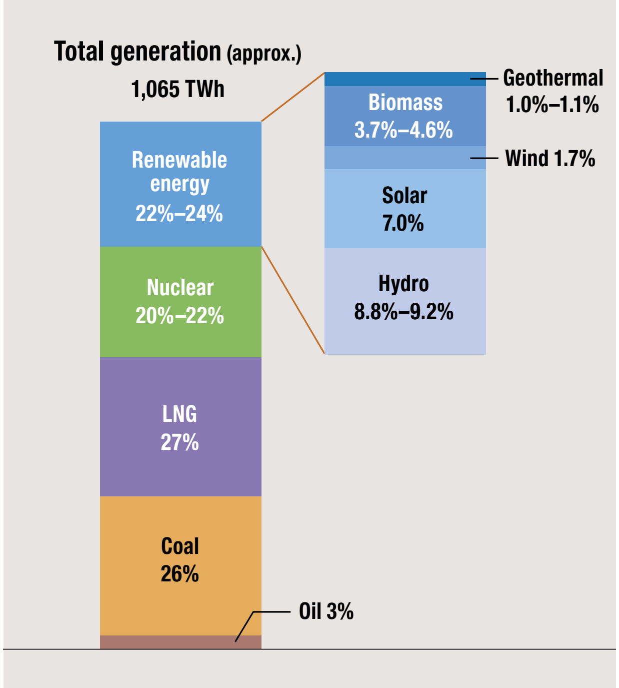
The plan lays down basic policies and measures towards 2030 and offers a scenario for energy transition and decarbonization in the years leading up to 2050.

(1) Basic Policies and Measures towards 2030

The Fifth Strategic Energy Plan adopts broad goals for each element of the 3E+S philosophy that underpins it. These are: (1) regarding energy security, an improvement in energy self-sufficiency to in excess of the level prior to the Great East Japan Earthquake (approximately 25%); (2) regarding economic efficiency, a lowering of electricity rates in the face of an anticipated increase in costs arising from reducing dependence on nuclear power and widening adoption of renewables; (3) regarding the environment, the adoption of greenhouse gas reduction targets on a par with those in the United States and Europe; and (4) regarding safety, action to increase the safety of nuclear power.

In view of these policies, the plan calls for electric power demand in fiscal 2030 to be kept to its fiscal 2013 level (around 980.8 TWh) by pursuing thoroughgoing energy (electric power) conservation efforts to counter the effect on demand of economic growth, which is expected to continue. Regarding the power generation mix, the aim is to make more balanced use of resources to simultaneously achieve the 3E+S while expanding use of renewables, improving the efficiency of thermal power plants, and reducing dependence on nuclear power. Nuclear power's share of the mix in fiscal 2030 is to be reduced from

Power Generation Mix in Fiscal 2030 Figure 2.1



Source: METI, "Long-term Energy Supply and Demand Outlook 2015" approximately 30% prior to the Great East Japan Earthquake to around 20%–22%, while renewables' share will be increased from approximately 10% before the earthquake to about 22%–24% (Figure 2.1).

(2) The Challenge of Energy Transition and Decarbonization by 2050

The Fifth Strategic Energy Plan offers a scenario for Sophisticated 3E+S. This involves, among other things, turning renewables into core elements of the power generation mix, developing storage batteries, hydrogen systems, and digital technologies, improving safety, economic efficiency, and flexibility to reduce nuclear dependence and retain nuclear as an option for decarbonization, and reducing the carbon footprint of thermal power plants, which will remain core elements of the mix during the transitional period.

2. Nuclear Power Generation

(1) Government Policy

The Fukushima Daiichi accident caused huge damage and led to the evacuation of residents over a wide area, increasing public concerns about nuclear power. The region's recovery and the restoration of public confidence are matters of the very highest priority to the government and the utilities.

At the same time, however, Japan's energy self-sufficiency has been seriously hit by the delayed restart of nuclear power plants, and IEA statistics show that the country's self-sufficiency rate stood at just 9.6% in 2017. The increase in imports of fossil fuel to power the thermal power plants used to replace nuclear power since the Fukushima Daiichi accident has imposed a greater financial burden on the public. The need to reduce greenhouse gas emissions to combat global warming has also risen in recent years.

(2) Action on Nuclear Safety

a. Reorganization of Nuclear Power Administration and Establishment of the Nuclear Regulation Authority

The Fukushima Daiichi accident led to an overhaul of the system of administration of nuclear power in order to separate safety regulation from use and to unify nuclear safety regulation work. The Act for Establishment of the Nuclear Regulation Authority was enacted in June 2012, and the authority was established in September 2012 as an affiliated agency of the Ministry of the Environment. The Nuclear Regulatory Agency was further created to act as the authority's secretariat. Affairs concerning nuclear safety regulation that had previously fallen under the jurisdiction of multiple agencies were simultaneously centralized under the highly independent Nuclear Regulation Authority.

b. Adoption of New Regulatory Standards and Continuous Improvement of Nuclear Safety Regulation

Following the Fukushima Daiichi accident, the Act on the Regulation of Nuclear Source Material, Nuclear Fuel Material and Reactors ("Nuclear Reactor Regulation Act") was revised to incorporate a number of new provisions designed to strengthen nuclear safety regulation. These included:

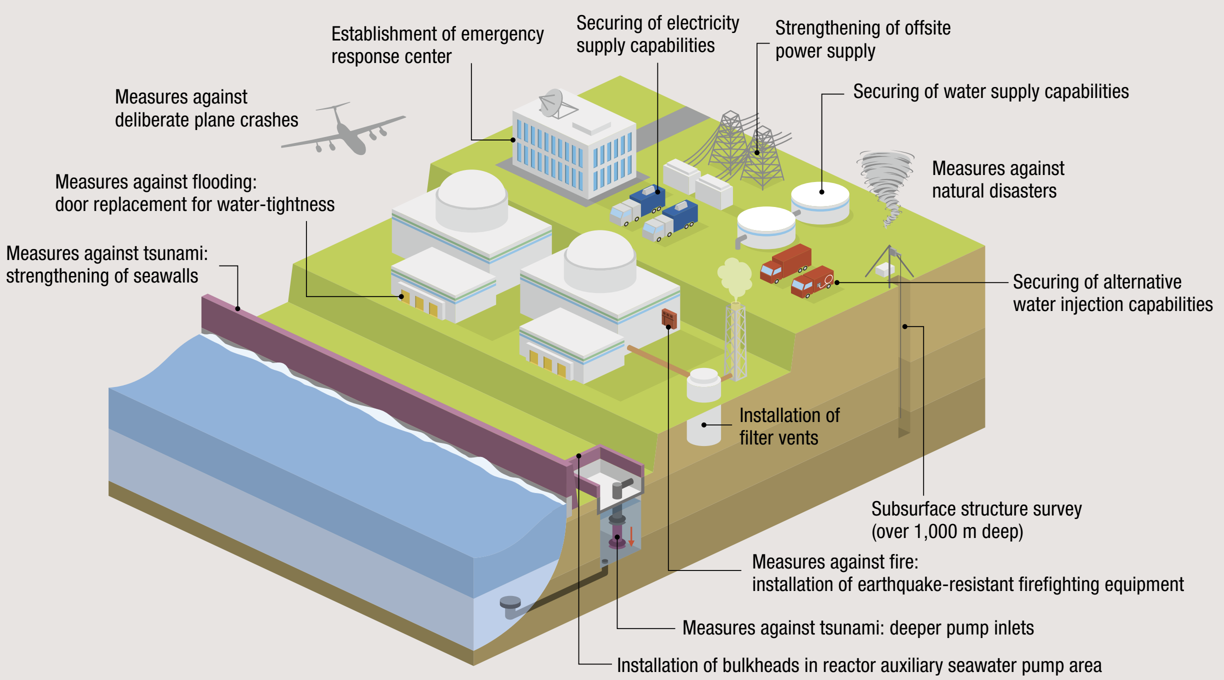
- Reinforcement of strategies for severe accidents.
- Introduction of a "backfitting" program requiring existing nuclear power facilities to comply with any new regulatory standards incorporating the latest technological expertise.
- Modification of procedures for extending the period of operation of nuclear reactors (setting the period of operation at 40 years from the date of initial entry into commercial operation, and allowing a one-time extension to this term not to exceed 20 years where permitted by the Nuclear Regulation Authority).
- Unification of regulation of nuclear power plants under the Nuclear Reactor Regulation Act.

c. Initiatives by the Private Sector

Alongside the measures being taken by the regulatory agencies described above, the Japan Nuclear Safety Institute (JANSI) was launched in November 2012 to allow private-sector entities to voluntarily perform their own peer reviews in order to improve safety, and this has strengthened action to improve safety at individual power plants. It has been joined by the Atomic Energy Association (ATENA), established in July 2018 as an organization that interacts with regulatory authorities on behalf of industry. The aim of this association is to strengthen arrangements to address common safety issues by utilities and manufacturers affecting the nuclear power industry as a whole. JANSI and

Safety Measures Required by New Safety Regulatory Requirements

Figure 2.2



Source: Federation of Electric Power Companies of Japan (FEPC), “Energy and Environment” (2018)

ATENA will be working closely together to restore public confidence in nuclear power by continuing to promote independent action by the private sector to achieve high standards of safety.

(3) State of Nuclear Power Generation

As of August 2019, 15 nuclear reactors had been declared compliant and granted permission for their installation licenses to be amended in accordance with the new regulatory standards. The nine pressurized water reactors (PWR) shown in Table 2.1 have reentered commercial service. In addition to these PWRs, six boiling water reactors (BWR) of the same type as those used at the Fukushima Daiichi Nuclear Power Plant have also now been confirmed compliant and are being prepared to come back online pending local approval and the completion of safety improvement work.

At Fukushima Daiichi and Daini Nuclear Power Plants, following the request of Fukushima Prefecture, all 10 reactors will be decommissioned. Decisions have also been made to decommission other reactors after considering the cost of ensuring compliance with the new regulatory standards. Altogether, 24 reactors nationwide have been earmarked for decommissioning. The situation regarding restarts and decommissioning is summarized in the table below.

As for the extension of the period of operation of nuclear reactors, extensions had been approved, as of the end of November 2018, for three PWR reactors operated by Kansai Electric Power Co.—Units 1 and 2 at the Takahama Nuclear Power Plant and Unit 3 at the Mihama Nuclear Power Plant—and work is now underway to implement safety measures to meet the conditions mandated for the extension of operation. In addition, an extension for The Japan Atomic Power Company’s Tokai No. 2 Nuclear Power Plant was approved in November 2018, making it the first BWR to secure approval, and implementation of safety measures is under way with a target completion date of 2021. The plants that are undertaking improvement work to comply with the new safety standards will also need to obtain local government approval before they can restart.

Compliance with New Regulatory Standards

Table 2.1

Restart approved (15 units)	Restarted	9 units
	Preparing for restart (Implementation of safety work, etc.)	6 units
Under review (including 2 units under construction)		12 units
Applications not yet filed (including 1 unit under construction)		9 units
Total (including 3 units under construction)		36 units
To be decommissioned		24 units*1

Company	Plant	Restart date
Kyushu Electric Power Co.	Sendai Unit 1	Aug. 11, 2015
Kyushu Electric Power Co.	Sendai Unit 2	Oct. 15, 2015
Kansai Electric Power Co.	Takahama Unit 3	Jan. 29, 2016
Kansai Electric Power Co.	Takahama Unit 4	Feb. 26, 2016
Shikoku Electric Power Co.	Ikata Unit 3	Aug. 12, 2016
Kansai Electric Power Co.	Ohi Unit 3	Mar. 14, 2018
Kyushu Electric Power Co.	Genkai Unit 3	Mar. 23, 2018
Kansai Electric Power Co.	Ohi Unit 4	May 9, 2018
Kyushu Electric Power Co.	Genkai Unit 4	June 16, 2018

*1 Not including the three JPDR, Monju, and Fugen reactors.

Source: Compiled from Nuclear Regulation Authority website (accessed on August 31, 2019)

To comply with the new regulatory standards, work to improve preparedness for natural disasters and severe accidents had to be performed prior to startup. Anti-terrorism measures, on the other hand, must be completed within five years from approval. Due to delays, there are fears that work may not be completed until between one and two and a half years after the completion deadline. If this happens, it is expected that some plants will again have to suspend operations until work is completed (from March 2020 for the earliest plant to have been approved).

Entrance door and equipment hatch of Tokai II Power Station (The Japan Atomic Power Co.) made watertight
Tokai II Power Station entered operation in November 28, 1978

(4) Nuclear Fuel Cycle

a. Government Policy

As Japan is dependent on imports for the bulk of its energy resources, a basic policy of the government has been to establish a nuclear fuel cycle in order to reprocess the spent fuel generated by nuclear power generation and reuse the recovered plutonium and uranium as fuel. Steps are therefore being taken to promote recycling and use of MOX fuel in thermal reactors. Based on this policy, the Agreement for Cooperation between the Government of Japan and the Government of the United States of America concerning Peaceful Uses of Nuclear Energy that expired in July 2018, 30 years after it entered effect, was automatically renewed. In order to contribute to nuclear non-proliferation and to gain the understanding of the international community, Japan is working to reduce its plutonium stockpile under the principle of not possessing any plutonium that does not have a use. To this end, it is pursuing greater use of MOX fuel in thermal reactors and managing and using plutonium appropriately in accordance with the system introduced in 2016.

b. Uranium Enrichment

As the uranium-235 used by nuclear power plants constitutes only about 0.7% of natural uranium, uranium must be enriched to a uranium-235 concentration of 3%–5% before use. Japan Nuclear Fuel Ltd. (JNFL), a private-sector company established to implement the nuclear fuel cycle on a commercial basis, built a commercial uranium enrichment plant in Rokkasho, Aomori Prefecture, that entered operation in March 1992. JNFL subsequently filed an application to the Nuclear Regulation Authority for permission to switch to using a new, cost-efficient type of centrifuge offering improved performance and to introduce other changes in compliance with the new regulatory standards. The Nuclear Regulation Authority granted permission for these operational changes in May 2017.

c. Spent Fuel Reprocessing

JNFL has been building a commercial reprocessing plant at Rokkasho that is expected to be completed in the first half of 2021. In light also of the changing business environment faced by the nuclear power industry, including the deregulation of the electricity market, the Spent Nuclear Fuel Reprocessing Implementation Act was enacted in May 2016 to ensure the steady implementation of reprocessing work. The Nuclear Reprocessing Organization of Japan was also established in October of that year to serve as the corporation authorized to manage the funds necessary for reprocessing and to reliably perform reprocessing work and related activities.

Meanwhile, the Recyclable-Fuel Storage Company, jointly financed by Tokyo Electric Power Company Holdings and Japan Nuclear Fuel Limited, is currently building a recyclable fuel storage center (the "Mutsu Interim Storage Facility") in Mutsu City, Aomori Prefecture, to provide a site for dry cask based interim storage of spent fuel until it is transported to a reprocessing plant. This interim storage facility will enter operation with an initial storage capacity of 3,000 tons, which is scheduled to be increased to 5,000 tons.

d. Disposal of Radioactive Waste

Low-level radioactive waste generated by nuclear power plants is buried by JNFL's Low-level Radioactive Waste Disposal Center in Rokkasho, Aomori Prefecture.

As for high-level radioactive waste generated from spent fuel, METI published in July 2017 the Nationwide Map of Scientific Features for Geological Disposal showing potential candidate sites as a preparatory step toward its final disposal. The government plans to narrow down the number of candidate sites based on this map.

e. Development of Fast Reactors, etc.

In resource-poor Japan, construction of the Joyo experimental fast breeder reactor was followed by the Monju prototype fast breeder reactor in line with basic government policy. However, it was officially decided in December 2016 to decommission Monju. Research and development work on fast reactors conducted using the Joyo experimental reactor will continue to be pursued in partnership with other countries following the road map developed in accordance with the new policy on fast reactor development adopted by the Inter-Ministerial Council for Nuclear Power in December 2016.

(5) Decommissioning Work at Fukushima Daiichi Nuclear Power Plant

Recovery from the damage caused by the Fukushima Daiichi accident and smoothly decommissioning the Fukushima Daiichi Nuclear Power Plant and dealing with the problem of contaminated water are all top priorities for the government and Tokyo Electric Power Company Holdings. Latest news on progress toward these goals can be viewed on Tokyo Electric Power Company Holdings' website (http://www.tepco.co.jp/en/decommision/index-e.html) (accessed on September 9, 2019).

a. Basic Policy on Decommissioning of the Fukushima Daiichi Nuclear Power Plant

In December 2011, nine months after the accident, the government and Tokyo Electric Power Company Holdings formulated a Mid-and-Long-Term Roadmap towards the Decommissioning of TEPCO's Fukushima Daiichi Nuclear Power Station Units 1–4, based on which decommissioning work and related measures at the plant are to be implemented.

This roadmap describes plans for decommissioning Units 1–4 and measures for dealing with radioactive contaminated water produced at the site. The decommissioning plans include plans for the moving of the spent fuel being stored in spent fuel storage pools in each unit and the removal of fuel debris melted in the reactors. A basic principle of the roadmap is that it is subject to continuous review in light of the actual situation at the plant, progress on development of relevant technologies, and other factors, and revisions are being made to the roadmap as necessary.

b. Moving Fuel from Spent Fuel Pools

When the accident occurred, it was decided in the interests of risk mitigation to remove the spent fuel then being stored in spent fuel storage pools from the pools at Units 1–4 and to store it appropriately in a shared pool at the site. The removal of spent fuel from the pool in Unit 4, where the most spent fuel was stored, was completed in December 2014, and work to remove spent fuel from Unit 3 started in April 2019. For Units 1 and 2, rubble impeding the removal of fuel is being removed, while steps are being taken to prevent the release of dust containing radioactive material and to monitor the concentration of radioactive material in the atmosphere.

c. Removal of Fuel Debris

Extensive fuel debris, consisting of fuel and internal reactor structures that melted during the accident and then cooled and solidified, is believed to be present in Units 1, 2, and 3. Because of the extremely high levels of radiation in the reactor buildings, surveys of the interiors are presently being conducted using remote-controlled equipment in advance of the removal work to be started in 2021.

d. Control of Radioactive Contaminated Water

At the Fukushima Daiichi accident site, groundwater is penetrating the reactor buildings, and more contaminated water is being generated as a result of such groundwater mixing with accumulated core cooling water that contains radioactive materials. In line with the three principles of (1) the removal of sources of contamination, (2) the isolation of water from contamination sources, and (3) the containment of contaminated water, various countermeasures against contaminated water are now being pursued to achieve stable control of groundwater. Radioactive contaminated water is stored at the site after being treated to a level below the discharge standards using an advanced liquid processing system (ALPS), etc. The government is now considering how to handle this treated water, taking a comprehensive approach that examines social impact as well as scientific assessments of safety.

3. Renewable Energy

(1) Current Status and Targets

The Fifth Strategic Energy Plan sets a target for renewable energy adoption to be achieved by fiscal 2030 of 22%–24% of total power generation, based on a policy of adopting renewable energies to the greatest extent possible to make them core energy sources while balancing this with containing the burden imposed on customers. To assist the adoption of renewables, a system for purchasing excess electricity generated by solar power plants was launched in November 2009, and a feed-in tariff (FIT) scheme covering a wider range of power sources (see below for details) was introduced in July 2012. This scheme accelerated capital investment in renewables, with installed capacity growing by 46 GW between the launch of the FIT scheme and the end of December 2018. Including pre-FIT capacity, total installed renewables capacity reached approximately 67 GW.

(2) FIT Scheme and Issues

The government passed the Act on Special Measures Concerning Procurement of Electricity from Renewable Energy Sources by Electricity Utilities in August 2011, which requires the electricity utilities to purchase all the electricity generated from renewable energy sources (including hydropower plants with a capacity of under 30 MW).[1] This act led to implementation of the FIT scheme for renewable energy on July 1, 2012.

The electricity supply sources, purchase prices and purchase periods covered by the FIT scheme for each fiscal year are to be determined by METI. The purchase prices and periods for fiscal 2019 are as shown in Table 2.3. Under the FIT scheme, the former general electricity utilities are permitted to pass on their costs for the purchase of electricity generated by renewable energy sources to their customers in the form of a surcharge by including them in the electricity bill.
The surcharge for fiscal 2019 is 2.95 yen per kWh (2.4287 trillion yen for Japan as a whole), or 9,204 yen per year for the standard model household. Under this system, former general electricity utilities collect the surcharge from customers and transfer the funds to a cost-bearing adjustment organization called the Green Investment Promotion Organization, which refunds their purchase costs to them in due course (Figure 2.3).

The scheme also contains a provision that reduces the surcharge for industrial customers who use extremely high volumes of electricity and who satisfy certain conditions.

Notwithstanding the increase in investment in renewable energies and growth in FIT-approved capacity since 2012, problems have emerged and the government revised the FIT scheme in 2016. Many solar power generation projects remain unfinished despite having already been approved under the FIT scheme. Most of these were approved between 2012 and 2014 just after the launch of the FIT scheme when purchase prices were high, and so the government revised the startup deadlines and purchase prices for these projects. Regarding wind power, geothermal, small/medium hydropower, and biomass

Sakai Solar Power Station (Kansai Electric Power Co.)

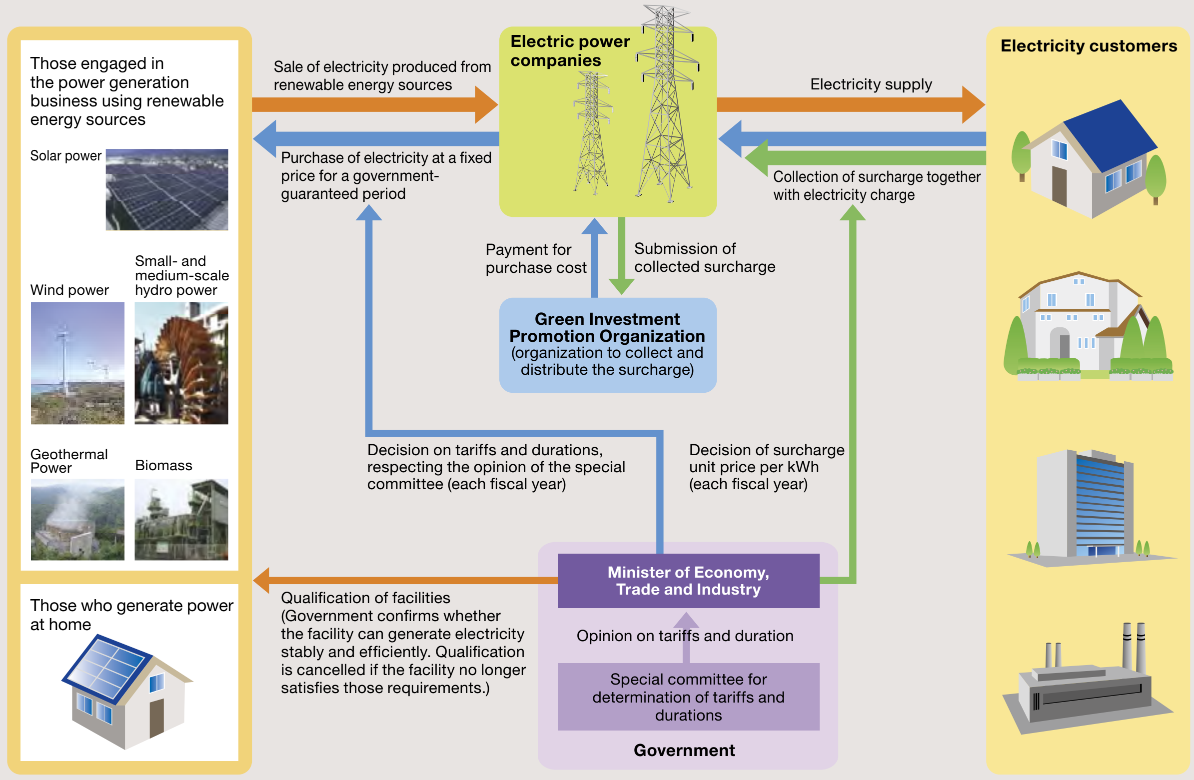
Installed Capacity of Renewable Energy (as of end December 2018) Table 2.2

Unit: MW

Type	Combined total by end June 2012	Combined capacity installed under FIT	Total
Solar power (residential)	4,700	5,830	10,530
Solar power (non-residential)	900	37,220	38,120
Wind power	2,600	1,110	3,710
Small/medium hydropower	9,600	350	9,950
Biomass	2,300	1,520	3,820
Geothermal power	500	20	520
Total	20,600	46,050	66,650

Source: METI, Submission to the 13th meeting of the Coordination Subcommittee of the Advisory Committee for Natural Resources and Energy (2019)

Outline of the FIT Scheme Figure 2.3



Source: METI website (accessed on September 9, 2019)

1 General electricity utilities cannot purchase electricity from renewable energy power generation facilities that they have installed themselves.

Purchase Prices, Durations, and Installations under the FIT Scheme

Table 2.3

Purchase category			Purchase price (yen/kWh) FY2017	FY2018	FY2019	FY2020	Duration (years)
Solar	Less than 10 kW	Output controller not required	28	26	24	–	10
		Output controller required[*1]	30	28	26	–	
		Output controller not required, dual generation	25		24	–	
		Output controller required, dual generation[*1]	27		26	–	
	10 kW–500 kW		21	18	14	–	20
	500 kW–2,000 kW		21	18	Bidding system		20
	2,000 kW or above		Bidding system				20
Onshore wind power	20 kW or above	Newly installed	21	20	19	18	20
	Less than 20 kW		55	20	19	18	
	All capacities	Replacement capacity	18	17	16	16	
Offshore wind power	Bottom-fixed offshore wind power		36	36	36	–	
	Floating offshore wind power		36	36	36	–	
Geothermal	Less than 15,000 kW		40	40	40	40	15
	15,000 kW or above		26	26	26	26	
Geothermal (replacement of all equipment)	Less than 15,000 kW		30	30	30	30	
	15,000 kW or above		20	20	20	20	
Geothermal (replacement of equipment excepting underground equipment)	Less than 15,000 kW		19	19	19	19	
	15,000 kW or above		12	12	12	12	
Hydro	Less than 200 kW		34	34	34	34	20
	200 kW–1,000 kW		29	29	29	29	
	1,000 kW–5,000 kW		27	27	27	27	
	5,000 kW–30,000 kW		20	20	20	20	
Hydro using existing conduits[*2]	Less than 200 kW		25	25	25	25	
	200 kW–1,000 kW		21	21	21	21	
	1,000 kW–5,000 kW		15	15	15	15	
	5,000 kW–30,000 kW		12	12	12	12	
Biomass	Methane fermentation gasification (biomass-derived)		39	39	39	39	20
	Woody biomass (thinnings, etc.) and agricultural crop residue	Less than 2,000 kW	40	40	40	40	
		2,000 kW or above	32	32	32	32	
	Construction material waste	All capacities	13	13	13	13	
	General waste and other biomass	All capacities	17	17	17	17	

*1 Power generation facilities whose connection applications were received on or after April 1, 2015, and that are located in areas subject to supply and demand control by Hokkaido, Tohoku, Hokuriku, Chugoku, Shikoku, Kyushu, or Okinawa Electric Power Companies are required to install output controllers.
*2 Upgrades to electrical facilities and penstocks utilizing existing conduits.

Source: Compiled from Agency for Natural Resources and Energy website (accessed on September 9, 2019)

Results of Tenders for Solar Power Generation

Table 2.4

	Results of tenders	Successful bids
First tender (November 2017)	Eligible facilities: 2 MW or above Requirement: 500 MW	Successful bids: 9 Total output: 141 MW Successful bid price: 17.20-21.00 yen/kWh
Second tender (September 2018)	Eligible facilities: 2 MW or above Requirement: 250 MW	Successful bids: 0 (no bids came in below the ceiling price) Total output: Successful bid price:
Third tender (December 2018)	Eligible facilities: 2 MW or above Requirement: 196.96 MW	Successful bids: 7 Total output: 197 MW Successful bid price: 14.25-15.45 yen/kWh
Fourth tender (September 2019)	Eligible facilities: 0.5 MW or above Requirement: 300 MW	Successful bids: 63 Total output: 196 MW Successful bid prices: 10.50-13.99 yen/kWh

Source: Compiled from Green Investment Promotion Organization website (accessed on September 11, 2019)

power generation, the pricing system was changed to allow purchase prices to be set for multiple years. A tender scheme for solar power generation of 500 kW or above has also been introduced to bring down purchase prices. Results of tenders are shown in shown in Table 2.4.

(3) Complete Overhaul of the FIT Scheme

The rapid growth in the installation of renewables has made it necessary to impose output controls. While the solar power connection limit in Kyushu Electric Power Co.'s electricity service area is 8.2 GW, connected solar capacity had already reached 8.1 GW by the end of August 2018. Despite restricting output from thermal power plants, using interconnections, and employing excess power to pump up water for pumped storage, output controls have had to be imposed on solar and wind power generation operators since October 2018. Looking ahead, it is likely that output controls will be imposed more frequently in more areas, particularly during public holidays in spring or autumn when electricity demand is low.

As adoption of renewables has spread, a number of problems with FIT have emerged, including rising surcharges on renewables and difficulties with receiving power generated by renewables on the grid side. The government has decided to overhaul FIT by the end of fiscal 2020 in order to make renewables an economically self-sustaining core element of the power generation mix. More specifically, large commercial solar power generation and wind power generation are expected to become competitive sources of electric power, and action will be taken to make them even more competitive and integrate them into the electric power market. A study will also be made of mechanisms that will allow renewable power generation operators to sell electricity via the electric market while addressing imbalances and providing a certain degree of predictability regarding payback. The new system will be applied taking into consideration the state of project development in each category of power generation and is expected to initially cover large commercial photovoltaic power generation.

(4) Termination of Purchase Period under the Surplus Electric Power Purchasing System

Under the surplus electric power purchasing system launched in November 2009 prior to the start of FIT scheme, power was purchased for a period of 10 years at solar power plants with a capacity of less than 500 kW. Beginning in November 2019 plants will come to the end of their ten-year periods, creating a problem that has been dubbed the "Year 2019 Problem." The plants affected are estimated to reach a capacity of about 6.7 GW in total by 2023. Electricity retailers that will be required to buy a certain proportion

(44%) of their electricity from non-fossil fuel sources in 2030 under the Act on Sophisticated Methods of Energy Supply Structures are showing interest in purchasing power from solar power plants when the purchase period terminates. The majority of electricity retailers set purchase prices at 7–10 yen/kWh, and competition for customers is intensifying as various purchasing options are offered. In addition to straightforward purchases, for example, some electricity retailers are now offering to purchase electricity on condition that storage batteries are installed.

4. Global Warming Countermeasures

(1) International Frameworks and Japanese Government Initiatives

a. Greenhouse Gas Emission Reduction Targets

At the 21st Conference of the Parties to the United Nations Framework Convention on Climate Change (COP21) held in December 2015, 195 countries and regions adopted the Paris Agreement, which addresses greenhouse gas (GHG) emission reductions from 2020 onward. The Paris Agreement sets forth long-term shared global targets including keeping the average global temperature increase well below 2°C above pre-industrial revolution levels and balancing anthropogenic GHG emission and absorption in the second half of this century. Unlike the Kyoto Protocol, which required only advanced nations to reduce their emissions, the Paris Agreement requires all signatory countries to set out emissions reduction targets as well as the domestic policies to be employed to achieve those targets. The extent to which those targets have been attained is to be evaluated every five years.

The Plan for Global Warming Countermeasures was approved at a cabinet meeting in May 2016, setting out how the GHG emission reduction target for 2030 (26.0% reduction compared to fiscal 2013) outlined in the INDC submitted by Japan in 2015 will be achieved. This plan notes that it is important to steadily implement the countermeasures outlined in the INDC on the way to achieving the mid-term targets, and the government is looking to utilize a diverse range of policy tools including voluntary measures, regulatory measures and economic measures, exploiting their respective characteristics in an

Folding wind turbines being promoted by Okinawa EPco delivered to Tonga (Okinawa Electric Power Co.)

Government Action on GHG Reduction Targets

Table 2.5

Date	Trend
December 1997	Kyoto Protocol adopted at COP3. Japan's GHG reduction target set at 6% below 1990 levels.
October 1998	Act on Promotion of Global Warming Countermeasures instituted in response to adoption of the Kyoto Protocol.
April 2005	Kyoto Protocol Target Achievement Plan outlining the measures necessary to attain Japan's 6% GHG reduction target approved at a meeting of the cabinet.
January 2010	The Japanese government responds to the Copenhagen Accord (COP15) by submitting a GHG reduction target for 2020 of 25% below Japan's 1990 levels to the Secretariat of the United Nations Framework Convention on Climate Change, premised on establishment of a fair and effective international framework and agreement to ambitious targets by all major countries.
November 2011	At COP17, Japan declares that it will not participate in the second commitment period under the Kyoto Protocol.
November 2013	At COP19, Japan announces a target of achieving a 3.8% reduction relative to fiscal 2005 by 2020.
July 2015	Following the decision of COP19, the Japanese government submits to the UNFCCC Secretariat a target of reducing emissions by 26% below fiscal 2013 levels (a 25.4% reduction relative to fiscal 2005 levels) by fiscal 2030.
May 2016	The Plan for Global Warming Countermeasures approved at a cabinet meeting in response to the conclusion of the Paris Agreement.
June 2019	The Long-term Strategy under the Paris Agreement approved by the cabinet.

Source: Agency for Natural Resources and Energy website (accessed on September 9, 2019)

effective manner. The policy for the electricity sector is to maximize the deployment of renewable energies, improve thermal power plant efficiency, and utilize nuclear power plants that have been confirmed to be safe.

In June 2019, the cabinet adopted a long-term strategy for reducing emissions up to 2050 as required by the Paris Agreement, and this was presented to the UN Secretariat. This strategy sets a long-term target of achieving an 80% reduction in GHG by 2050. Noting the difficulty of achieving this target simply by continuing to pursue conventional means of reducing emissions, it calls for innovation coupled with a virtuous circle of environmental and economic growth to solve environmental issues.

Table 2.5 shows the government's initiatives relating to GHG reduction targets since adoption of the Kyoto Protocol in 1997.

b. Joint Crediting Mechanism

The Japanese government employs the Joint Crediting Mechanism (JCM) to effectively address climate change, based on the belief that achieving "low-carbon growth" globally depends on both developed and developing countries alike making adequate use of technologies, markets, and funds.

The JCM allows contributions to GHG emission reductions and carbon capture achieved in partner countries through transferals of Japanese low-carbon technologies and outcomes to be counted as part of Japan's contribution.

The Japanese government has consulted with developing countries concerning the JCM since 2011. It has signed bilateral documents with 17 countries, the latest being with the Philippines in January 2017.

International discussions are underway concerning the validity of the JCM under the Paris Agreement.

(2) GHG Emissions and Voluntary Efforts by the Private Sector

a. GHG Emissions in Japan

In fiscal 2017, Japan's GHG emissions measured 1,292 million tons (CO_2 equivalent), and emissions of CO_2 accounted for 92.1% (1,190 million tons) of this total. CO_2 emissions showed 9.6% decrease from fiscal 2013 and a 8.0% decrease from fiscal 2005.

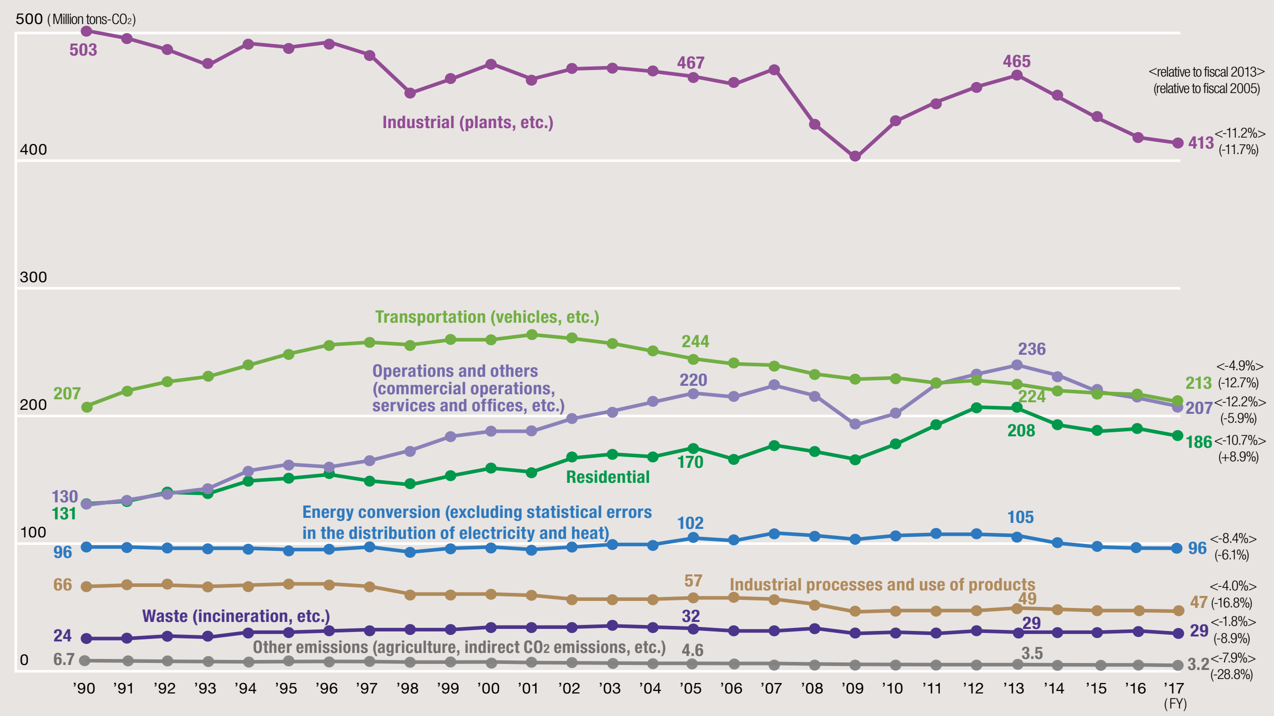
CO_2 emissions in individual sectors have been decreasing since 2013 (Figure 2.4), and declining by 11.2%, 12.2%, and 10.7% respectively in the industrial sector, the commercial sector, and the residential sector between fiscal 2013 and fiscal 2017. This was due largely to lower energy consumption resulting from energy conservation in all sectors and to improvements in the CO_2 emission intensity for electricity.

b. Voluntary Efforts by the Private Sector

In order to better contribute to global GHG emission reductions over the long-term, the Japan Business Federation (Keidanren) issued the Commitment to a Low Carbon Society (Phase I) in 2013, followed in 2015 by the Commitment to a Low Carbon Society (Phase II) laying down commitments up to 2030 in order to further contribute to action on climate change. Commitment to a Low Carbon Society calls for participants to set targets and review progress themselves to ensure the effectiveness of their actions, and further commits the Japanese business community with its technological strengths to play a key role in the drive to halve global GHG emissions by 2050.

As of March 2019, 62 industries had adopted targets for emissions resulting from business activities in Japan in 2030, and action is underway to reduce emissions throughout entire value chains and to accelerate the development of innovative technologies and contribute more internationally.

Changes in CO_2 Emissions by Sector Figure 2.4

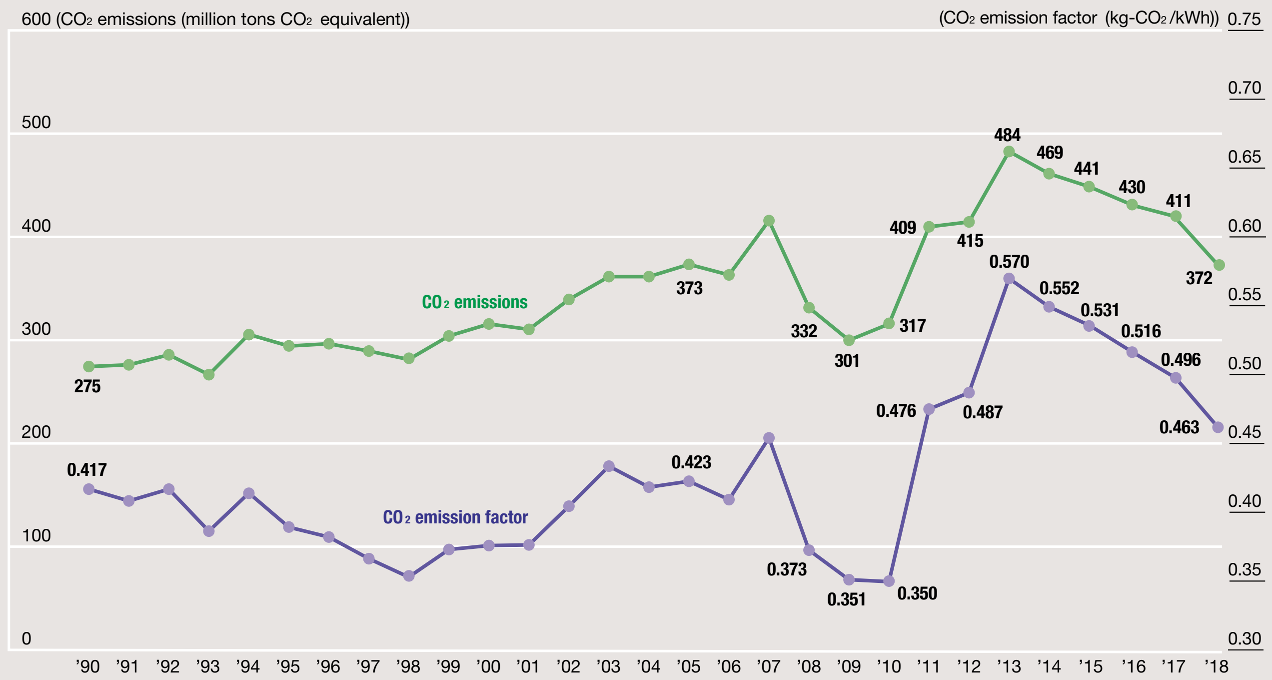


Note 1: Emissions by sector are calculated by distributing the emissions that accompany power generation and thermal generation among the respective final consumption sectors.
Note 2: Percentages in angle brackets indicate change in emissions in each sector relative to fiscal 2013, and percentages in parentheses indicate change relative to fiscal 2005.

Source: Ministry of the Environment, "Japan's National Greenhouse Gas Emissions in Fiscal Year 2017 (Final Figures)" (2019)

CO_2 Emissions in the Electric Power Industry

Figure 2.5



Note: Reflected adjustments made for Kyoto Mechanism credits

Source: Compiled from FEPC, "Energy and Environment" (2018)

c. CO_2 Emission and Global Warming Countermeasures Implemented by the Electric Power Industry

The Federation of Electric Power Companies of Japan (FEPC) (consisting of former general electricity utilities) is participating in the Japan Business Federation's Commitment to a Low Carbon Society and are promoting measures on both the supply and demand sides of the electricity. In July 2015, 12 members of FEPC and 23 PPSs announced their own Commitment to a Low-Carbon Society in the Electricity Industry, which commits them to achieving a CO_2 emission factor in the electricity in fiscal 2030 of approximately 0.37 kg-CO_2 /kWh (equivalent to a reduction of 35% from the fiscal 2013 level). The Electric Power Council for a Low Carbon Society (ELCS) was established in February 2016 with the aim of moving forward with the attainment of these targets for all electricity utilities as a whole.

According to data released by ELCS, CO_2 emissions in fiscal 2018 (final figures) came to 372 million tons-CO_2 and the CO_2 emission factor was 0.463 kg-CO_2/kWh.

On the supply side, electricity utilities are working on a range of initiatives, including restarting nuclear power plants which are confirmed to be safe and feeding electricity derived from renewable energy sources into the grid based on the FIT scheme for renewable energy.

On the demand side, they are actively promoting energy conservation, providing information to realize more efficient electricity use, and pursuing the widespread installation of smart meters.

The utilities are also actively pursuing research and development, working to develop a range of promising technologies, including clean coal technologies, CO_2 capture and storage technologies, next-generation power transmission and distribution technologies, and ultra-high-efficiency heat pumps.

Figure 2.5 shows CO_2 emission trends in the electric power industry.

III. Supply and Demand

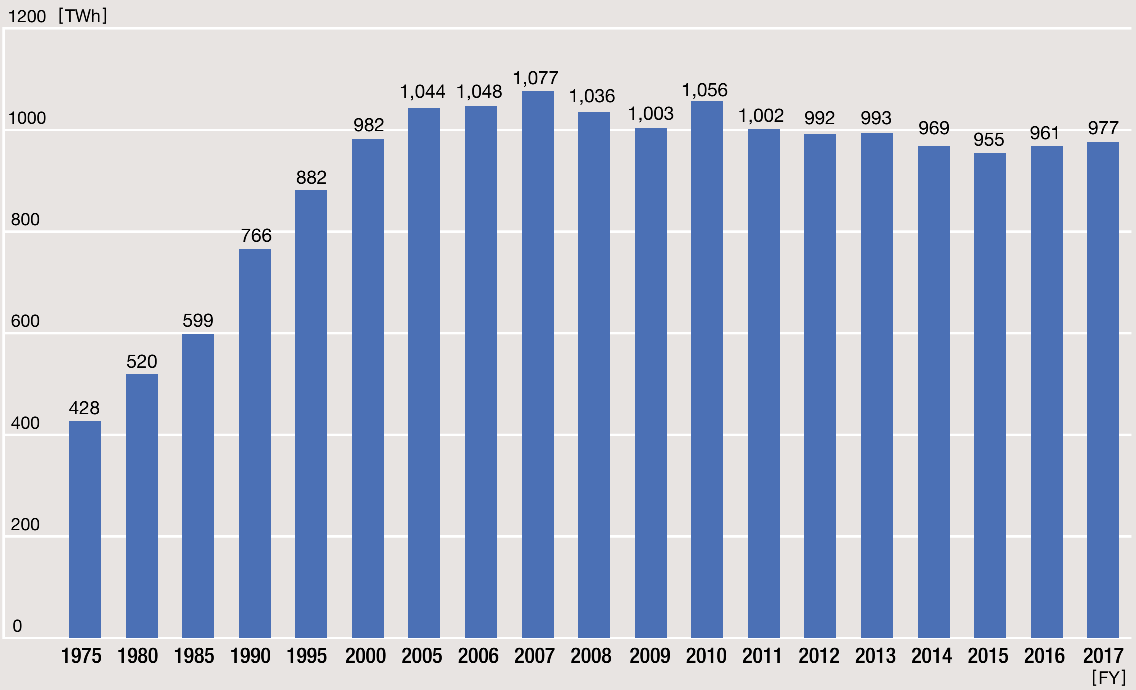
1. Electricity Demand and Peak Load

Japan's electricity demand has increased practically in tandem with post-war economic growth. Japan's gradual economic recovery continued in fiscal 2017 as real GDP grew by 1.9% from fiscal 2016 when real GDP rose 1.2% from a year earlier. The unemployment rate also improved in fiscal 2017, falling 0.3 percentage points to 2.8% from fiscal 2016 when it stood at 3.1%.

Electricity demand in Japan has either declined or remained unchanged since reaching 1,077.5 TWh in 2007, and in fiscal 2017 came to 977.4 TWh. This trend is attributable to several factors, including 1) the slowing of economic growth, 2) improved energy conservation, and 3) demographic decline. More recently, however, growing solar power generation in the residential sector, which these statistics do not capture, also appears to have played a part. Peak national demand has also remained largely unchanged since 2011 and came to 155.8 GW in fiscal 2017.

Power consumption breaks down by use as follows: 28% residential demand, 34% commercial demand, and 36% industrial demand. Industry remains the largest consumer of electricity. Since the 1990s, however, industrial demand has entered a downward trend due to changes in industrial structure and growing energy conservation. Over the longer term, the growth in power consumption has thus been driven by consumption in non-industrial sectors, namely the residential and commercial sectors. Growth in

Changes in Electricity Demand, 1975-2017 Figure 3.1



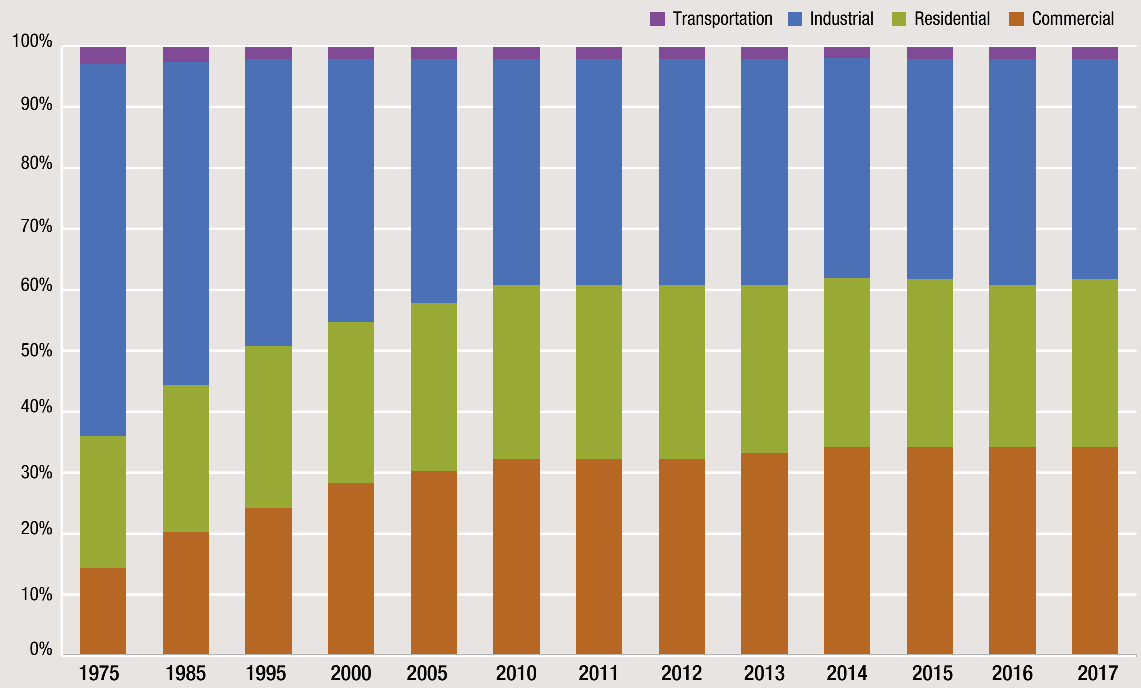
Source: Agency for Natural Resources and Energy, "Handbook of Electric Power Industry" (2018)

consumption in the commercial sector has been propelled by growth in offices and commercial facilities triggered by development of a service economy and the accompanying use of air conditioners and other appliances. In the residential sector, the rapid spread of heating and cooling appliances, such as air conditioners and electric carpets and other household appliances, driven by rising living standards, ensured that power consumption continued to grow until fiscal 2005. Growth then leveled off as appliance ownership reached a saturation point and energy-saving devices began to capture a growing share of the market. In fiscal 2011, increased awareness of the importance of saving electricity in the aftermath of the Fukushima Daiichi accident caused consumption to go into decline. In fiscal 2017, non-industrial consumption accounted for 62% of final power consumption.

The proportional rise in non-industrial demand has resulted in higher demand in recent summers and winters due to demand for heating and air-conditioning. There have thus emerged greater divergences in demand between the winters and summers and other seasons (Figure 3.3), and also between daytime and nighttime hours (Figure 3.4). Since the 2011 Great East Japan Earthquake, however, power conservation and other measures have curbed daytime power consumption during the summer, and the disparities between the summer and other seasons, and between daytime and nighttime hours during the summer, have shrunk.

Efficiency in the use of generation facilities declines with growing variation in demand, pushing up power supply costs. Nevertheless, while the annual load factor (i.e., the ratio of annual average load to annual peak load, an indicator of the efficiency of use of generation facilities) followed a downward trend in the late 1990s, it actually improved to 60%-70% from the mid-2000s. This is thanks in large part to the introduction of electricity rates designed to level loads, nighttime electricity use, and the wider adoption of solar power generation.

Breakdown of Power Consumption by Sector, 1975-2017 Figure 3.2

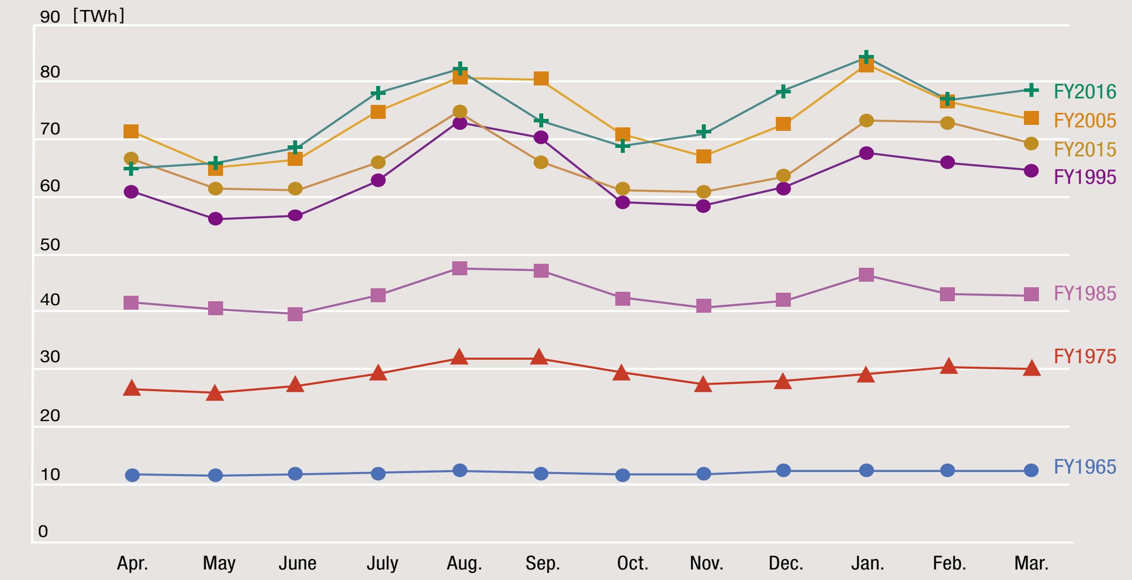


Note: The method of calculation was changed from fiscal 1990.

Source: Agency for Natural Resources and Energy, "Handbook of Electric Power Industry" (2018)

Electric Power Consumption over the Course of a Year

Figure 3.3

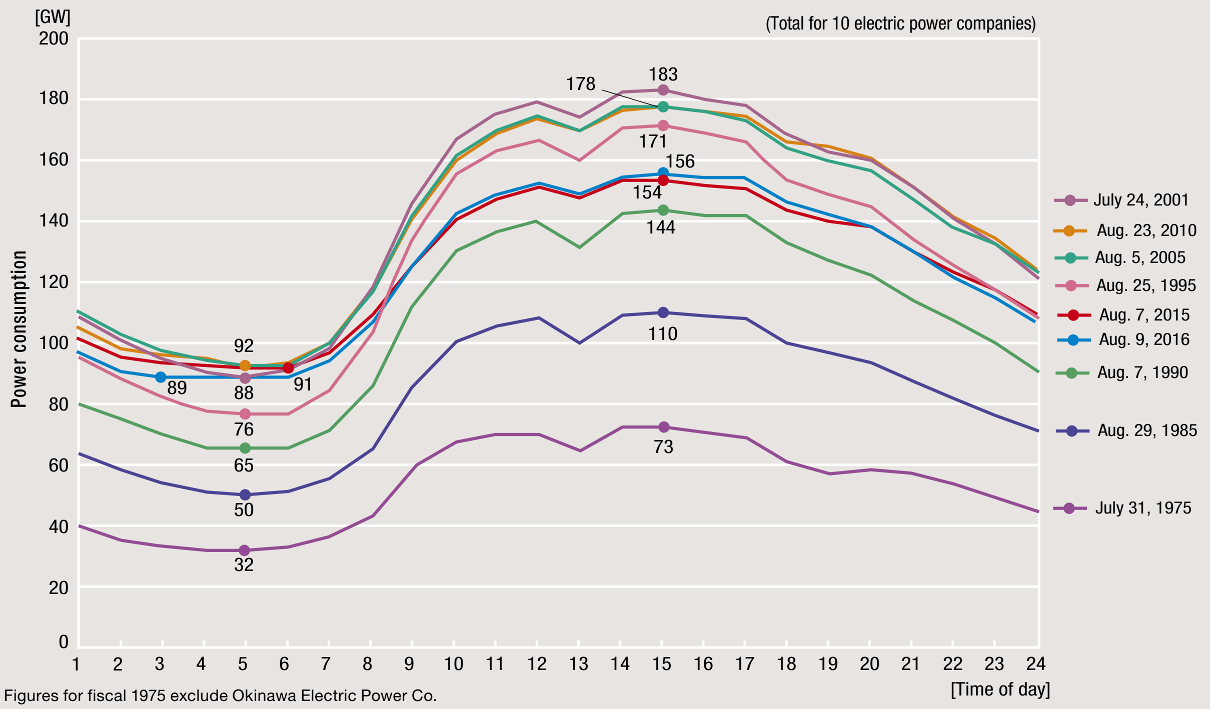


Note 1: Figures for fiscal 1975 and 1985 exclude Okinawa Electric Power Co.
Note 2: Figures are totals for 10 electric power companies through fiscal 2015, and for 10 areas in fiscal 2016.

Source: Compiled from Agency for Natural Resources and Energy, “Energy White Paper 2018”

Power Consumption over the Course of Days on Which Peak Loads Occurred

Figure 3.4

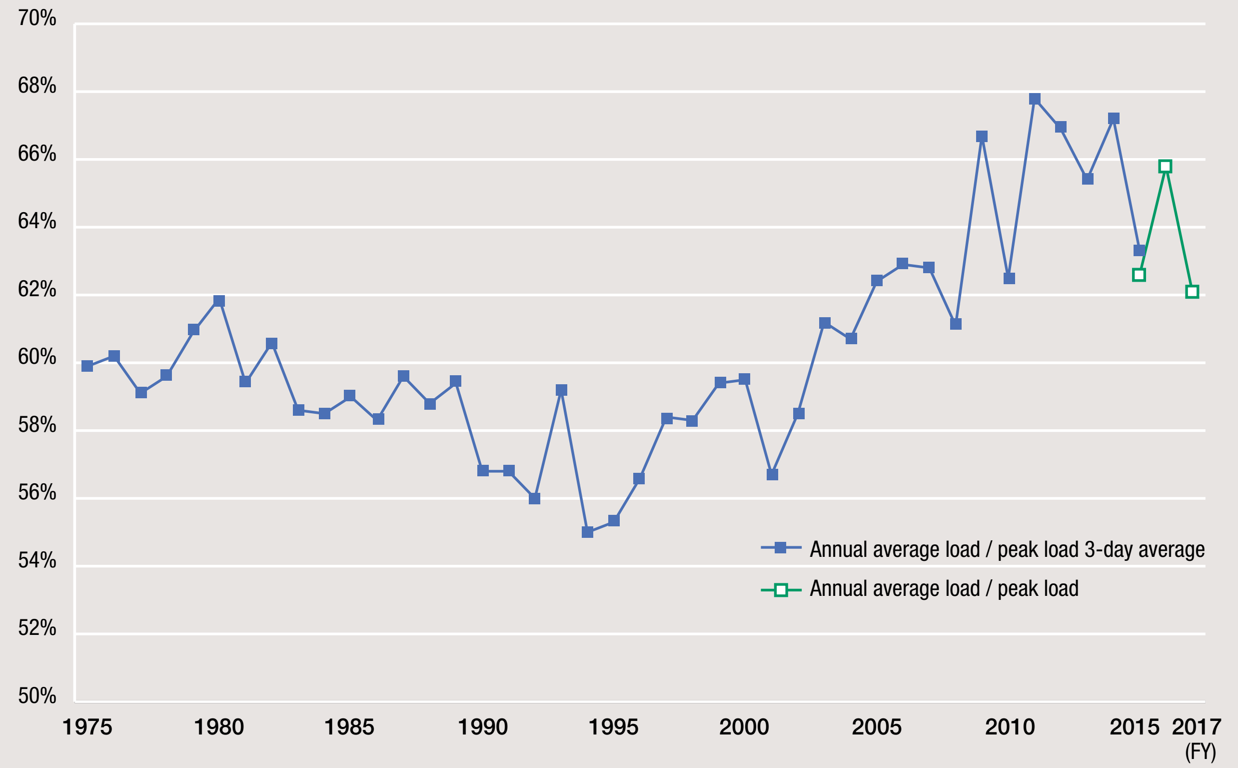


Note: Figures for fiscal 1975 exclude Okinawa Electric Power Co.

Source: Agency for Natural Resources and Energy, “Energy White Paper 2018”

Annual Load Factor, 1975-2017

Figure 3.5



Source: Compiled from Agency for Natural Resources and Energy, "Handbook of Electric Power Industry" (2018) for annual average load / peak load 3-day average (up to fiscal 2015); and OCCTO, "Outlook of Electricity Supply-Demand and Cross-regional Interconnection Lines" for annual average load / peak load (from fiscal 2015)

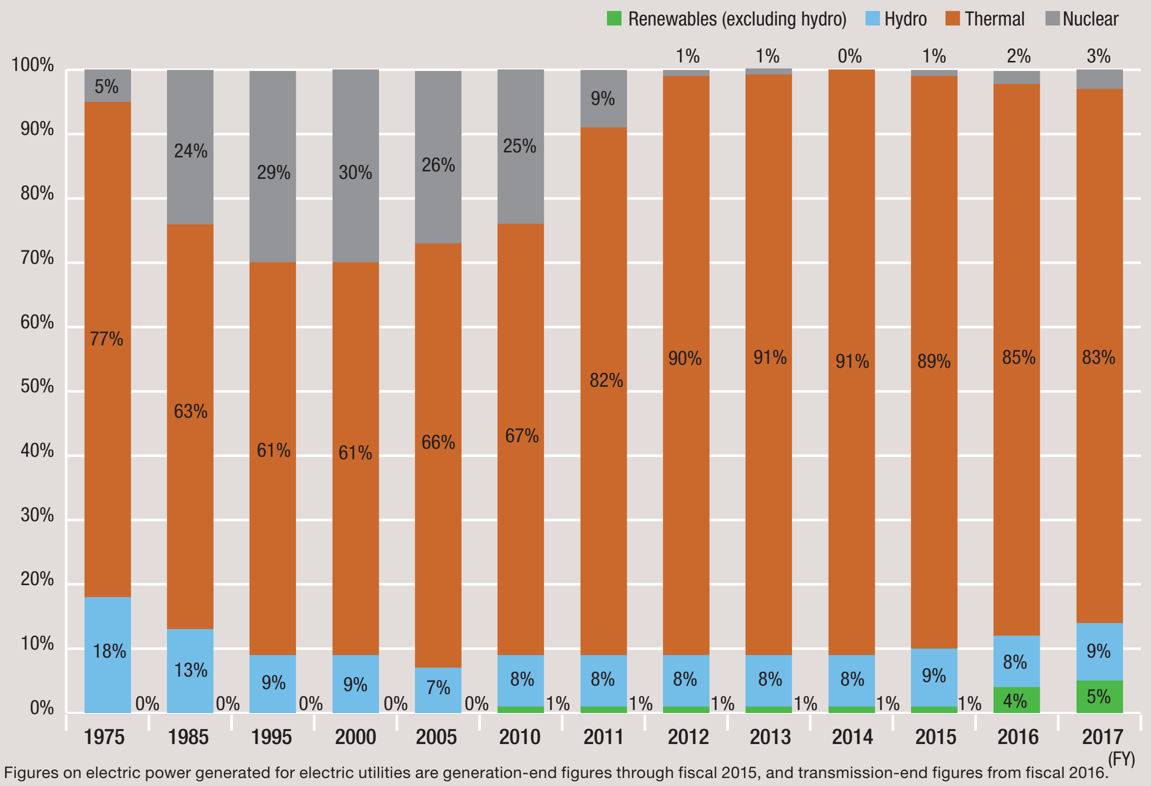
2. Electric Power Generated

Electric power generated came to 1,007.4 TWh in fiscal 2017. The progressive shutdown of nuclear power plants following the March 2011 earthquake increased dependence on thermal power plants and caused thermal's share of power generated to rise from 66.7% in fiscal 2010 to 83.3% in fiscal 2017. While nuclear power's share stood at 24.9% in fiscal 2010, the shutdown of all nuclear power plants in September 2013 caused this figure to drop to 0% in fiscal 2014 while thermal's share rose to 90.7%. Since the restart of Kyushu Electric Power Co.'s Sendai Nuclear Power Plant in August 2015, several other plants have gradually come back online. However, nuclear's share of power generated in fiscal 2017 was still only 3.0%.

On the other hand, the construction of renewable energy installations such as wind and solar power plants has increased. In fiscal 2017, 6.1 TWh of electric power was generated by wind power, and 15.9 TWh by solar power. Although wind power was first introduced in the 1990s, growth has been sluggish in recent years, increasing by only around 18% over the past five years. Solar power, on the other hand, has grown rapidly despite not entering the mix until around 2005. Following the launch of the FIT scheme in July 2012, solar power installations have surged, with solar output surpassing wind power in fiscal 2015. In fiscal 2017, about 2.6 times as much power was generated by solar power than by wind power.

Power Generation Mix, 1975-2017

Figure 3.6

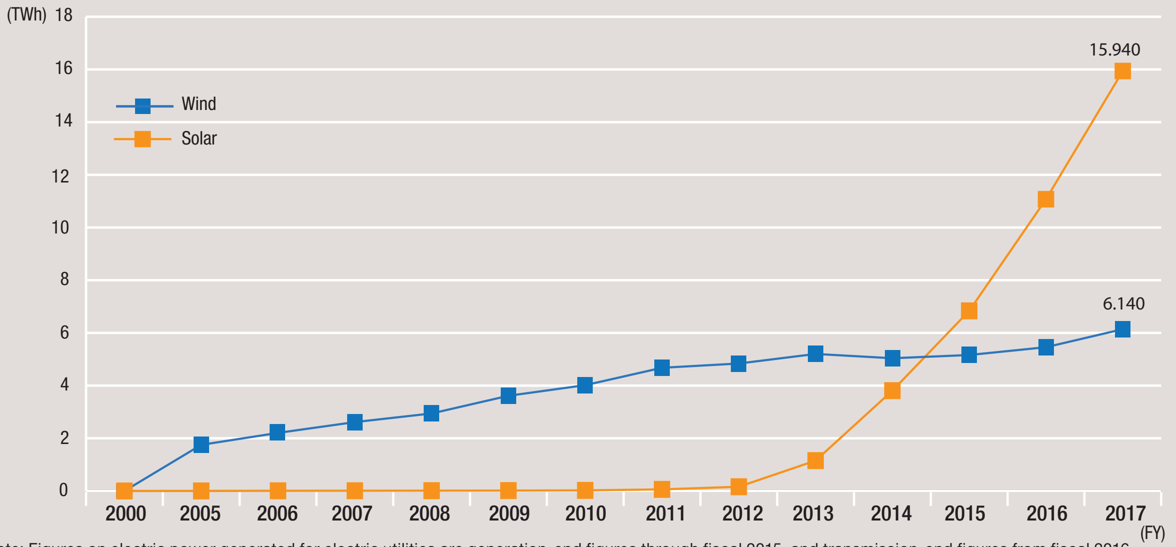


Note: Figures on electric power generated for electric utilities are generation-end figures through fiscal 2015, and transmission-end figures from fiscal 2016.

Source: Agency for Natural Resources and Energy, "Handbook of Electric Power Industry" (2018)

Wind and Solar Power Generation

Figure 3.7



Note: Figures on electric power generated for electric utilities are generation-end figures through fiscal 2015, and transmission-end figures from fiscal 2016.

Source: Agency for Natural Resources and Energy, "Handbook of Electric Power Industry" (2018)

3. Electricity Supply and Demand Balance

(1) Present and Projected State of Supply and Demand Balance

a. Recent Developments

Eight years since the Great East Japan Earthquake, Japan's electricity supply and demand situation is improving. Due to the prolonged shutdown of nuclear power plants, however, the country still remains dependent on thermal power to ensure a stable supply of electricity.

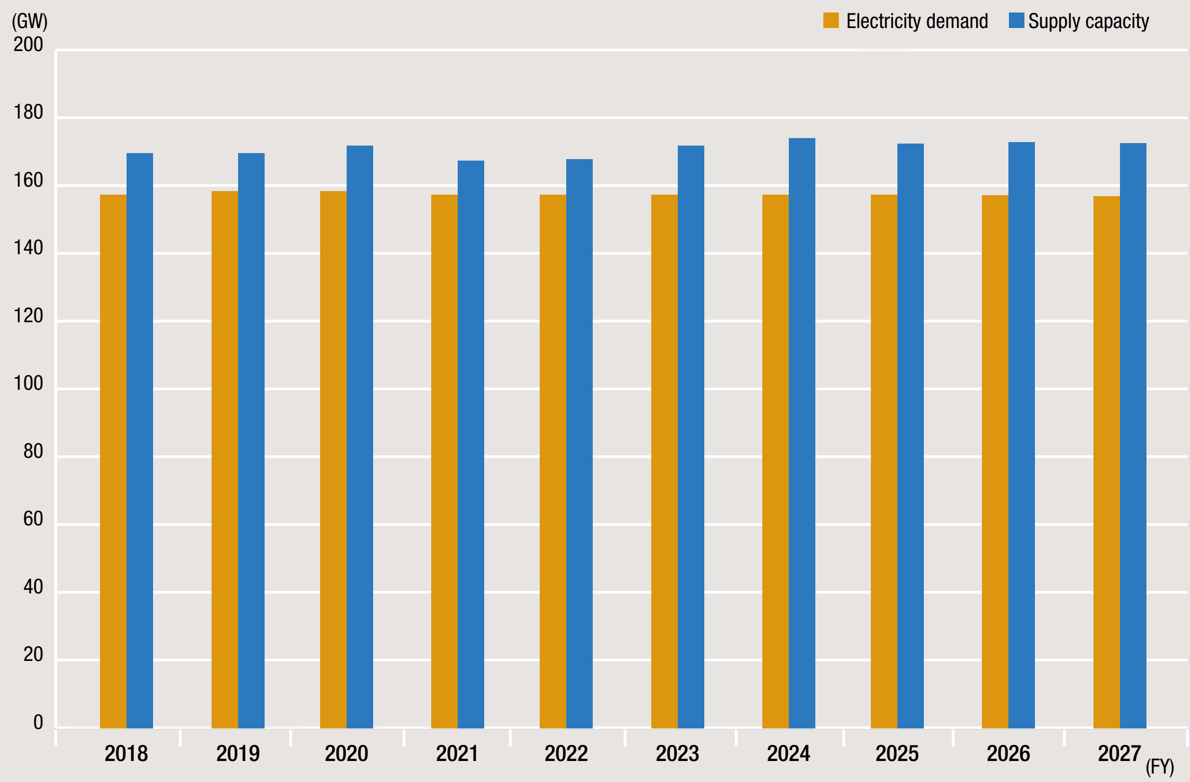
b. Supply and Demand Projections

As for the electricity supply and demand situation, it has remained possible in recent years to maintain the minimum 3% reserve margin needed to ensure supply continuity in all areas of Japan. The average rate of change in both electricity demand and supply capacity over the 10-year period from fiscal 2018 to fiscal 2027 will be almost 0%, and electricity demand and supply capacity are expected to remain at current levels.

(2) Securing Balancing Capacity

Electricity retailers have to be able to always match supply and demand, and they secure the necessary supply capacity to do so. It falls upon general electricity transmission and distribution utilities to secure the supply capacity required to be able to deliver adequate electricity to retailers to meet supply and demand fluctuations. Since fiscal 2017, the capacity required to balance supply and demand has been procured by tenders conducted by these transmission and distribution utilities in order to ensure that balancing capacity is procured in a fair and transparent manner.

Projected Electricity Demand and Supply Capacity Figure 3.8



Source: Agency for Natural Resources and Energy, "Handbook of Electric Power Industry" (2018)

The balancing capacity procured is of two main types: power source I and power source II. Power source I consists of power provided by dedicated sources of balancing capacity that are always available to transmission and distribution utilities; and power source II consists of surplus power from sources that can be used following gate closure for retail power sources. Power source I' provides balancing capacity when weather conditions are severe, and is procured utilizing generated output and demand response programs.

In fiscal 2019, 11,440 MW of power source I and 140,680 MW of power source II were procured. In addition, 1,940 MW of power source I' was procured, of which 890 MW of demand was met by demand response.

Power source I' was used a total of seven times in the Tokyo and Kansai areas in fiscal 2018. In the Tokyo area, it was used four times in August 2018 because of the tight supply and demand situation due to a heat wave. In the Kansai area, it was used twice in July 2018 because of the tight supply and demand situation due to a heat wave, and once in January 2019 because of a similarly tight situation in the winter. As of September 2019, power source I' had been used once in fiscal 2019 due to unseasonably cool weather in April.

Nishi-Sendai Substation Storage Battery System (Tohoku Electric Power Co.)

IV. Supply Structure

1. Power Generation Facilities

Total generating capacity was 305.5 GW at the end of fiscal 2018. This consisted of 53% thermal power (14% coal, 27% LNG, and 12% oil), 12% nuclear power, 16% hydro, and 19% renewables (excluding hydro). Figure 4.1 shows the breakdown of power generation facilities in Japan by power source at the end of fiscal 2018. The data on power generation facilities in this chapter are for facilities owned by electric utilities and facilities generating electricity procured by electric utilities from entities other than electric utilities.

(1) Power Generation Facilities for Electric Utilities

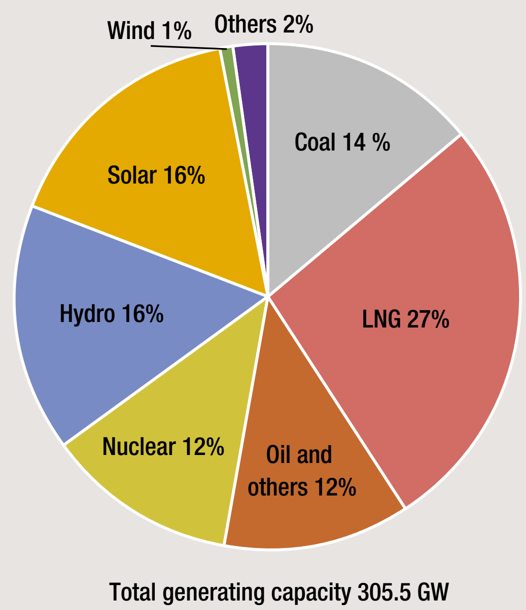
a. Thermal Power

The total installed capacity of thermal power plants was 160.6 GW as of the end of fiscal 2018, and the average power generation efficiency of all thermal plants in Japan was maintained at a world-class level of 44.1%[1] in fiscal 2016.

Coal-fired generating capacity came to 43.1 GW. Coal generates higher CO_2 emissions than other fuels. However, recent years have seen emissions reduced by the introduction of ultra-supercritical (USC) coal power plants. The power generation efficiency of coal-fired power plants in Japan was maintained at a world-class level of 41.6% in fiscal 2016.

LNG-fired generating capacity came to 82.0 GW. LNG-fired power plants produce lower SOx, NOx, and CO_2 emissions than oil- and coal-fired plants. Construction of large LNG-fired power plants employing high-efficiency combined-cycle technologies is underway to further reduce emissions of these substances. A new plant[2] added to the grid in 2018

Breakdown of Commercial Power Generation Facilities by Power Source (FY2018) Figure 4.1

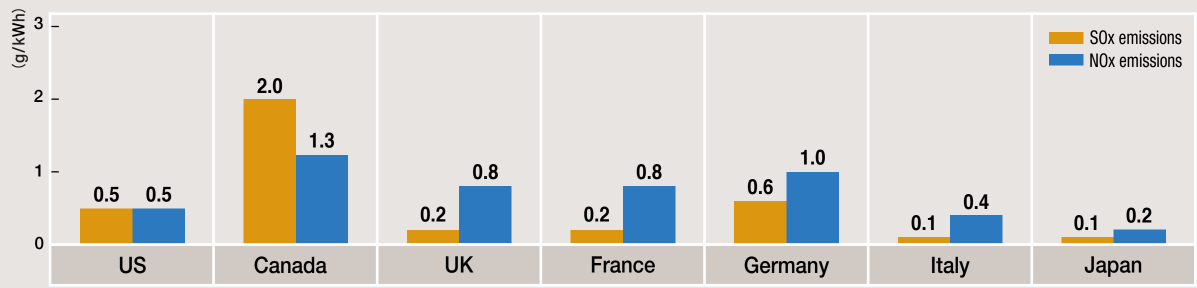


Source: OCCTO, "Aggregation of Electricity Supply Plans, FY2019"

1 Power generation efficiency is calculated on a low heating value (LHV) basis.
2 Chubu Electric Power Co.'s Nishi-Nagoya Thermal Plant Unit 7-2 (operation started in March 2018).

Comparison of SOx and NOx Emissions per Unit of Power Generated at Thermal Power Plants of Major Countries (2016)

Figure 4.2



Source: FEPC, "Energy and Environment" (2018)

exhibits significant improvements in performance, with gas turbine inlet temperatures of 1,600°C and power generation efficiency of approximately 63.08%.

Oil-fired generating capacity came to 35.5 GW. However, oil accounted for just 3.8% of power generated at the end of fiscal 2018. Oil-fired power plants are declining due to the promotion of highly economical coal power plants and low-carbon LNG power plants.

Unit 2 of Sakaide Power Station (Shikoku Electric Power Co.)
Reentered service after conversion from oil to LNG-CC in August 2016.

Jimah East Coal-fired Power Plant in Negeri Sembilan, Malaysia (Chugoku Electric Power Co., TNB, and Mitsui & Co.)
Jimah East is a USC plant with an output of 2,000 MW (1,000 MW × 2 units). Commercial operation started in 2019.

b. Hydro Power

Hydro power plants have been promoted in Japan to take advantage of the country's high levels of rainfall. Hydro generating capacity at the end of fiscal 2018 came to 49.1 GW, of which conventional hydro accounted for 21.6GW and pumped storage for 27.5 GW. Variable speed pumped storage systems have also been adopted. These systems provide a means of addressing fluctuations in output from renewables as they allow power output to be flexibly adjusted.

c. Renewable Energy

• Solar

Installed solar power generating capacity at the end of fiscal 2018 was 49.6 GW. Solar power makes up approximately 90% of total FIT-certified renewable power generating capacity. In Japan, solar power has led growth in renewables.

• Wind

As of the end of fiscal 2018, a total of 3.8 GW of wind power generating capacity had been installed in Japan. However, wind power has lagged behind solar because it takes longer to assess the environmental impacts (including the impact on the landscape) and there are constraints on grid capacity. For this reason, the introduction of wind power generation facilities is delayed compared to solar power generation. The majority of installed wind power generation facilities are onshore, and only around 20 MW of capacity is offshore. One obstacle to development of offshore wind farms was the lack of clarity surrounding the rules on occupancy of marine areas. The situation was clarified, however, with the entry into force in April 2019 of the Act on Promoting Utilization of Sea Areas for Development of Power Generation Facilities Using Maritime Renewable Energy Resources, and the introduction of offshore wind farms is expected to increase in the future.

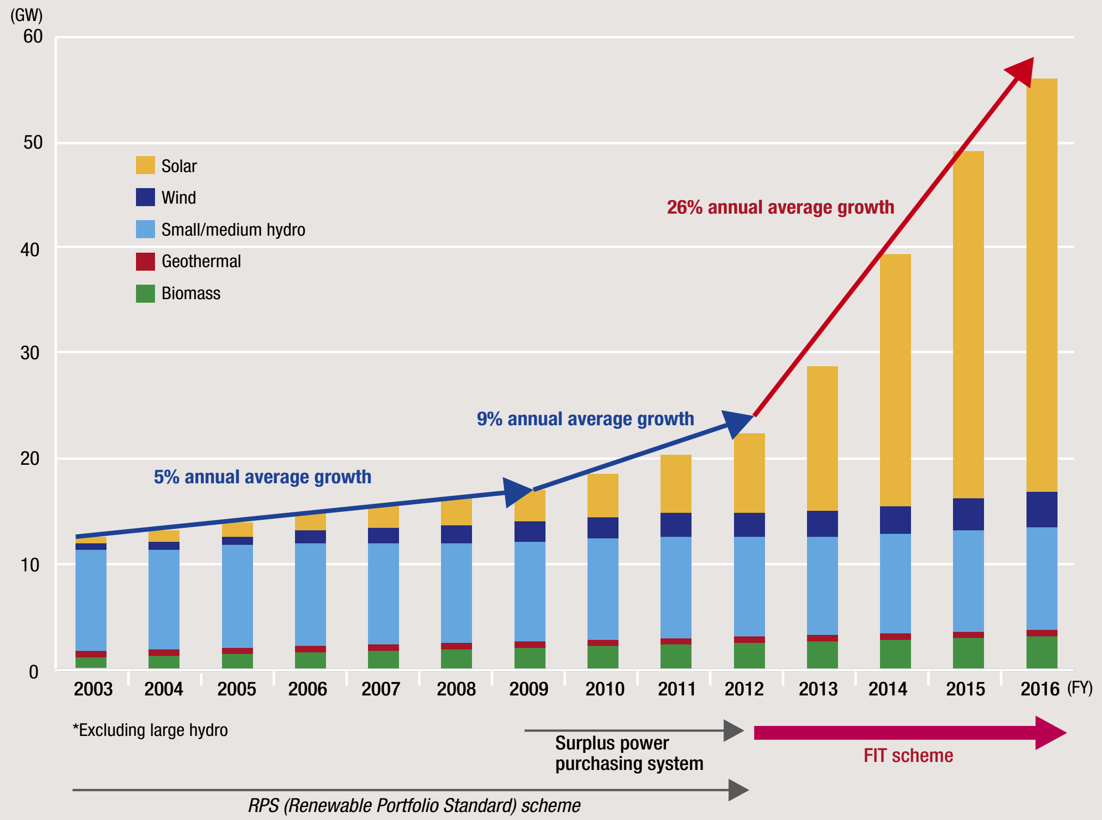
d. Nuclear Power Generation

Total nuclear power generating capacity (by 17 PWRs and 22 BWRs) at the end of fiscal 2018 came to 38.6 GW. As of the end of August 2019, nine nuclear reactors (all PWRs) were in commercial operation (see "Nuclear Power Generation" in Section 2, Chapter II).

Sakuma Dam (J-POWER)
Entered operation in 1956 with an output of 350 MW.

Trends in Renewable Energy Generating Capacity

Figure 4.3



Source: Agency for Natural Resources and Energy, "Energy White Paper 2018"

Hatchobaru Geothermal Power Station (Kyushu Electric Power Co.)
Hatchobaru Geothermal Power Station has a total capacity of 110 MW, which is the largest capacity of the geothermal power station in Japan.

(2) Future Plans

a. Transition of Power Generating Capacity and Power Development Plans

In March 2019, OCCTO published the "Aggregation of Electricity Supply Plans" for FY2019.[3] Figure 4.4 shows generating capacity by power source, and Table 4.1 shows the breakdown of power development plans up to fiscal 2028 (new installation, uprating/derating, and retirement plans).[4]

Looking forward, coal- and gas-fired generating capacity will trend upward overall as construction of new capacity will outweigh ongoing decommissioning. As the global trend to reduce GHG emissions continues, however, the withdrawal of plans for new coal-fired power plants and the shift to gas-fired power plants are observed in Japan. Decommissioning of oil-fired power plants will continue and generating capacity will shrink. While renewable generating capacity will increase driven by construction of new solar power plants and wind farms, hydro will increase only marginally.

b. Moves to Expand Capacity by Power Source

• Thermal Power

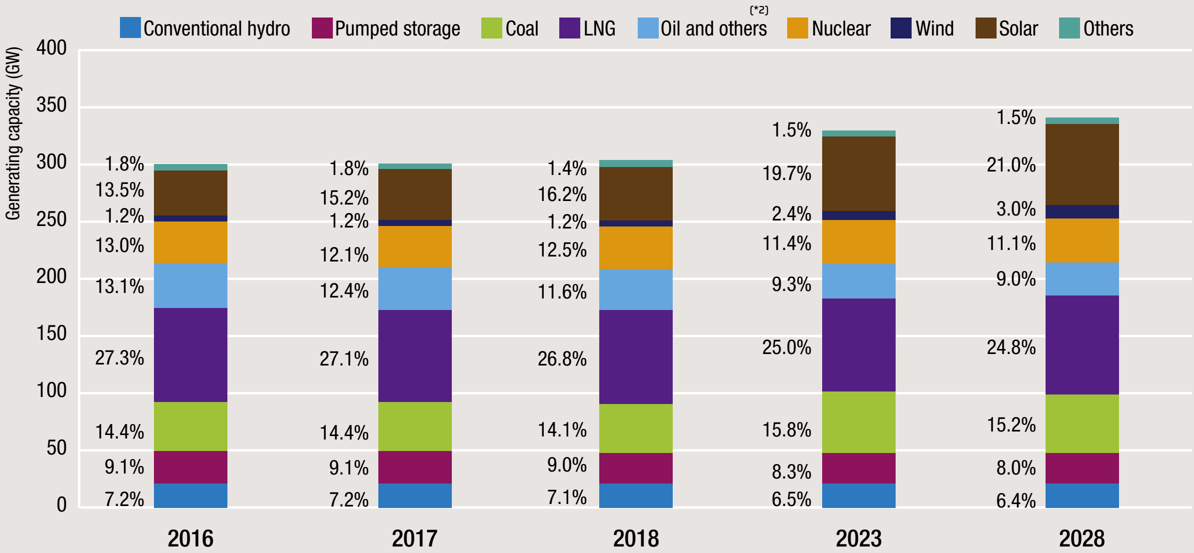
In June 2016, the government published its "Technology Roadmap for Next-Generation Thermal Power Generation." Among other things, this aims to reduce CO_2 emissions from thermal power plants by improving the efficiency of gas- and coal-fired power generation.

More specifically, the aim regarding gas-fired plants is to develop ultra-high temperature (1,700oC class) gas turbines[5] and fuel cell combined cycle (GTFC)[6] systems that generate electricity in three steps (by means of a fuel cell, gas turbine, and steam turbine). Regarding coal-fired plants, the aim is to develop integrated coal gasification combined cycle

3 In this report, the installed power generation capacity is the aggregation of the capacity of electric power plants owned by electricity utilities and those owned by companies other than electricity utilities that are registered as procured supply capacity of electricity retailers and general electricity transmission and distribution utilities.
4 Aggregated including facilities for which the date of commercial operation is "uncertain."
5 Development will be completed by around 2020 (approx. 57% power-generation efficiency and CO_2 emission intensity of 310 kg/MWh).
6 Development will be completed by around 2025 (approx. 63% power-generation efficiency and CO_2 emission intensity of 280 kg/MWh).

Trends in Generating Capacity by Power Source, 2016-2028 (*1)

Figure 4.4



*1 Generating capacity is the sum of the values submitted by electricity utilities.

*2 "Oil and others" includes the total installed capacities from oil, LPG, and other gas and bituminous mixture fired capacities.

Source: OCCTO, "Aggregation of Electricity Supply Plans, FY2019"

Power Development Plans up to FY 2028 by Stages

Table 4.1

(Output: MW)

Power source		New installation plan		Updating/derating plan		Retirement plan		Total
		Output	Sites	Output	Sites	Output	Sites	Output
Hydro		326	41	52	47	-200	26	178
	Conventional	326	41	52	47	-200	26	178
	Pumped storage	–	–	–	–	–	–	–
Thermal		16,118	41	-240	1	-10,096	45	5,782
	Coal	8,241	13	–	–	-756	3	7,485
	LNG	7,817	16	–	–	-5,287	10	2,530
	Oil	60	12	-240	1	-4,053	32	-4,223
Nuclear		10,180	7	152	1	-559	1	9,773
Renewables		6,658	379	6	2	-324	45	6,340
	Wind	1,859	62	–	–	-170	33	1,689
	Solar	3,780	285	–	–	-2	1	3,778
	Geothermal	46	1	6	2	–	–	52
	Biomass	909	26	–	–	-69	5	840
	Waste	64	5	–	–	-83	6	-19
Total		33,282	468	-29	51	-11,179	117	22,074

Source: OCCTO, "Aggregation of Electricity Supply Plans, FY2019"

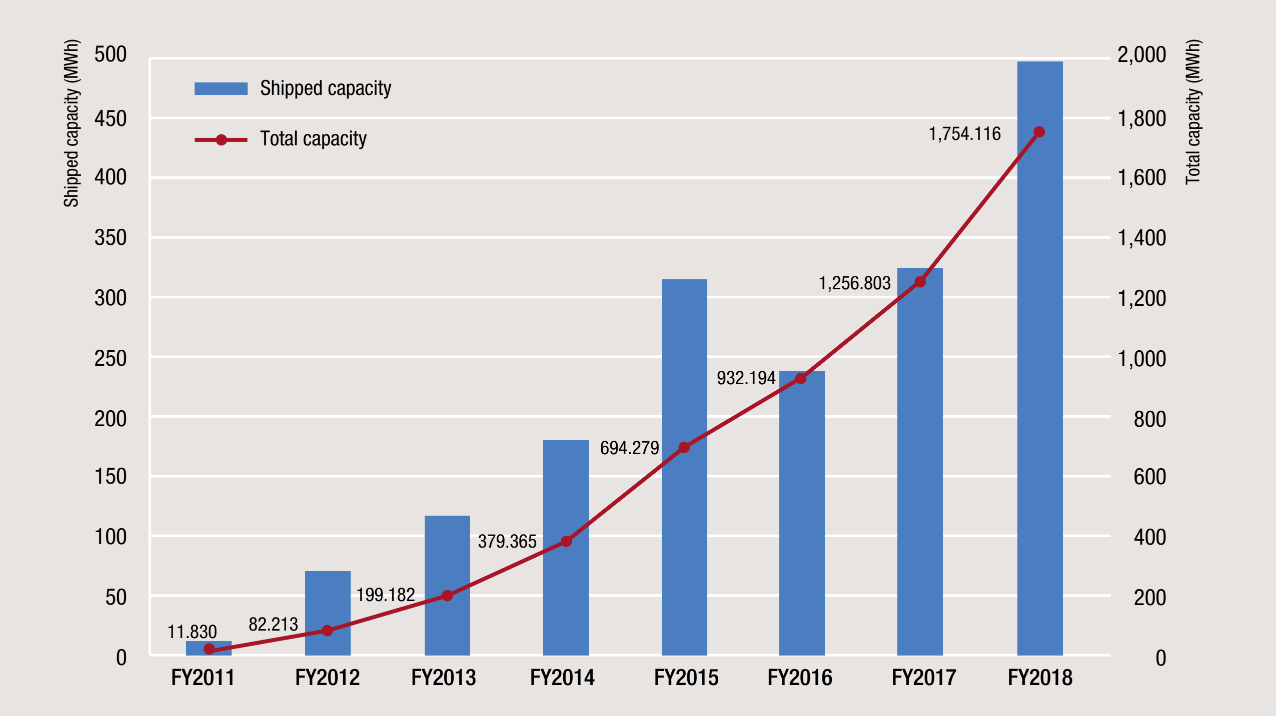
(IGCC)[7] and integrated coal gasification fuel combined cycle (IGFC)[8] systems.

• Renewable Energy
METI aims to expand adoption of renewables by solving the problem of fluctuations in output by making use of storage batteries, hydrogen, and other technologies.

Use of storage batteries is rising. Over 240,000 stationary lithium-ion storage battery systems with a capacity in excess of 1.7 GWh were in use in fiscal 2018 **(Figure 4.5)**. METI is conducting experimental projects using storage batteries. Themes selected for these projects include the adoption of large grid stabilization systems for storing power generated from renewables and the development of virtual power plants using customer-side energy resources (such as storage batteries and demand response). An example of the kinds of projects underway is that being conducted at the Buzen storage battery substation by Kyushu Electric Power Co. using NAS batteries. This commenced with the installation of NAS batteries with an output of 50 MW and capacity of 300 MWh in fiscal 2016, and it has demonstrated the possibility of avoiding having to control up to 300 MWh of solar power output per day.

Regarding hydrogen, METI formulated a "Strategic Roadmap for Hydrogen and Fuel Cells" in March 2019. In addition to setting targets for reductions in hydrogen prices, this sets targets for power generated by hydrogen-combustion gas turbines.[9] Regarding carbon recycling, METI formulated a "Roadmap for Carbon Recycling Technologies" in June 2019. This states that CO_2 emissions can be reduced by recycling CO_2 by separating and recovering it from the exhaust gas generated by power plants and other emission sources and combining it with "clean" hydrogen produced by fossil fuel reform and surplus power from renewables to synthesize fuel (such as methane). Using fuel produced from clean hydrogen at thermal power plants is also expected to reduce CO_2 emissions from thermal power plants.

Trend in Shipped Capacity of Stationary Lithium-Ion Storage Battery Systems Figure 4.5



Source: The Japan Electrical Manufacturers' Association, "Shipments of Stationary Lithium-Ion Storage Battery Systems" (2019)

7 Development will be completed by around 2020 (approx. 46%-50% power-generation efficiency and CO_2 emission intensity of 650 kg/MWh).
8 Development will be completed by around 2025 (approx. 55% power-generation efficiency and CO_2 emission intensity of 650 kg/MWh).
9 The aim is to achieve 27% power-generation efficiency by around 2020 (power output of 1 MW).

2. Transmission and Distribution Facilities

(1) Transmission Facilities

Japan's bulk transmission systems comprise 500 kV, 275 kV, 220 kV, 187 kV, 154 kV, and 132 kV transmission lines. The maximum transmission voltage is 500 kV for the 10 general electricity transmission and distribution utilities except Hokkaido Electric Power Co. (275 kV) and Okinawa Electric Power Co. (132 kV). As of the end of March 2018, these transmission lines had a total circuit length of approximately 179,000 km (Table 4.2).

Japan's three major metropolitan areas, Tokyo, Osaka and Nagoya, are served by bulk transmission systems comprising 500 kV multiple outer ring transmission lines surrounding demand areas with additional transmission lines for demand areas connected to the rings in a radial pattern. In the Tokyo Metropolitan Region, Tokyo Electric Power Company Holdings has constructed transmission lines designed to handle up to 1,000 kV as a third outer ring, which is currently operating at 500 kV. Extra-high voltage underground transmission cables (500 kV, 275 kV, 220 kV and 187 kV) are also being installed to enhance the reliability of the power supply to the central districts of large cities.

DC transmission lines are used in limited areas such as for the interconnections between Hokkaido and Honshu (two routes), and between Kansai and Shikoku.

(2) Substation Facilities

As of the end of March 2018, Japanese 10 general electricity transmission and distribution utilities have 6,774 substations with a total installed capacity of 843,886 MVA (Table 4.2). Almost all substations are now, with just some exceptions, remotely controlled and unmanned, and this has reduced the number of operators required at substations.

Due to the difficulty of finding sites for substations in urban areas, general electricity transmission and distribution facilities have reduced their footprints by adopting technologies such as gas insulated switchgear (GIS).

Total Circuit Length of Transmission and Distribution Lines and Transformation Facility Capacities Table 4.2

	1975	1985	1995	2005	2010	2015	2016	2017
Circuit length of transmission lines (km)								
220kV or above	14,167	23,486	29,107	35,209	35,791	36,949	36,845	36,865
110kV Under 220kV	28,913	35,106	36,952	35,962	35,696	35,588	35,709	35,459
Under 110kV	69,361	78,660	88,648	95,176	104,618	106,167	106,238	106,341
Total	112,441	137,252	154,707	166,347	176,105	178,704	178,792	178,665
Transformation facility capacities								
Substation output capacity (MVA)	234,748	447,866	657,536	778,740	810,924	833,112	842,084	843,886
Total Number of substations	3,466	5,152	5,814	6,570	6,686	6,718	6,766	6,774
Circuit length of distribution lines (km)								
Overhead	2,623,787	3,179,970	3,661,963	3,918,743	3,966,677	4,005,974	4,015,703	4,023,882
Underground	14,358	25,348	50,371	65,287	66,896	70,733	71,360	72,096
Total	2,638,145	3,205,318	3,712,334	3,984,030	4,033,573	4,076,707	4,087,063	4,095,978

Source: Agency for Natural Resources and Energy, "Handbook of Electric Power Industry" (2018)

Assist Arms (Hokuriku Electric Power Co.)
Hokuriku Electric Power Co. has been working with universities and manufacturers to develop “Assist Arm” robots for use by power distribution workers. In the near future, these will reduce labor requirements and improve efficiency by automating some work.

Removing snow from power lines (Hokkaido Electric Power Co.)

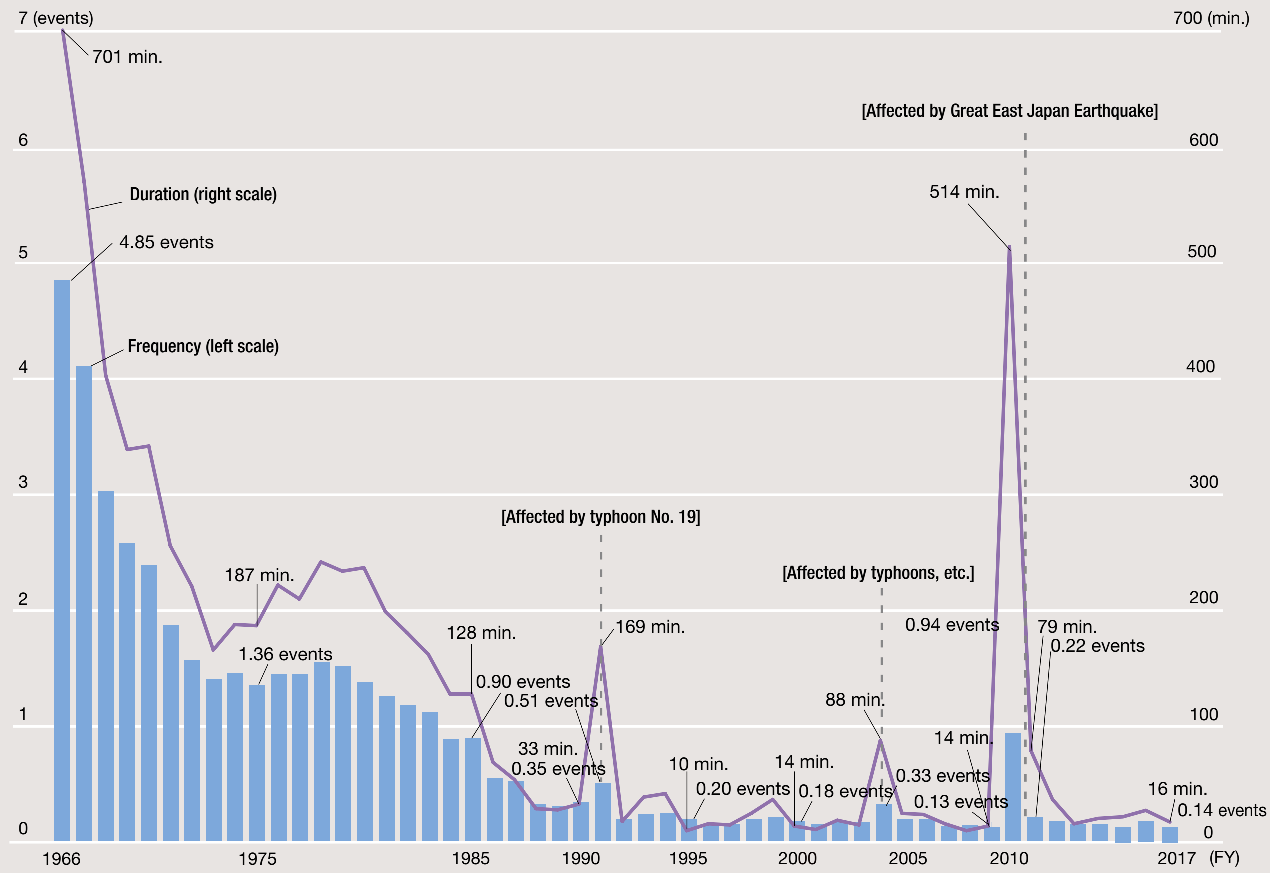
154kV Inawashiro Kyu-kansen transmission line (TEPCO Power Grid)
Constructed in 1914 with the third longest (225 km) transmission line in the world at that time. Still in commercial use more than a century later.
The transmission towers were manufactured by American Bridge.

(3) Distribution Facilities

Distribution lines are classified into special high-voltage lines (33/22 kV), high-voltage lines (6kV), and low-voltage lines (200/100 V), and the standard for high-voltage distribution systems is the 6 kV multi-divided, multi-connected system. In densely populated areas, electricity is supplied via special high-voltage lines to prevent equipment congestion and improve supply reliability, and spot network systems are used to meet the needs of customers who require particularly reliable supplies. Normally, electricity is supplied to low-voltage customers through 200/100 V single-phase three-wire or 200 V three-phase three-wire systems. Low voltage distribution lines are thus generally installed in three-phase four-wire open-delta connection distribution systems used to supply both single-phase and three-phase power. As of the end of March 2018, the total length of distribution lines in Japan was approximately 4,096,000 km. Of this, 72,000 km (approximately 1.8%) consisted of underground lines **(Table 4.2).**

Efforts to improve supply reliability and operating efficiency in the distribution sector include the widespread use of distribution automation systems for remote supervision and automatic control of distribution equipment. In response to the recent growth of distributed energy sources, switches with sensors and static automatic voltage regulators (such as STATCOMs) are increasingly being installed in distribution networks in order to maintain supply reliability and power quality.

SAIFI and SAIDI (Total for 10 electric power companies) Figure 4.6



Note: 9 electric power companies up to FY1988

Source: FEPC, "FEPC INFOBASE" (2018)

Smart meters for low-voltage customers have also been installed in order to (1) facilitate meter reading, (2) track individual customers' electricity usage so as to facilitate power-saving measures, and (3) provide a means of limiting power consumption when the supply and demand balance is tight. All special high-voltage and high-voltage customers and 49% of low-voltage customers (including households) had been provided with smart meters as of March 2018. All customers should have smart meters by the end of March 2025.

(4) Supply Reliability (SAIDI, SAIFI)

Supply reliability is being kept high compared to international standards by conducting patrols to prevent outages in advance as well as by developing high-voltage distribution network facilities as outlined above. Since the 1990s, a high level of supply reliability has been maintained except for major disasters such as the Great East Japan Earthquake. In fiscal 2017, the System Average Interruption Frequency Index (SAIFI) was just 0.14 interruptions and the System Average Interruption Duration Index (SAIDI) was only 16 minutes (Figure 4.6).

Very recently, maintaining supply reliability for more severe weather conditions (including typhoons and torrential rain) and meeting customers' electricity needs have emerged as challenges. METI has therefore set up a committee to investigate the development of electricity infrastructure that is highly disaster resilient.

3. Cross-Regional Operation and Interregional Interconnections

(1) Cross-Regional Operation

The Japanese power grid is divided into two frequency systems: a 50 Hz system in eastern Japan and a 60 Hz system in western Japan[10]. The neighboring grids of nine of the general electricity transmission and distribution utilities' service areas are connected to one another (Okinawa Electric Power Co. is the exception). Japan has no international interconnections.

The individual electric power companies are responsible, in principle, for operating their own systems independently and mainly compensate for load fluctuations on their own grids using their own generating sources. However, they have also worked with each other interregionally in order to improve economic efficiency and ensure a stable power supply by developing optimal power sources, conducting capital investment, and exchanging power so as to benefit from differences in their regional characteristics and demand structures. Today, use of the interconnections that span the service areas of different general electricity transmission and distribution utilities is administered by OCCTO. Traditionally, electricity generation utilities have been allowed to use these interconnections on a first-come, first-served basis.

However, in October 2018 this first-come, first-served model was abandoned, and an implicit-auction approach was introduced under which, in principle, use of the interconnections will be assigned based on contracts concluded in the spot market for next-day delivery. The introduction of these new rules should expand the use of the interconnections by new market participants and put in place a fair and competitive environment. At the same time, by implementing cross-regional merit orders, it is hoped that increases in electricity rates can be held to a minimum and additional business opportunities created for operators.

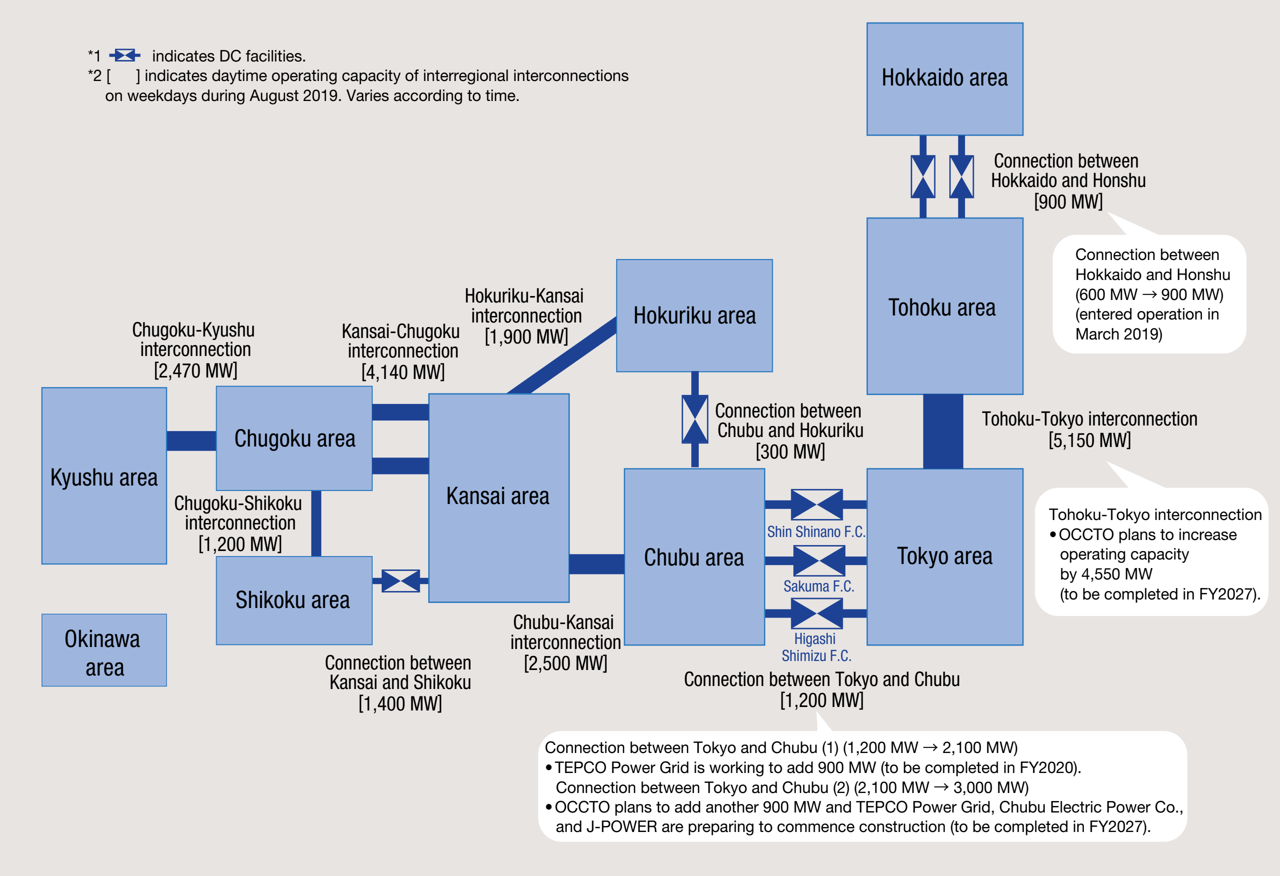
(2) Interregional Interconnections

As of 2019, the interregional interconnections in operation are mainly AC transmission lines. In the 50 Hz eastern region, Tokyo Electric Power Company Holdings and Tohoku Electric Power Co. are linked by 500 kV AC transmission lines, while Tohoku Electric Power Co. and Hokkaido Electric Power Co. are linked by DC submarine cables that span the approximately 20 km strait between Honshu and Hokkaido. Until recently the only connection between Tohoku Electric Power Co. and Hokkaido Electric Power Co. was a single ±250 kV (600 MW) connection. In March 2019, however, a second route (±250 kV, 300 MW) started commercial operation.

In the 60 Hz western region, Chubu Electric Power Co., Hokuriku Electric Power Co., Kansai Electric Power Co., Chugoku Electric Power Co., Shikoku Electric Power Co. and

10 The frequency difference is said to date back to 1896, when 50 Hz German-made power generation equipment was introduced in eastern Japan and 60 Hz U.S.-made equipment in western Japan.

National Grid Connections (As of August 2019) Figure 4.7



Source: Agency for Natural Resources and Energy (2019)

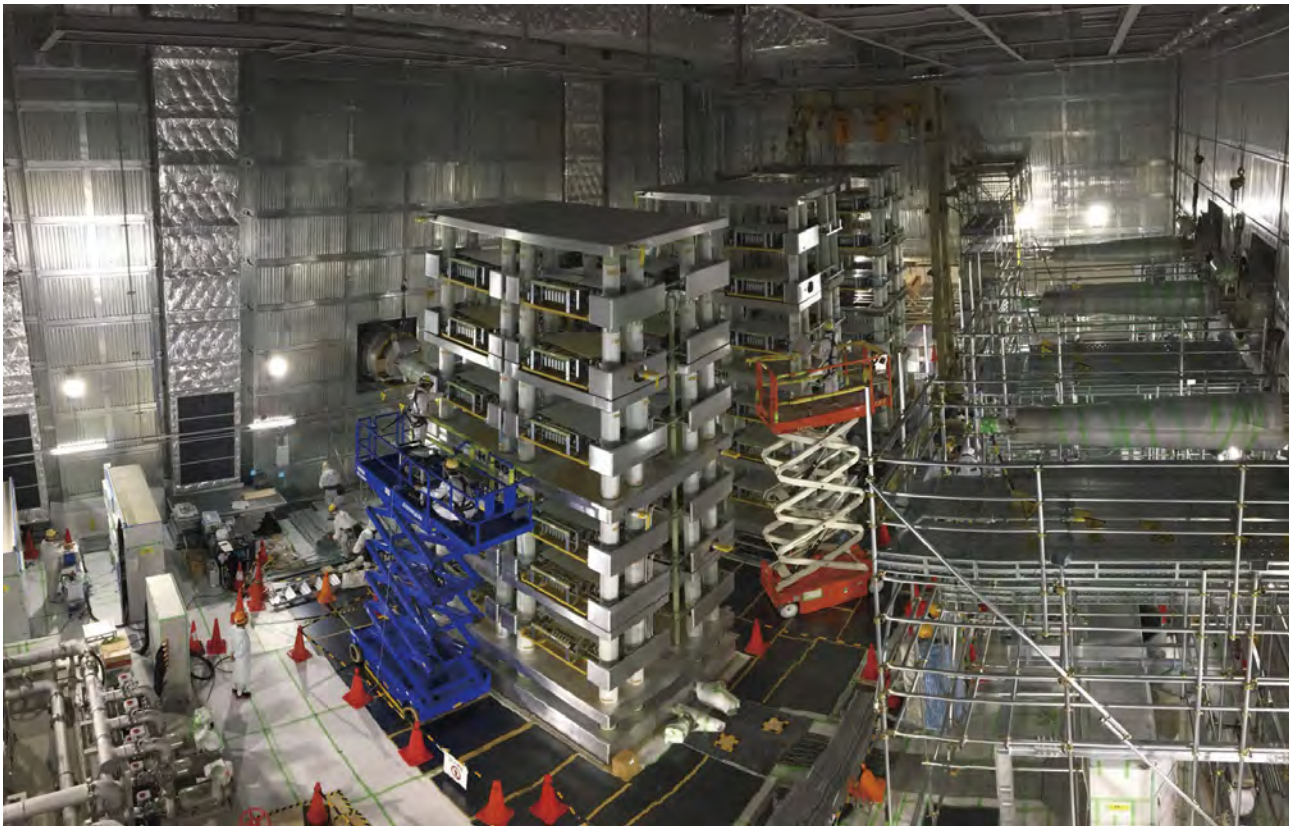
Kyushu Electric Power Co. are linked by 500 kV AC transmission lines. DC lines are used by Chubu Electric Power Co. and Hokuriku Electric Power Co., which are connected by back-to-back DC linkage facilities (300 MW), and by Kansai Electric Power Co. and Shikoku Electric Power Co., which are linked by ±500 kV DC submarine cables (initially operated at ±250 kV) that span the Kii Channel. The 50 Hz and 60 Hz systems are linked by the interconnections between the Tokyo Electric Power Company Holdings and Chubu Electric Power Co. networks (Sakuma Frequency Converter (300 MW), Shin-Shinano Frequency Converter (600 MW), and Higashi-Shimizu Frequency Converter (300 MW): total 1,200 MW) (Figure 4.7).

The large-scale adoption of distributed energy sources has made it difficult in recent years to maintain the optimum configuration of facilities. OCCTO is therefore considering plans to enhance these interconnections, taking into account the individual utilities' views. It has already been decided that the Shin-Shinano Frequency Converter at the Tokyo-Chubu interconnection will be upgraded by 900 MW by fiscal 2020, and plans are being made to expand the Sakuma and Higashi-Shimizu frequency converters' capacity by a total of 900 MW by the late 2020s (from 1.2 GW to 2.1 GW and then 3.0 GW in total). Responding to calls from IPPs and others, OCCTO plans to increase the capacity of the Tokyo-Tohoku interconnection by 4.6 GW by fiscal 2027.

OCCTO is required to develop a long-term policy that sets a course for developing and updating Japan's cross-regional interconnection systems on a nationwide scale. In this process it has identified the following three key issues for facility formation over the mid- and long-term.

- Growth in electricity demand is slowing.
- If new interconnection needs are to be addressed through the conventional approach to facility formation and grid use, it will require a huge increase in transmission and distribution facilities.
- This will result in a decreased capacity factor for transmission and distribution facilities, with inevitable upward pressure on wheeling charges.

Pivoting sharply from conventional thinking, which has revolved around boosting the grid to meet power source grid capacity, OCCTO has decided on a policy of making the best possible use of existing facilities. Premised on this, it has developed an approach to transmission and distribution facility development that tailors the "connect and manage" model already used in the United Kingdom and elsewhere to Japanese conditions. It employs three mechanisms. Firstly, available capacity is calculated based on estimates that closely resemble actual use, rather than on full-capacity operation of all power sources. This method has been in full use since fiscal 2018. Secondly, there is the "N-1 inter-trip scheme," which is a method of instantly limiting power output to secure stable transmission capacity in the event of N-1 failure.[11] This has been employed since October 2018. Thirdly, there is "non-firm access," which is a method of allowing fresh access on condition that output is limited while other power sources are in operation. As of fiscal 2019, action is underway to translate this into practice.



Construction of the Hida converter station (Chubu Electric Power Co.)

11 A single fault affecting one transmission or distribution line, one transformer, one generator, or one other item of electrical equipment.

V. Retail Business and Trading Markets

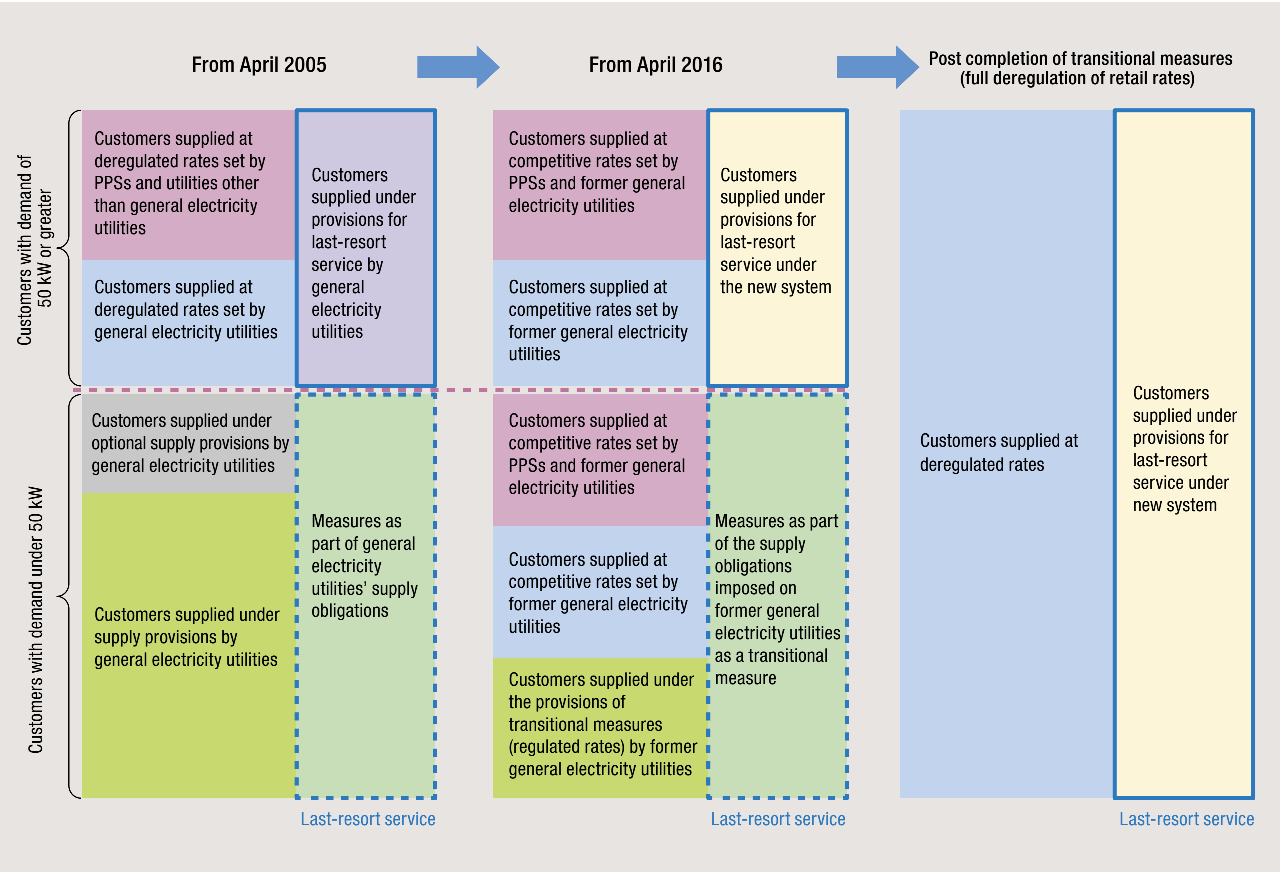
1. Electricity Rates

(1) Regulated Electricity Rates

Up until full liberalization of the retail electricity market in April 2016, general electricity utilities supplied electricity with the approval of the Minister of Economy, Trade and Industry at rates based on standard electricity use and at rates assuming use of electricity in a manner that contributed to load leveling, etc. The standard rates for households have remained regulated since full liberalization in order to protect customers. As of April 2019, 60.36 million low-voltage customers (78% of the total) paid regulated rates.

Regulated rates were originally to be discontinued at the end of March 2020. However, as competition had not developed sufficiently, METI decided in July 2019 to maintain regulated rates from April 2020 onwards. Discontinuation of regulated rates will continue to be considered, while paying close attention to developments at Tokyo Electric Power Company Holdings and Kansai Electric Power Co., which have comparatively more residential switchers.

Arrangements to Bridge the Transition to Competitive Rates Figure 5.1



Source: Agency for Natural Resources and Energy website (accessed on September 5, 2019)

Two-Component Rates Structure Table 5.1

Electricity rate = basic rate + unit electricity rate × electricity consumption ± fuel cost adjustment × electricity consumption + surcharges to encourage renewable energy generation × electricity consumption

Source: FEPC website (accessed on September 10, 2019)

a. Rate Structure

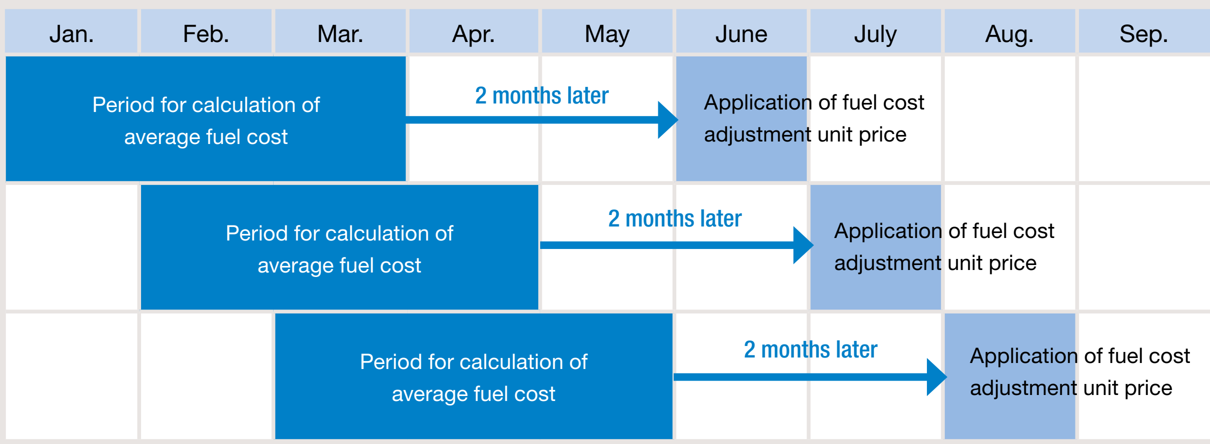
The electricity rates charged when former general electricity utilities supply electricity consist of two components: a basic rate that is determined according to the type of service agreement, and a consumption-based rate that is calculated based on the amount of electricity used (Table 5.1). The consumption-based component of the regulated rates paid by households is further divided into three tiers in order to, among other things, encourage energy conservation, which has been promoted since the first OPEC oil embargo. A relatively lower unit rate is charged for the first tier, which covers consumption up to the 120 kWh that is considered necessary for daily life. The unit rate for the second tier reflects the average supply cost, and a slightly higher unit rate is charged for the third tier. There is also a regulated rate that applies mainly to small factories.

b. Fuel-Cost Adjustment Scheme

A fuel-cost adjustment scheme was introduced in January 1996 in order to externalize the effects of fuel prices and exchange rates, which are beyond the control of general electricity utilities in their efforts to enhance efficiency, and thus reflect the changes in rates as expediently as possible and to stabilize the general electricity utilities' management environment.

At present, the period (time gap) before fuel price fluctuations are reflected in electricity prices is set to two months in order to level rate fluctuations, and fuel price three-month averages are reflected in the electricity rates charged each month (Figure 5.2).

Fuel-Cost Adjustment Timing (Example: June, July, August) Figure 5.2



Source: Compiled from FEPC materials

c. Feed-in Tariff Scheme for Renewable Energy

A system of purchasing surplus electric power generated by solar power systems was introduced in 2009. In 2012, the scope of sources covered was expanded and former general electricity utilities were required to purchase electricity generated using renewable resources (solar, wind, hydroelectric, geothermal, and biomass) at a fixed price for a certain period. The cost of purchase was to be recovered via a surcharge calculated in proportion to the volume of use by customers that constitutes one component of electricity rates (see "Renewable Energy" in Section 3, Chapter II).

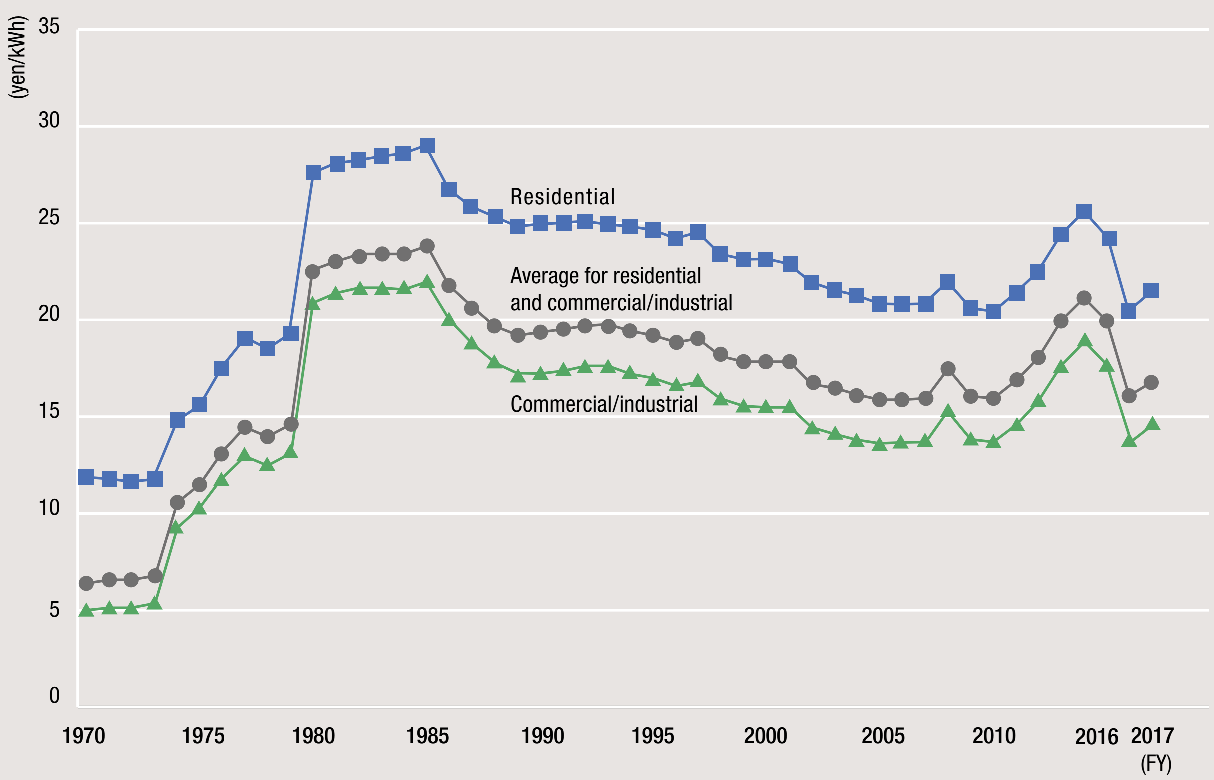
(2) Unregulated Rates

Liberalization of retail supply to special high-voltage customers commenced in April 2000. Coverage was progressively expanded, and full liberalization of the retail market commenced in April 2016. Large customers' contracts are determined through negotiation with electricity retailers based mainly on their planned and actual electricity usage. In addition to being able to simply carry on paying regulated rates for service provided by former general electricity utilities, households and other low-voltage customers can also choose from among the unregulated rate plans offered by former general electricity utilities and PPSs. Former general electricity utilities and PPSs provide a range of new rate options tailored to customer lifestyles based on their own sales strategies (see "Efforts to Acquire Customers" in Section 2, Chapter V).

(3) Trends in Unit Electricity Rates

Electricity rates in Japan have declined since rising sharply from the 1970s to the early 1980s due to the oil crises. Since

Trends in Electricity Rates Figure 5.3



Note: Figures are totals for general electricity utilities through fiscal 2015, and for electricity utilities from fiscal 2016.

Source: Agency for Natural Resources and Energy, "FY2018 Annual Report on Energy" (2019)

Average Unit Wheeling Charges of General Electricity Transmission and Distribution Utilities
(As of July 2017)

Table 5.2

Average unit wheeling charges of general electricity transmission and distribution utilities (yen/kWh) (excluding tax)			
	Low voltage	High voltage	Special high voltage
Hokkaido	8.76	4.17	1.85
Tohoku	9.71	4.50	1.98
Tokyo	8.57	3.77	1.98
Chubu	9.01	3.53	1.85
Hokuriku	7.81	3.77	1.83
Kansai	7.81	4.01	2.02
Chugoku	8.29	3.99	1.62
Shikoku	8.61	4.04	1.79
Kyushu	8.30	3.84	2.09
Okinawa	9.93	5.20	3.01

Source: Agency for Natural Resources and Energy, "Process of Rates Reform Allowing for Changes in the Business Environment" (2017)

the Great East Japan Earthquake in 2011, however, rates have again risen due to the increased cost of generating power at thermal power plants resulting from the shutdown of nuclear power plants and escalating fuel prices. Electricity rates fell from 2015 due to lower fuel costs, but again rose in fiscal 2017 (Figure 5.3).

(4) Wheeling Charges

Even in a deregulated environment, it is general electricity transmission and distribution utilities that build, operate, and maintain transmission and distribution networks to ensure stable supply. When PPSs retail electricity and former general electricity utilities supply electricity on a retail basis outside of their own service areas, they must use the network of the general electricity transmission and distribution utilities that own the supply facilities in the service area concerned. Wheeling charges are the fees imposed by transmission and distribution utilities on the users of their network (Table 5.2). The wheeling charges are deliberated by a review meeting of specialists on electricity pricing under the auspices of the Electricity and Gas Market Surveillance Commission, taking into account both the appropriate recovery of requisite costs and fairness for network users. They are then opened to public comment prior to final adoption.

Since April 2016, general electricity transmission and distribution utilities have been required to provide electricity via a universal service for customers on isolated islands, applying the same rate levels as on the mainland in order to protect customers. The electric power supplied to islands is mainly generated by thermal power plants, and the cost of provision of universal service to islands (including the portion of the price that varies according to thermal fuel costs) is passed on to all customers in the individual service areas of general electricity transmission and distribution utilities in question via wheeling charges under what is known as the "universal island service price adjustment system."

2. Efforts to Acquire Customers

(1) State of Switching

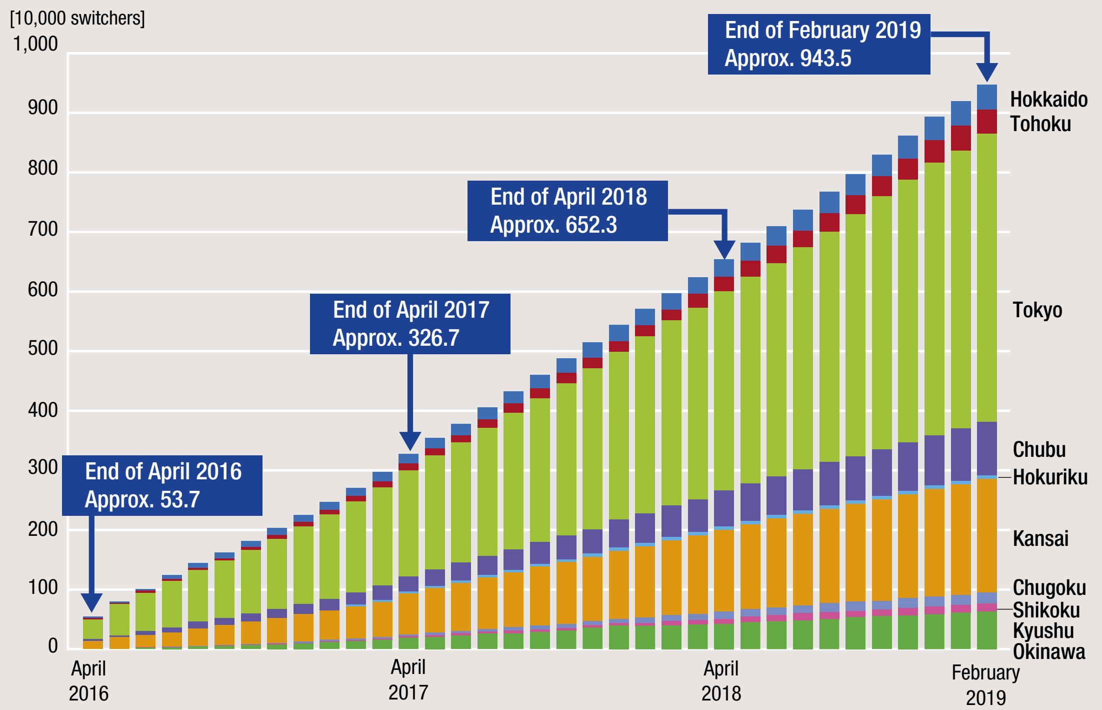
As of the end of February 2019, there had been a cumulative total of approximately 9.435 million cases of switching since March 2016 (Figure 5.4), when applications for switching were first accepted. Among general households, some 15% of the regular contracts in effect immediately prior to liberalization (approximately 62.53 million) had been switched.

(2) Activities of Electricity Retailers

Electricity retailers supply extra high-voltage and high-voltage customers in accordance with contracts and unit prices negotiated on the basis of projected electricity usage and actual circumstances. Former general electricity utilities are working to strengthen their business capacity by establishing specialized marketing operations, increasing personnel to take charge of business for corporate customers, and implementing business training. For example, they have assigned a dedicated business manager for each customer and increased the frequency of customer contact so that the customer's needs can be suitably met. In addition, they are diagnosing and analyzing the customer's energy usage, and making proactive proposals to their customers regarding the efficient use of energy.

On the other hand, electricity retailers provide low-voltage customers with customer services and so on through rate plans tailored to customers' needs and lifestyles, point-based loyalty programs, and membership websites. Services that utilize information on electricity usage obtained from smart meters are also emerging. Former general electricity utilities are installing smart meters that can measure usage at 30-minute intervals, and all customers will have smart meters by the end of fiscal 2024 (see "Uses of Digital

Trends in Number of Low-Voltage Switchers by Service Area (As of end of February 2019) Figure 5.4



Note: Switching refers only to changing from a former general electricity utility to a PPS contract.
It does not include changing to an unregulated-rate contract that is offered by a former general electricity utility.

Source: Agency for Natural Resources and Energy, "Progress on Full Liberalization of the Electricity and Gas Retail Markets" (2019)

Technologies by Former General Electricity Utilities" in Section 2 of "Topics").

a. Rate Plans Tailored to Lifestyles

Electricity retailers are offering time-of-use rate plans for customers who tend to be out during the day and consume most of their electricity at night, as well as for customers who use storage heaters and/or water heaters overnight and during off-peak hours. Such plans offer lower unit rates for nighttime electricity use. Other options are also available. These include plans that provide discounts off the contracted unit price as usage increases for customers who use large amounts of electricity due to family size or pets, and plans that offer lower rates for devising ways of using electricity more wisely.

There are also plans that offer summer-only discounts for households with elderly members in order to encourage the use of air conditioning to prevent heat stroke.

b. Additional Services and Discounts for Bundled Goods

There are also rate plans that offer non-electricity-related goods and services to households. These include inspection and emergency repair of faulty electrical equipment, such as wiring faults that keep the power from turning on. Other everyday support services include services to identify and report water leaks, find lost keys, and check on elderly customers at home. Other plans provide discounts for supply contracts that are bundled with cellular phone, internet, gas, automobile gasoline, and other services. Bundling lifestyle-related commodities and services with rate discounts in this way is expected to improve customer satisfaction and help electricity retailers to attract and retain customers.

c. Renewable Energy Rate Plans

Among the green options being offered are rate plans that deliver electricity generated using renewable resources. Although there are limits to how much electricity can be generated and procured from renewables, a growing number of electricity retailers are offering plans of this kind, and they are also increasing their disclosure of information on their power generation mix and CO_2 emissions.

(3) Rate Comparison Sites

As seen above, electricity retailers are offering a variety of rate plans, and about 1,000 types of plans were available as of the end of August 2019. Rate comparison websites have therefore been launched to help customers choose the plans that best meet their needs. Competition is intensifying in the major conurbations of Tokyo, Osaka, and Nagoya, and there are also signs of growing competition in provincial urban areas in regions such as Hokkaido and Kyushu. Although the number of electricity retailers has declined since fiscal 2018, there has been little change in the number of plans. Some electricity retailers may have pulled out due to the competition, while others are expanding the range of plans that they offer.

(4) Regulations and Guidelines

The Electricity and Gas Market Surveillance Commission established the Guidelines Concerning the Management of the Electricity Retail Business in January 2016. The purpose of these guidelines is to enhance protection for electricity customers, allowing them to receive electricity with confidence while also contributing to the healthy growth of the electricity business itself. These guidelines provide instructions to the utilities in question, such as electricity retailers, on how to observe relevant laws and regulations, as well as instructions encouraging their autonomous efforts. Specifically, the guidelines indicate desirable conduct by operators in order to protect customers and bring about the healthy growth of Japan's electricity business. These include: (1) provision of appropriate information to customers, (2) suitable forms of business and contracts, (3) optimized contract contents, (4) appropriate handling of customer complaints and inquiries, and (5) optimized contract cancellation procedures. The guidelines also identify behavior which would constitute a problem under the Electricity Business Act (i.e., actions that could lead to the issuance of a business improvement order or a business improvement recommendation).

These guidelines are to be revised as and when necessitated by future changes in the electricity retail environment. Four revisions have been made so far, with the latest revision being made in December 2018.

3. Trading Markets

(1) Wholesale Electricity Market

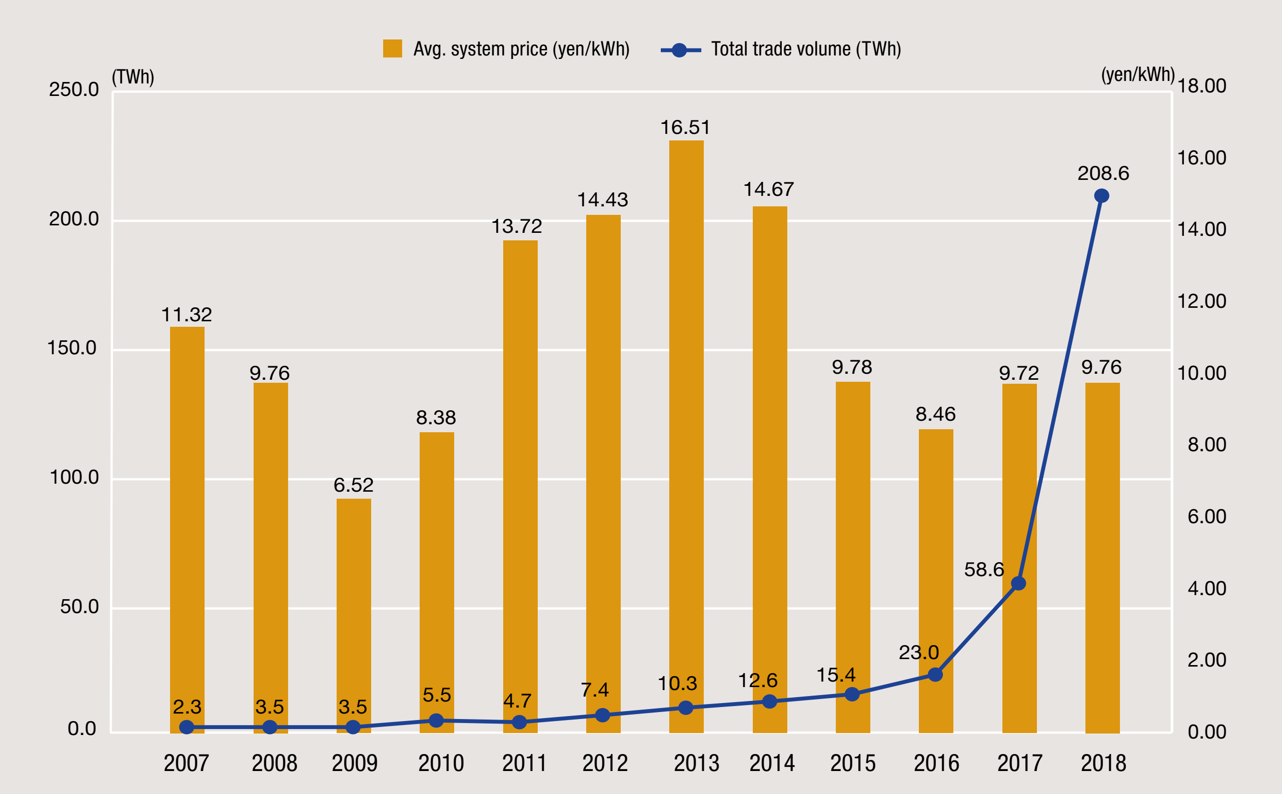
The Japan Electric Power Exchange (JEPX) was established in November 2003 and commenced trading in April 2005. The purpose of JEPX is to stimulate electricity transactions on the exchange. Specifically, transactions will be stimulated by offering enhanced instruments for selling and sourcing electricity and encouraging the formation of index prices to assist assessments of investment risk, etc. Initially, JEPX was treated as a privately operated, voluntary wholesale exchange. Later, it was designated a wholesale electricity market under the provisions of the Electricity Business Act in April 2016.

The principal market participants are the electricity generation utilities and electricity retailers involved in wholesale power transactions. However, other players, such as general electricity transmission and distribution utilities that accept electricity generated by feed-in tariff plans, are also involved as "special trading members" in order to facilitate the sale and purchase of "non-fossil value," as described in a later section. Businesses such as demand response aggregators that enter into negawatt trading contracts with transmission and distribution utilities have also been permitted to participate in the market since March 2017. As of July 2019, 167 companies are trading members.

JEPX currently provides a marketplace for the following electricity transactions:

- Spot market: Trading in 30-minute increments of electricity for next-day delivery.
- Forward market: Trading in electricity for delivery over the course of a specified future period. Products are created by packaging together specific periods and times, such as monthly 24-hour products or weekly daytime products.

Average System Prices and Trade Volumes on the Spot Market Figure 5.5



Source: Compiled from Agency for Natural Resources and Energy, "Handbook of Electric Power Industry" (2018), and JEPX website (accessed on August 1, 2019)

- Intra-day market: A market for correcting unexpected misalignments between supply and demand occurring between a spot market transaction and delivery (a minimum of one hour later).
- Bulletin board trading market: JEPX mediates the trading of electricity for prospective buyers and sellers.

The spot market is the largest of the above four markets in trading volume and is a particularly important market. Trading is done through a blind single-price auction system. It is blind because participants cannot see other participants' bids when they make their bids. A single-price system is one that defines the intersections between the sell and buy bid curves as the system price and trade volume. As a rule, high buy bids and low sell bids are executed at the system price.

Market fragmentation can occur due to the existence of constraints concerning, for example, the available capacity of connections between services areas. When market fragmentation occurs, system prices and trade volumes are calculated at the level of each of the fragmented markets.

The volume of trades on the spot market has been on the rise since 2016, and reached approximately 208.6 TWh in fiscal 2018. This is more than a three-fold increase in year-on-year terms and means that about one quarter of all electricity sold in Japan is sold through JEPX. The average system price has hovered around the 8-9 yen/kWh mark since fiscal 2015, and stood at 9.76 yen/kWh in fiscal 2018 (**Figure 5.5**).

(2) New Markets

For the purpose of encouraging further competition in electricity markets, securing stable power supply, and actualizing environmental value, the Japanese government is considering the establishment of several new markets. The intention is that the creation of these unconventional new markets will serve to actualize and render tradable new forms of value to accompany the lowered entry/exit barriers in existing markets. The main mechanisms under consideration are (a) a baseload power market, (b) a capacity market, (c) a balancing market, and (d) a non-fossil value trading market.

a. Baseload Power Market

New market entrants find it difficult to own or enter contracts to buy electricity from affordable baseload power sources such as coal, large hydropower, and nuclear power plants. To surmount this difficulty, a market dedicated to the trading of electricity produced by baseload power plants was created, in which former general electricity utilities and new entrants are given equal access to electricity from baseload power plants. It is expected that the resulting increase in transactions in the wholesale market will lead to increased competition in the retail market.

The first baseload trades of fiscal 2020 took place on August 9, 2019. The clearing prices were 12.47 yen/kWh in the Hokkaido area, 9.77 yen/kWh in the Tohoku/Tokyo area, and 8.70 yen/kWh in the West Japan area (**Table 5.3**). Trade volumes came to 12.7 MW in the Hokkaido area, 88.2MW in

Results of First Baseload Market Trades in fiscal 2020 Table 5.3

Area	Trade	First of FY2020 (Trade date: Aug. 9)
Hokkaido	Clearing price (yen/kWh)	12.47
	Trade volume (MW)	12.7
Tohoku and Tokyo	Clearing price (yen/kWh)	9.77
	Trade volume (MW)	88.2
Western Japan	Clearing price (yen/kWh)	8.70
	Trade volume (MW)	83.4

Source: JEPX, "Notification of Results of Fiscal 2020 Trades on the Baseload Trade Market" the Tohoku/Tokyo area, 83.4 MW in the West Japan area, and 184.3 MW in the three areas combined.

b. Capacity Market

The predictability of the payback on investment in power generation business is likely to decline, depending on the increasing competition and changes in environmental trends. If the adoption of renewables expands simultaneously, it is expected that the power generation operating rate will decline, the selling price of electricity will fall, and revenues from selling electricity from all sources will come down. Conversely, however, regulatory organizations consider that if investments in power generation capacity are not made at the appropriate time, there could be more situations in which the supply and demand balance becomes too tight, and electricity balancing capacity cannot be secured. Therefore, the creation of a capacity market is now under consideration for the purpose of 1) ensuring a greater degree of investment predictability, 2) the replacement of old power plants with new ones and 3) the securing of actual (installed) supply capacity through market mechanisms.

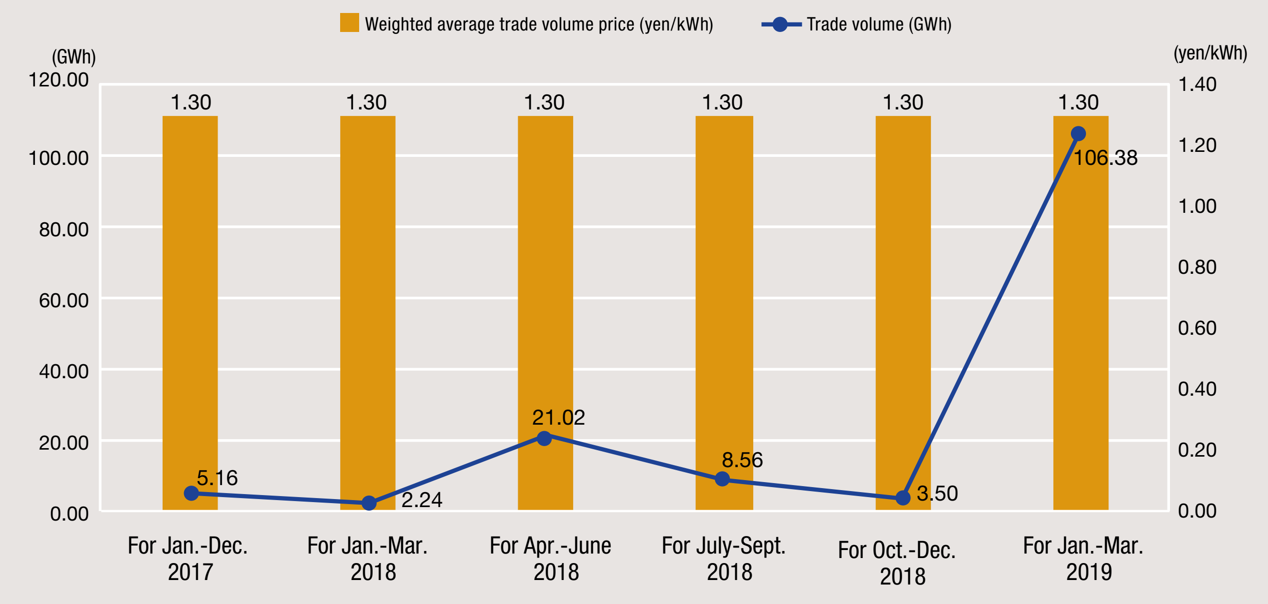
The intent is to open the capacity market to transactions in fiscal 2020, and to have capacity contracts become effective from fiscal 2021.

c. Balancing Market

The tasks of controlling frequency and balancing supply and demand are performed by general electricity transmission and distribution utilities in each area. With regard to balancing, it is important that operators secure the capacity required for practical purposes while avoiding giving preferential treatment to particular sources of electricity or creating too great a cost burden. Japan's first auction for balancing supply and demand was held by general electricity transmission and distribution utilities at the end of fiscal 2016 for balancing supply and demand for fiscal 2017 (see "Securing Balancing Capacity" in Section 3 (2), Chapter III).

A balancing market for procuring and operating balancing supply and demand more efficiently on a cross-regional basis is now under consideration, with a view to launching the market in or after 2020.

Results for Non-fossil Value Trading Market Figure 5.6



Source: Compiled from JEPX, "Notification of Results of Trades on the Non-Fossil Fuel Trading Market"

d. Non-Fossil Value Trading Market

The wholesale electricity market described above makes no distinction between fossil fuel and non-fossil fuel power generation, and there were concerns that this omission could obscure the actual value of non-fossil power generation capacity. It was also pointed out that it would be difficult for new entrants to buy electricity from non-fossil fuel sources, as they do not have enough sufficient trading experience compared with former general electricity utilities. Furthermore, it was proposed that the cost of the environmental value of electricity derived from renewables purchased through the FIT scheme should not have to be borne by all customers, but instead should be borne primarily by those customers who desire that value. As one step to help address these concerns, a non-fossil value trading market was established in the wholesale electricity market described above to isolate non-fossil value of the electricity only and to certify it for trading. It is hoped that the establishment of this market will help Japan reach its global warming targets by fostering use of a power generation mix consistent with its most suitable energy mix.

Six auctions of non-fossil certificates for FIT electricity had been held as of August 9, 2019. The weighted average trade volume price on each occasion was 1.30 yen/kWh. The trade volumes of the first through fifth auctions ranged between 2-21 GWh. The sixth auction covering January to March 2019, however, saw the trade volume surge to in excess of 100 GWh for the first time (Figure 5.6). Trading of electricity generated by non-fossil fuel sources not covered by FIT scheme is scheduled to commence in fiscal 2020.

Topics

1. Digital Transformation of Japan's Electric Power Industry

For many years now, Japan's former general electricity utilities have automated their facility monitoring and control systems and other hardware in the electricity generation sector and the transmission and distribution sector in order to make operation and maintenance less labor intensive. Recently, they have also been forging ahead with digital technologies such as Big Data and the Internet of Things (IoT), and this digital transformation is expected to raise profitability and generate new business (Figure 1). Further labor savings are being pursued by greater automation of operation and maintenance, mainly in the generation and the transmission and distribution sectors, with the aim of improving profitability. In the retail sector in particular, efforts to generate new business include proactively rolling out energy management services and other new services, including services in non-energy fields.

Directions in Digitization of the Electric Power Industry Figure 1

Objectives and value offered		Typical initiatives
Improvement of profitability	Automation and control optimization (optimum control, etc.)	• Superefficient operation of power plants using IoT, AI technologies, etc. [generation] ··· **Fig. 2** • Optimized procurement planning and revenue analysis by electricity retailers [transmission and distribution, retailing]
	Manpower reduction and safety improvement (remote control and automation)	• Improvement of safety technologies using IoT, AI, etc. [generation, transmission and distribution] ··· **Fig. 3** (e.g., visual inspection of transmission lines and use of drones to diagnose deterioration of pylons)
	Data mining/knowledge management (for forecasting, sharing, and making tacit knowledge explicit)	• Optimized procurement planning and revenue analysis by electricity retailers [retailing] • Forecasting of energy conservation outputs [transmission and distribution] ··· **Fig. 4**
Generation of new business	Development of energy management services, etc.	• Peer-to-peer blockchain power trading [transmission and distribution, retailing] • Development of distributed systems of supply and demand [transmission and distribution, retailing] ··· **Fig. 5**
	Development of new non-energy services, etc.	• Utilization of data on electricity usage (smart meters) [transmission and distribution, retailing] ··· **Fig. 6**

Source: METI, "Digital Transformation of the Electric Power Industry" (2018)

2. Uses of Digital Technologies by Former General Electricity Utilities

(1) Electricity Generation Sector

Key challenges for the generation sector in recent years have been operating cost reduction, environmental impact, and labor shortages for maintenance. Former general electricity utilities aim to make more sophisticated use of data on power generation by pursuing technological innovations in data compilation, analysis, and forecasting.

The former general electricity utilities, for example, have strengthened their cooperative ties with IT firms and plant manufacturers, and demonstration projects for combustion control modeling using AI have been conducted at coal-fired power plants. The projects demonstrated lower NOx emissions than achieved through operation by engineers.

(2) Electricity Transmission and Distribution Sector

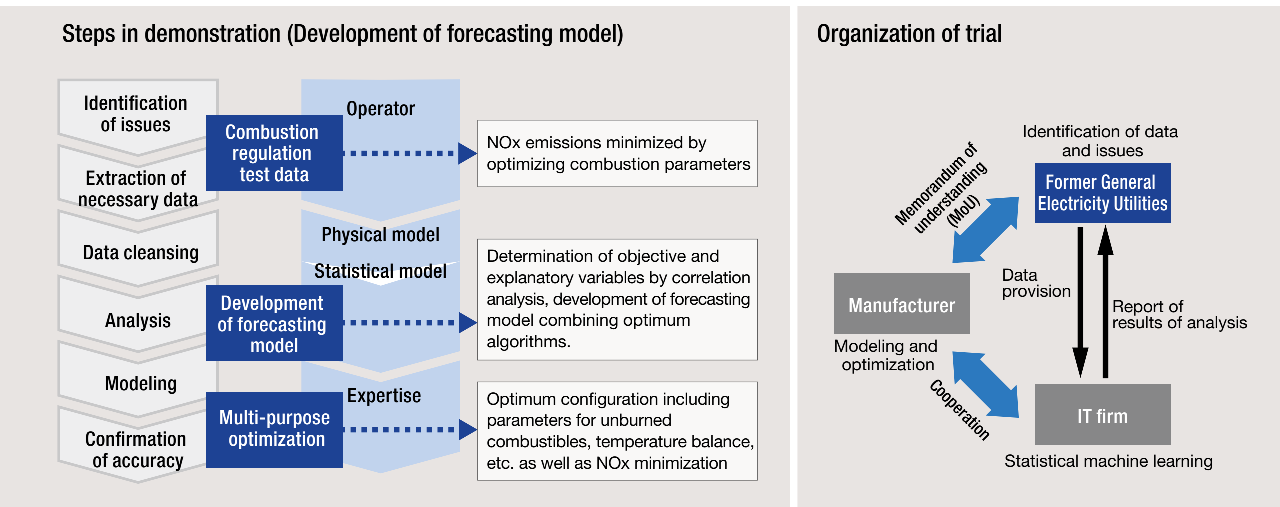
In the transmission and distribution sector, maintenance and inspection work needs to be streamlined to cope with aging facilities and fewer maintenance personnel. To make this work less labor intensive, therefore, the former general electricity utilities are trialing remote capture of images using drones during transmission line inspections and determination of abnormalities by means of AI-based image analysis.

As intermittency of renewable sources has a major impact on the stability of supply and demand, technologies are also being developed to forecast solar power output more accurately. For example, former general electricity utilities estimate solar radiation intensity at ground level by using cloud images taken by weather satellites to analyze cloud characteristics. Advection of clouds captured in weather satellite images is also forecast in order to forecast the amount of solar radiation at 3-minute intervals in a 1 km grid up to 3 hours and 30 minutes ahead. This has made it possible to predict fluctuations in solar power output in advance and allow stable control of supply and demand.

(3) Retail Sector

Installation of renewables such as solar has surged in recent years. Output from such sources is heavily dependent on weather conditions, however, leading to concerns for power supply reliability. There is thus a growing need for the balance of supply and demand to be made more flexible. Virtual power plants (VPPs) are attracting interest as a solution. VPPs use IoT technologies to remotely control energy sources such as distributed energy systems, storage

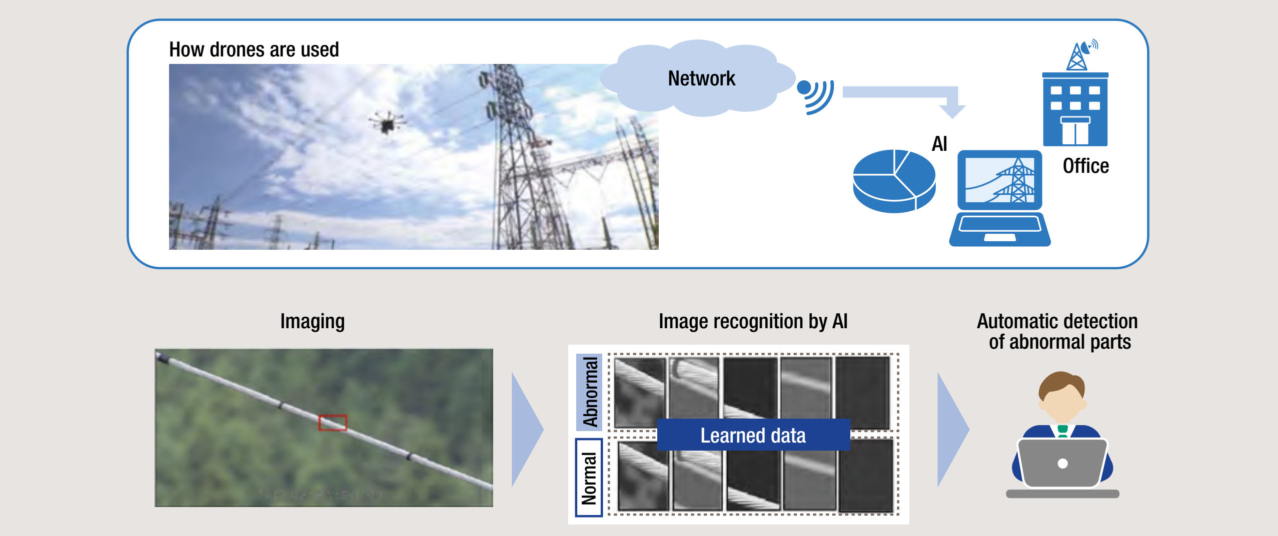
Use of AI at Coal-fired Thermal Power Plants Figure 2



Source: METI, “Digital Transformation of the Electric Power Industry” (2018)

Use of Drones for Transmission Facility Maintenance

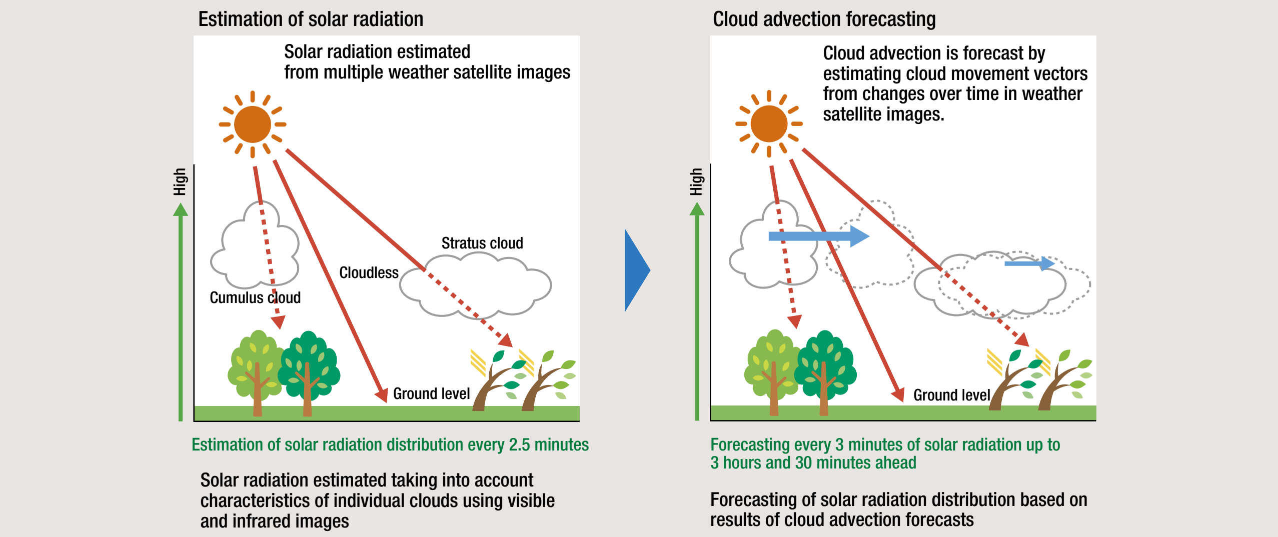
Figure 3



Source: METI, "Digital Transformation of the Electric Power Industry" (2018)

Short-term Forecasting of Solar Radiation by Means of Image Analysis

Figure 4



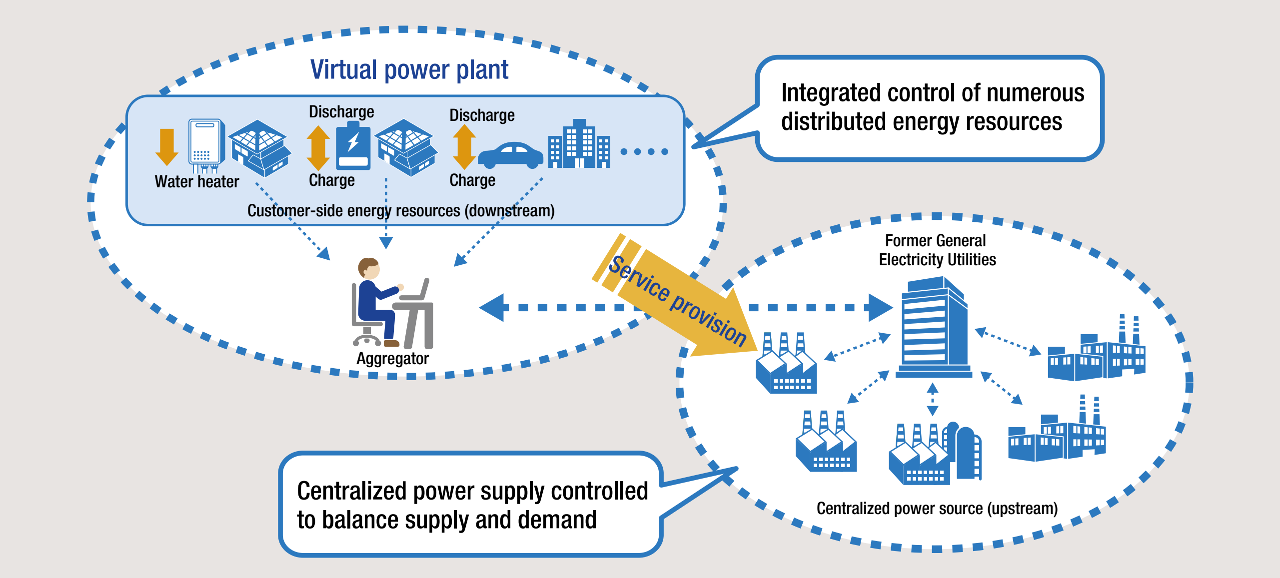
Source: METI, "Digital Transformation of the Electric Power Industry" (2018)

batteries, and demand response in order to deliver electric power like a large power station.

With the business opportunities created by the future establishment of a balancing market, major former general electricity utilities are pushing ahead with a business called "resource aggregation," which enables integrated control of customer-side energy resources in order to provide balancing capacity. These utilities are pursuing demonstration projects to aggregate resources by, for example, remotely adjusting customer side facilities (water heaters, storage batteries, and EVs) to balance electricity supply and demand.

Business Scheme Using Storage Batteries and Other Energy Resources

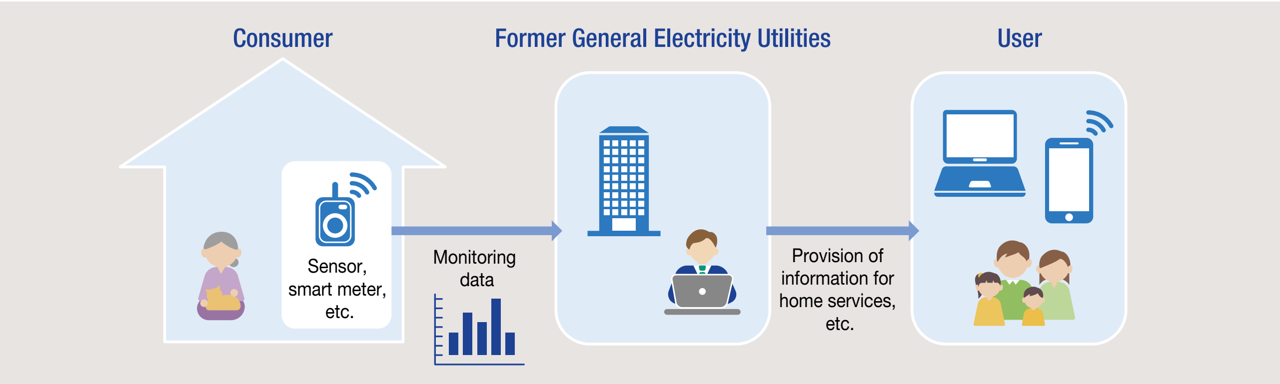
Figure 5



Source: METI, "Progress Report on Subsidies for Projects to Develop and Trial Virtual Power Plants Utilizing Customer-Side Energy Resources" (2017)

Overview of Smart Home Services

Figure6



Source: Compiled from Ministry of Internal Affairs and Communications, "A Structural Analysis of the ICT Industry in the IoT Age and a Study to Verify the Multifaceted Contributions of ICT to Economic Growth" (2016)

Moreover, with the progress of smart meter introduction, a number of initiatives are underway to generate new business using the data obtained from customers' smart meters, all premised on proper protection of privacy. Data from smart meters (customer electricity use every 30 minutes, etc.) is first collected by a data management system operated by a former general electricity utility, and then provided to electricity retailers that have contracts with customers. Former general electricity utilities provide non-energy services using the data obtained from smart meters.

For example, leading former general electricity utilities are developing services that contribute to everyday comfort and security (such as systems to monitor the wellbeing of older people) by developing data platforms that use and analyze the data on daily life obtained from home appliances, sensors, smart meters, and other devices.

Statistical Data

Electric Power Generation*

(TWh)

FY	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Hydroelectric	83.5	83.8	90.7	91.7	83.6	84.9	86.9	91.4	84.6	90.1
Electric Utilities	75.9	74.5	74.2	74.4	67.4	68.6	70.3	74.9	81.9	87.9
Industry-owned	7.6	9.3	16.5	17.3	16.3	16.3	16.7	16.5	2.7	2.3
Thermal**	798.9	742.5	771.3	906.9	986.8	987.3	955.3	908.8	877.0	861.5
Electric Utilities	621.3	568.4	553.3	678.5	735.9	743.1	717.8	675.7	794.4	777.6
Industry-owned	177.6	174.1	218.0	228.4	250.8	244.2	237.6	233.1	82.6	83.9
Nuclear	258.1	279.8	288.2	101.8	15.9	9.3	–	9.4	17.3	31.3
Electric Utilities	258.1	279.8	288.2	101.8	15.9	9.3	–	9.4	17.3	31.3
Industry-owned	–	–	–	–	–	–	–	–	–	–
Wind Power	2.9	3.6	4.0	4.7	4.8	5.2	5.0	5.2	5.5	6.1
Electric Utilities	0.0	0.0	0.1	0.2	0.2	0.2	0.0	0.1	5.0	5.5
Industry-owned	2.9	3.6	3.9	4.5	4.7	5.0	5.0	5.1	0.5	0.7
Solar	0.0	0.0	0.0	0.1	0.2	1.2	3.8	6.8	11.1	15.9
Electric Utilities	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	6.5	8.7
Industry-owned	0.0	0.0	0.0	0.0	0.1	1.1	3.7	6.7	4.6	7.2
Geothermal	2.8	2.9	2.6	2.7	2.6	2.6	2.6	2.6	2.2	2.1
Electric Utilities	2.6	2.7	2.5	2.5	2.5	2.4	2.4	2.4	2.2	2.1
Industry-owned	0.2	0.2	0.2	0.2	0.1	0.2	0.2	0.2	0.1	0.1
Others	–	–	–	–	–	–	–	–	0.3	0.2
Electric Utilities	–	–	–	–	–	–	–	–	0.3	0.2
Industry-owned	–	–	–	–	–	–	–	–	–	–
Total	1,146.3	1,112.6	1,156.9	1,107.8	1,094.0	1,090.5	1,053.7	1,024.2	997.9	1,007.4
Electric Utilities	957.9	925.4	918.2	857.4	822.0	823.7	790.6	762.6	907.6	913.3
Industry-owned	188.4	187.2	238.6	250.4	272.0	266.8	263.2	261.6	90.4	94.1

*Figures for industry-owned generation represent the total amount generated by power plants with a generating capacity of 1,000kW or above.
**Including biomass and waste-to-energy.
Source: FEPC (2008-2009), METI (2010-2017)

Electric Power Consumption

(TWh)

FY		2008	2009	2010	2011	2012	2013	2014	2015
Low Voltage	Residential	285.3	285.0	304.2	289.0	286.2	284.3	273.1	266.9
	Commercial and Industrial	46.8	45.2	47.5	44.9	43.7	42.8	40.5	39.2
Specified-Scale Demand		571.7	544.0	574.9	545.6	541.0	544.4	537.8	531.5
Specified Supply		12.1	9.9	0.0	0.0	0.0	0.0	0.0	0.0
Self-Consumption		9.6	12.6	4.4	4.3	4.4	4.5	3.9	4.0
Supplied by Electric Utilities		925.5	896.7	931.1	883.8	875.3	876.0	855.4	841.5
Power Generated and Consumed by Privately-owend Power Facilities		110.0	106.2	125.4	118.7	116.3	116.6	114.1	113.8
Total Consumption		1,035.5	1,002.8	1,056.4	1,002.4	991.6	992.6	969.4	955.3

FY		2016	2017
Low Voltage	Residential	271.8	280.4
	Commercial and Industrial	37.6	38.4
Specified-Scale Demand	High Voltage	307.4	310.6
	Extra-High Voltage	231.4	233.8
Specified Supply		3.4	3.4
Others (Last Resort Supply and Isolated Area Supply)		2.3	–
Self-Consumption		45.8	47.8
Supplied by Electric Utilities		899.8	914.4
Power Generated and Consumed by Privately-owend Power Facilities		71.3	63.0
Total Consumption		971.1	977.4

Source: METI

Installed Generating Capacity*

(MW)

FY	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Hydroelectric	47,949	47,966	48,111	48,419	48,934	48,932	49,597	50,035	50,058	50,014
Electric Utilities	46,252	45,221	43,849	44,168	44,651	44,676	45,403	45,786	49,521	49,562
Industry-owned	1,697	2,745	4,262	4,250	4,282	4,256	4,194	4,248	536	452
Thermal**	179,324	181,736	182,381	185,309	188,903	191,258	193,356	190,805	193,910	193,462
Electric Utilities	140,023	142,574	135,070	136,132	139,794	141,901	143,777	143,040	174,392	173,261
Industry-owned	39,302	39,162	47,312	49,177	49,109	49,357	49,579	47,765	19,517	20,201
Nuclear	47,935	48,847	48,960	48,960	46,148	44,264	44,264	42,048	41,482	39,132
Electric Utilities	47,935	48,847	48,960	48,960	46,148	44,264	44,264	42,048	41,482	39,132
Industry-owned	–	–	–	–	–	–	–	–	–	–
Wind Power	1,756	1,997	2,294	2,419	2,562	2,646	2,750	2,808	3,203	3,483
Electric Utilities	4	12	85	85	83	82	30	50	2,893	3,091
Industry-owned	1,752	1,985	2,209	2,334	2,479	2,563	2,720	2,758	310	391
Solar	13	16	32	85	267	1,559	4,085	5,624	9,110	12,592
Electric Utilities	0	0	13	61	65	67	81	87	5,655	7,318
Industry-owned	13	16	19	24	202	1,492	4,005	5,536	3,455	5,274
Geothermal	532	535	537	537	512	512	508	517	526	471
Electric Utilities	497	500	502	502	477	477	473	473	511	466
Industry-owned	35	35	35	35	35	35	35	43	15	5
Others	1	1	–	–	–	–	–	–	64	54
Electric Utilities	–	–	–	–	–	–	–	–	64	54
Industry-owned	1	1	–	–	–	–	–	–	0	0
Total	277,511	281,099	282,315	285,729	287,327	289,171	294,560	291,836	298,352	299,209
Electric Utilities	234,711	237,153	228,479	229,908	231,219	231,468	234,028	231,484	274,519	272,885
Industry-owned	42,800	43,946	53,836	55,821	56,107	57,703	60,532	60,352	23,834	26,324

*Figures represent the total amount generated by power plants with a generating capacity of 1,000kW or above.
**Including biomass and waste-to-energy.
Source: FEPC (2008-2015), METI (2016-2017)

Transmission, Substations and Distribution Facilities of Former General Electricity Utilities (As of March 31, 2018)

Voltage (kV)	Transmission Lines (km)				Substations	
	Route length		Circuit length		Number	Output Capacity (MVA)
	Overhead	Underground	Overhead	Underground		
500	7,853	89	15,320	177	84	223,550
275	7,429	606	14,692	1,514	159	174,225
220	2,617	61	5,028	134	62	39,260
187	2,735	15	5,229	35	39	16,760
110–154	15,537	1,011	28,247	1,948	681	155,801
66–77	38,196	7,335	68,346	13,248	4,468	224,351
≦55	13,408	6,133	14,651	10,096	1,281	9,754

Distribution Lines (km)				Transformers	
Route length		Circuit length		Output Capacity [MVA]	
Overhead	Underground	Overhead	Underground	Overhead	Underground
948,120	42,945	4,023,882	72,096	334,833	34,433

Source: METI

Peak Load, Supply Capability, Annual Electricity Demand, Reserve Margin and Load Factor

FY	2010	2011	2012	2013	2014	2015	2016	2017	2018
Peak Load (GW)	178.9	156.4	157.2	161.6	154.3	161.2	156.2	157.1	159.7
Supply Capability (GW)	199.0	175.9	176.9	179.5	179.8	184.2	180.4	185.2	178.9
Annual Electricity Demand (TWh)	974.3	926.8	914.7	917.5	898.9	888.2	887.1	892.6	886.9
Reserve (GW)*	20.1	19.5	19.7	17.9	25.6	23.0	24.2	28.1	19.2
Reserve Margin (%)*	11.2	12.5	12.6	11.1	16.6	14.3	15.5	17.9	12.0
Load Factor (%)**	62.2	67.4	66.4	64.8	66.5	62.9	64.8	64.9	63.4

* Reserve= Supply Capability-Peak Load
Reserve Margin= Reserve/Peak Load×100
**Load Factor= Annual Electricity Demand / (Peak Load ×365(366)×24hours) ×100
Source: Japan Electric Power Survey Committee (2010-2014), OCCTO (2015-2018)

Summarized Comparative Table Classified by Country for 2017

FY	USA	UK	France	Germany	Russia	China	Japan
Total Installed Capacity (MW)	1,193,885	81,170	130,761	219,299	272,400	1,777,080	299,209
Hydroelectric	100,899	4,365	25,517	10,271	53,200	343,590	50,014
Thermal	837,986	50,901	18,947	83,643	190,600	1,104,950	193,462
Nuclear	108,179	9,361	63,130	11,357	27,900	35,820	39,132
Renewables and others	146,820	16,542	23,168	114,028	–	292,720	16,601
Total Energy Production (GWh)	4,041,335	338,172	529,235	653,655	1,094,290	6,417,100	1,007,423
Hydroelectric	300,281	8,774	53,541	26,155	187,130	1,193,100	90,128
Thermal	2,525,135	166,172	53,855	334,249	700,200	4,555,800	861,518
Nuclear	804,948	70,336	379,091	76,324	203,140	248,100	31,278
Renewables and others	410,971	92,891	42,749	216,927	3,810	420,100	24,470
Capacity Factor (%)	–	39.4	46.1	34.0	–	43.3	–
Total Energy Production per Capita (kWh)	12,429	5,139	8,184	7,909	7,452	4,616	7,946
Domestic Energy Supplies (GWh)	4,088,278	333,601	482,015	397,710	1,089,100	5,435,700	–
Energy Sales (GWh)	3,723,356	277,907	–	444,591	–	5,083,500	863,137
Number of Customers (At year-end; thousand)	151,780	30,589	–	–	–	–	66,027
Peak Load (MW)	776,155	52,279	94,236	78,710	151,200	–	155,770
Annual Load Factor (%)	59.4	66.5	58.3	57.7	78.5	–	66.0
Power Generation Efficiency (%)	–	34.9	–	45.8	39.3	39.8	–
Loss Factor (Transmission and Distribution) (%)	5.5	7.9	7.7	6.8	–	6.5	–
Total Consumption per capita (kWh)	–	4,554	6,881	6,288	6,700	4,557	7,710

Source: JEPIC, METI

Overseas Activities of Member Companies

This section presents information on member companies' overseas activities, provided by a number of member companies. Although JEPIC has compiled this information with care, no guarantee can be made as to its accuracy.

Data on Member Companies (as of March 31, 2019) *

	FY 2018			Approved maximum output of power facilities [MW]**				
	Capital (¥m) Non-consolidated	Sales (¥m) Consolidated	Electricity sold retail[GWh]	Hydro	Thermal	Nuclear	Renewable (excl. hydro)	Total
Hokkaido Electric Power Co.	114,291	752,238	22,774	1,650	4,469	2,070	–	8,190
Tohoku Electric Power Co.	251,441	2,244,314	68,876	2,556	12,049	2,750	243	17,598
Tokyo Electric Power Company Holdings	1,400,975	6,338,490	230,306	9,873	41,161	12,612	51	63,697
Chubu Electric Power Co.	430,777	3,035,082	123,602	5,459	24,376	3,617	39	33,491
Hokuriku Electric Power Co.	117,641	622,930	26,060	1,958	4,825	1,746	–	8,528
Kansai Electric Power Co.	489,320	3,307,661	117,826	8,228	19,441	6,578	11	34,259
Chugoku Electric Power Co.	185,527	1,376,979	52,944	2,909	7,802	820	6	11,538
Shikoku Electric Power Co.	145,551	737,274	23,296	1,151	3,395	890	2	5,438
Kyushu Electric Power Co.	237,304	2,017,181	72,219	3,580	10,355	4,699	211	18,845
Okinawa Electric Power Co.	7,586	205,481	7,453	–	2,145	–	2	2,147
J-POWER	180,502	897,366	–	8,575	8,523	–	444	17,542
Japan Atomic Power Co.	120,000	113,337	–	–	–	2,260	–	2,260

*Some consolidated data contains non-consolidated data.
**Calculated based on figures contained in the “key facilities” sections of financial statements.
Source: Compiled based on companies’ financial statements

Hokkaido Electric Power Co.

Training of hydroelectric engineers for EGAT, the Electricity Generating Authority of Thailand (2018)

Technical cooperation on maintenance and improvement of equipment in the hydroelectric power industry (2005~)

- Objectives
  - Improvement of technical skills and development of human resources in the hydroelectric power industry

- Trainees
  - EGAT hydroelectric engineers (3 people)

- Period
  - From July 23 to August 3, 2018

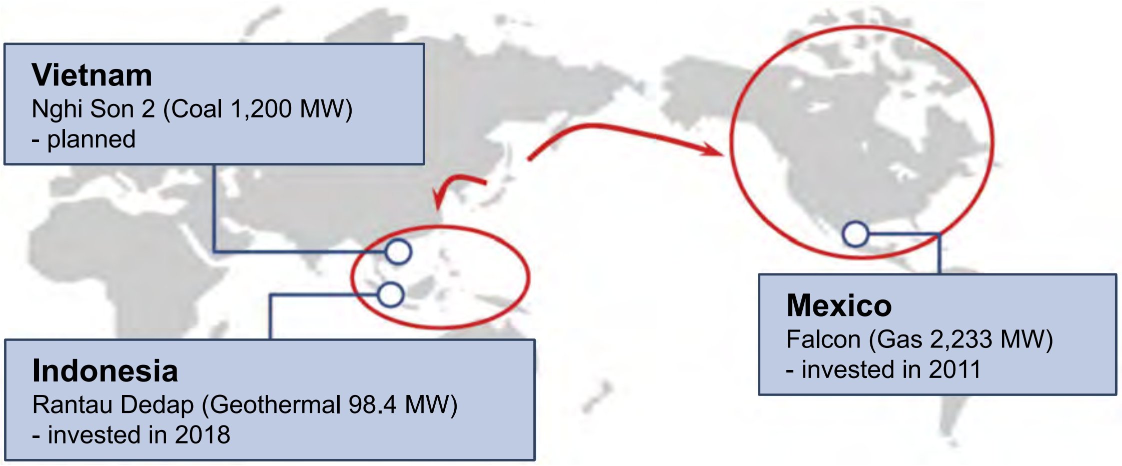
- Content
  - Training visits to plants including a pumped storage plant in Hokkaido
  - Lectures on hydroelectric power plant maintenance support systems, operation and maintenance of pumped storage plants, etc.

- Background to project
  - Training provided under the Memorandum on Technical Cooperation Regarding Hydroelectric Power Generation signed in May 2015.
  - Technical assistance has continued to be provided since the first cohort of hydroelectric engineers of EGAT was trained followed a request made through JEPIC in 2005.

Tohoku Electric Power Co.

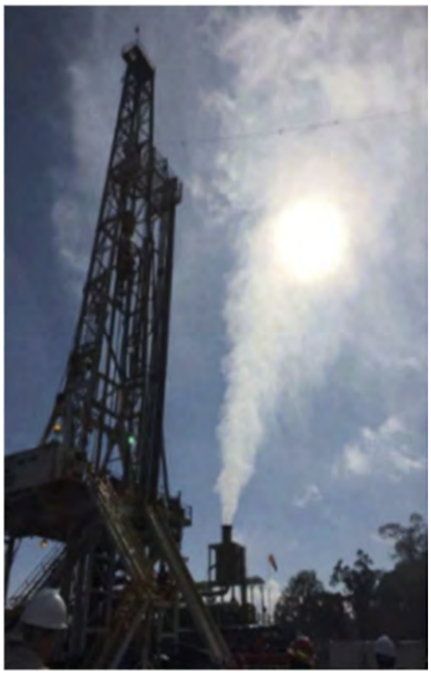
Overview of Projects

- We are actively participating in overseas power generation projects.
- We are leveraging our years of expertise in geothermal and high-efficiency thermal power generation in Japan to expand our overseas operations targeting mainly North America and Southeast Asia.



As of July 2019

Geothermal Power Project in Indonesia



- We are one of Japan's largest geothermal power producers and make up 40% of the country's total capacity.
- We contribute to management and technical support based on our 40-year experience in operating domestic power stations.

Location	South Sumatera, Indonesia
Investors	Engie (42%), Marubeni (32%) Supreme Energy (16%) Tohoku Electric Power Co. (10%)
COD	Second half of 2020

As of July 2019

Tokyo Electric Power Company Holdings

Developing Global Enterprises

Source: TEPCO Integrated Report 2018

The TEPCO Group continues to work as one to expand its reach in the global market. In particular, it has leveraged its technological expertise in supplying stable power to densely populated regions to provide consulting services to overseas utilities. To date it has provided such services more than 600 times in approximately 70 countries.

Power generation projects

Total of 5.1 GW in 23 countries
(as of the end of FY 2017)

Australia, Canada, Chile, Finland, India, Indonesia, Italy, Japan, Mexico, Netherlands, Norway, Oman, Philippines, Qatar, Singapore, South Korea, Spain, Thailand, UAE, UK, Uruguay, USA, Vietnam

Energy-related projects other than power generation

14 projects in 7 countries
(as of the end of FY 2017)

Australia, Canada, Germany, Singapore, Switzerland, UK, USA
(includes venture companies, venture capital funds, venture accelerators, and local holding companies)

Consulting services

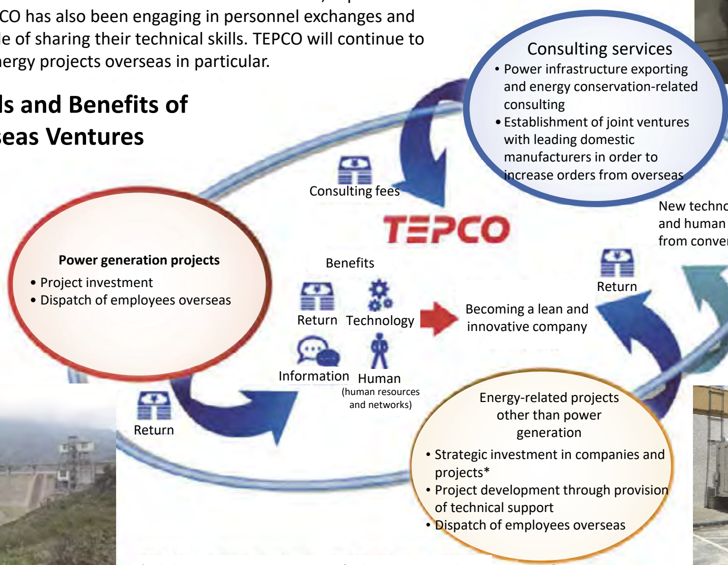
¥900 million in sales in 15 countries
(as of the end of FY 2017)

Bangladesh, Bhutan, China, Egypt, India, Iran, Laos, Myanmar, Philippines, Russia, Serbia, Singapore, Sri Lanka, Thailand, Vietnam

In the power generation, transmission/distribution, and power retail fields, TEPCO has been preparing for further growth by, among other things, establishing holding companies and investment companies overseas as it continues to search for new business opportunities. As well as joining and investing in projects after careful consideration of the risks, capital procurement, and profitability, TEPCO has also been engaging in personnel exchanges and cultivating human resources capable of sharing their technical skills. TEPCO will continue to proactively engage in renewable energy projects overseas in particular.

Energy conservation-related consulting at a hospital in India (TEPCO HD)

Details and Benefits of Overseas Ventures



Coc San Hydropower Project in Vietnam (TEPCO HD)

Installation of storage batteries in Hawaii (Oahu) (TEPCO Ventures)

*Includes participation in venture capital funds and venture accelerators in order to form relationships with venture companies that are predicted to grow in the future

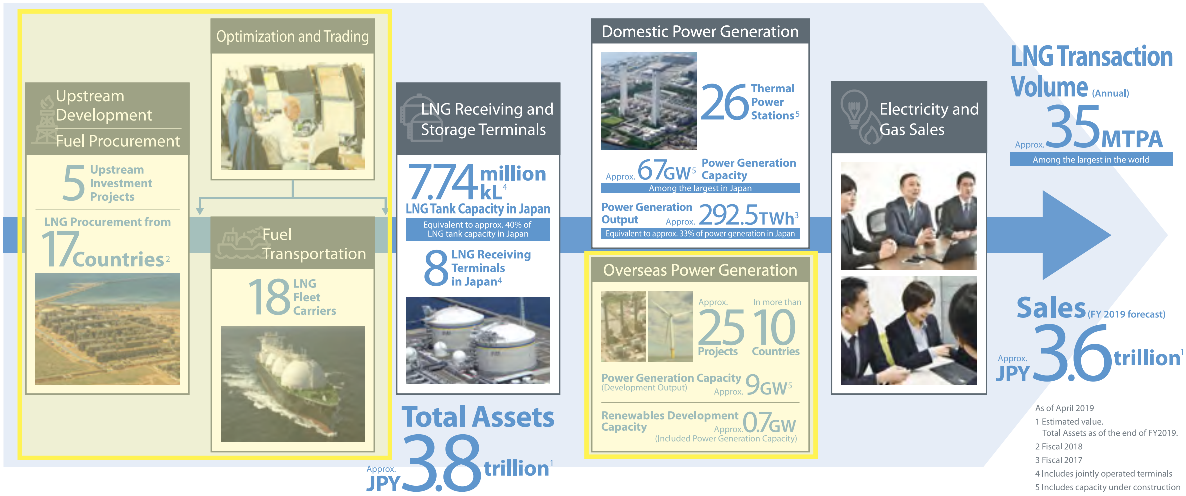
Source: TEPCO Integrated Report 2018 (partially modified)

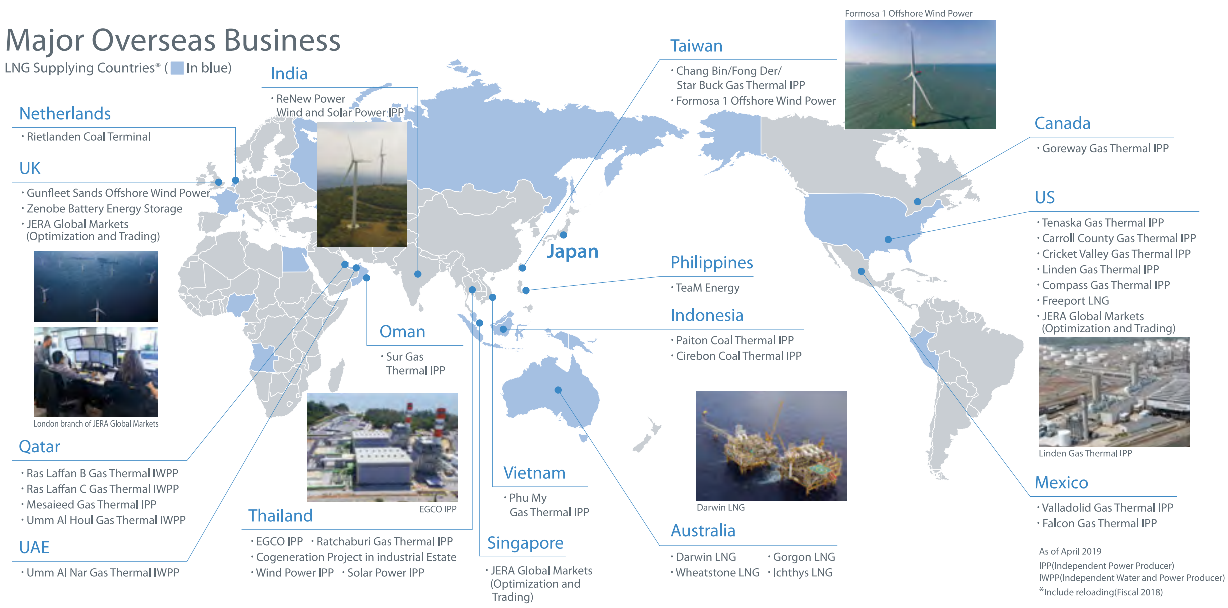
JERA

＊a joint venture of Tokyo Electric Power Company Holdings and Chubu Electric Power Co.

Who are we?	✓ JERA finished integrating the entire thermal power value chain of Tokyo Electric Power Company and Chubu Electric Power Company on April 1, 2019. ✓ JERA is the largest power generation company in Japan. It procures 35MT of LNG and has a worldwide power generating capacity of 75 GW.
What we aim for	✓ JERA aims to become a global leader in LNG and renewables, leading the transition to a clean energy economy by 2025.
Overseas businesses	✓ We engage in five upstream projects, 9 GW power generation projects, intercontinental optimization and trading, and O&M services all over the world.

JERA's Value Chain and Company Overview





Kansai Electric Power Co.

Overseas Power Business and International Contribution

We are involved in power projects around the world, including in Asia, Europe and the U.S.
In developing countries, we contribute by providing consulting services and organizing workshops on how to improve power infrastructure.

As of December 2019

Overseas Projects

Project	Location	Type	Status	Kepco's Participation	Equity Portion	Net Capacity (MW)
San Roque	Philippines	Hydro	Operational	since 1998	50.0%	218.0
Rojana	Thailand	CCGT Co-generation	Operational	since 2003	39.0%	197.0
Ming-Jian	Taiwan	Hydro	Operational	since 2005	24.0%	4.1
Kuo Kuang	Taiwan	CCGT	Operational	since 2006	20.0%	96.0
Senoko	Singapore	CCGT, Conventional	Operational	since 2008	15.0%	421.1
Rajamandala	Indonesia	Hydro	Operational	since 2012	49.0%	23.0
Nam Ngiep 1	Laos	Hydro	Operational	since 2013	45.0%	130.5
Bluewaters	Australia	Coal-fired	Operational	since 2013	50.0%	229.6
Tanjung Jati B	Indonesia	Coal-fired	Under Construction	since 2015	25.0%	535.0
West Deptford	U.S.	CCGT	Operational	since 2016	17.5%	134.4
Evalair	Ireland	Onshore Wind	Operational	since 2017	24.0%	53.5
Hickory Run	U.S.	CCGT	Under Construction	since 2017	30.0%	300.0
Triton Knoll	UK	Offshore Wind	Under Construction	since 2018	16.0%	137.1
Moray East	UK	Offshore Wind	Under Construction	since 2018	10.0%	95.4
St. Joseph Phase 2	U.S.	CCGT	In Development	-	20.0%	-
Electricity North West	UK	Distribution	Operational	since 2019	22.0%	-
New Clark City	Philippines	Distribution and Retail	Operational	since 2019	9.0%	-
NeuConnect	UK-Germany	Interconnector	In Development	-	18.3%	-

As of December 2019

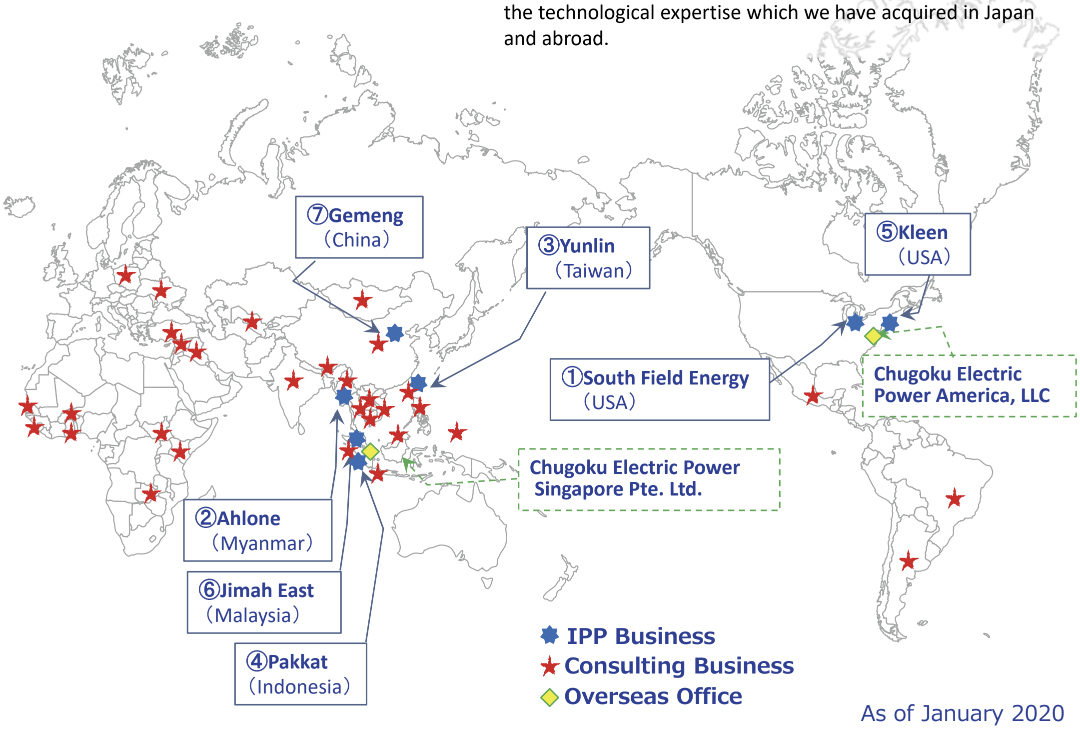
18 Projects in 11 Countries, Net Capacity : 2.57GW (Operational : 1.51GW)

The Kansai Electric Power Co., Inc.

Chugoku Electric Power Co.

Overseas Business

We are developing our international business by drawing on the technological expertise which we have acquired in Japan and abroad.



As of January 2020

Outline of IPP Projects

As of January 2020

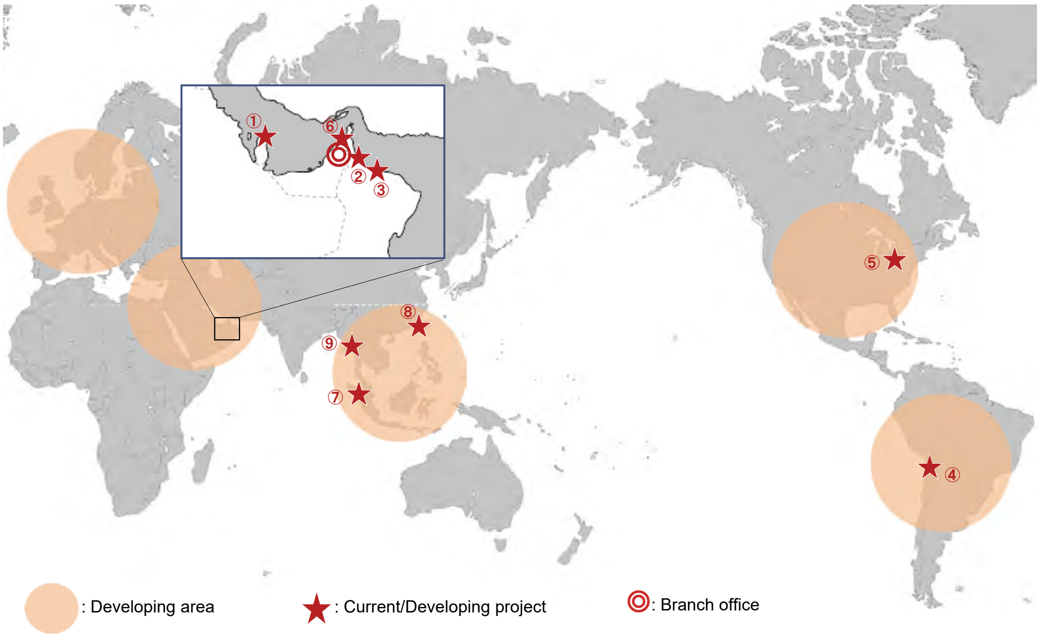
No	Project	Location	Type	Gross Capacity (MW)	Chugoku Electric Power's share (%)	Date of entry intro commercial operation
①	South Field Energy	Columbiana, Ohio, USA	CCGT[1] (Gas)	1,182	10.0	2021[2]
②	Ahlone	Yangon district, Myanmar	CCGT[1] (Gas)	121	28.5	April 2013
③	Yunlin	Yunlin County, Taiwan	Offshore wind	640	6.75 (C&C Investment Corporation)[3]	December 2021[2]
④	Pakkat	Humbang Hasundutan Regency, North Sumatra Province, Indonesia	Hydro (Run-of–river type)	18	25.0	April 2016
⑤	Kleen	Middletown, Connecticut, USA	CCGT[1] (Gas)	620	16.2	July 2011
⑥	Jimah East	Mukim Jimah, Negeri Sembilan, Malaysia	USC[4] (Coal)	2,000	15.0	December 2019
⑦	Gemeng	Shanxi Province, Taiyuan City, China	Conglomerate	6,400	3.0	April 2007 (date of establishment)

[1] Combined Cycle Gas Turbine [2] Scheduled
[3] Joint venture established by Chugoku Electric Power (50%) and Chudenko (50%) [4] Ultra Super Critical

Shikoku Electric Power Co.

Shikoku Electric Power Company

Target Areas and Overseas Assets



	Middle East			Americas	
	①	②③	⑥	④	⑤
Project	Ras Laffan C	Barka 3 Sohar 2	Hamriyah	Huatacondo	South Field Energy
Country	Qatar	Oman	UAE	Chile	USA
Output	2,730 MW(GTCC)Water: 290,000ton/day	744 MW each (GTCC)	1,800 MW (GTCC)	98 MW (PV)	1,182 MW (GTCC)
Equity	5%	7.15% for each project	15%	30%	8.9%
COD	2011 (25 year PWPA)	2013 (15 year PPA)	2023 (23.5 year PPA)	2019 (Merchant)	2021 (Merchant)

	Asia / Pacific		
	⑦	⑧	⑨
Project	Batang Toru 3	Yunlin	Ahlone
Country	Indonesia	Taiwan	Myanmar
Output	10 MW (Mini Hydro)	640 MW (Offshore Wind)	121 MW (GTCC)
Equity	15%	4.4%	28.5%
COD	2020 (20 year PPA)	2021 (20 year PPA)	2013 (30 year PPA)

Kyushu Electric Power Co.

Overseas Business Strategy

Target capacity (net) in 2030: 5,000 MW (current capacity: +2,810 MW)

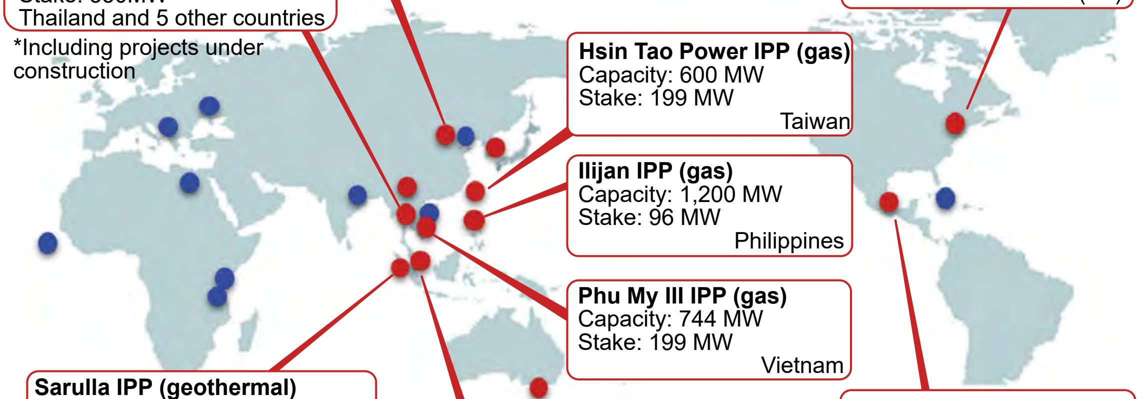
- **We contribute to international society by delivering stable, low-cost power supply solutions, as well as by developing human resources through our overseas IPP and consulting businesses.**
- **We became involved in managing the Electricity Generating Public Company Limited (EGCO), one of the largest independent power producers in Thailand, in May 2019.**

● **Overseas energy business**
12 countries/areas (2,190 MW)

● **Overseas consulting services***
78 projects in 22 countries

*● are recent projects

▼ **Our first power generation project Supplying ISO New England in the U.S.**
(Kleen Energy IPP)



Kleen Energy IPP (gas)
Capacity: 620 MW
Stake: 126 MW
USA (CT)

South Field Energy IPP (gas)*
Capacity: 1,182 MW
Stake: 214 MW
USA (OH)

*Under construction

Birdsboro IPP (gas)
Capacity: 488 MW
Stake: 54 MW
USA (PA)

Inner Mongolia IPP (wind)
Capacity: 50 MW
Equity ownership: 15 MW
China

EGCO*
Capacity: 5,968 MW
Stake: 350MW
Thailand and 5 other countries

*Including projects under construction

Hsin Tao Power IPP (gas)
Capacity: 600 MW
Stake: 199 MW
Taiwan

Ilijan IPP (gas)
Capacity: 1,200 MW
Stake: 96 MW
Philippines

Phu My III IPP (gas)
Capacity: 744 MW
Stake: 199 MW
Vietnam

Sarulla IPP (geothermal)
Approx. capacity: 330 MW
Approx. stake: 83 MW
Indonesia

Senoko Energy Pte. Ltd.
Capacity: 2,380 MW
Stake: 357 MW
Singapore

Tuxpan II & V IPP (gas)
Capacity: 495 MW x 2
Stake: 248 MW x 2
Mexico

▲ **One of the largest geothermal IPPs in the world**
(Sarulla IPP in Indonesia)

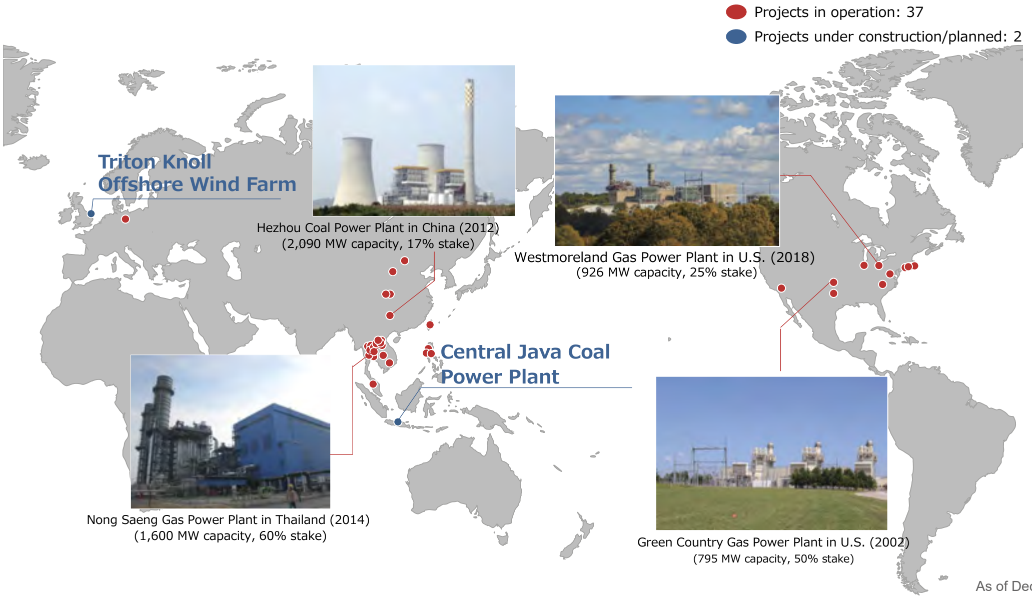
▲ **Inspection support**
(Tuxpan II IPP in Mexico)

As of July 2019

J-POWER

Overseas Power Generation Business

- Power plants in operation: 37 projects in 6 countries/regions (owned capacity of 6.91GW)



As of December 31, 2018

Expansion of Overseas Business

- We are expanding in Thailand, the U.S., and China, where we already have a strong presence. We aim to acquire projects in Indonesia and Taiwan (where we also have operations) and in new markets with robust energy demand.
- Leveraging the technological capabilities we have built up in our domestic business, we are taking steps to expand our presence in wind, hydro, and other renewables overseas.

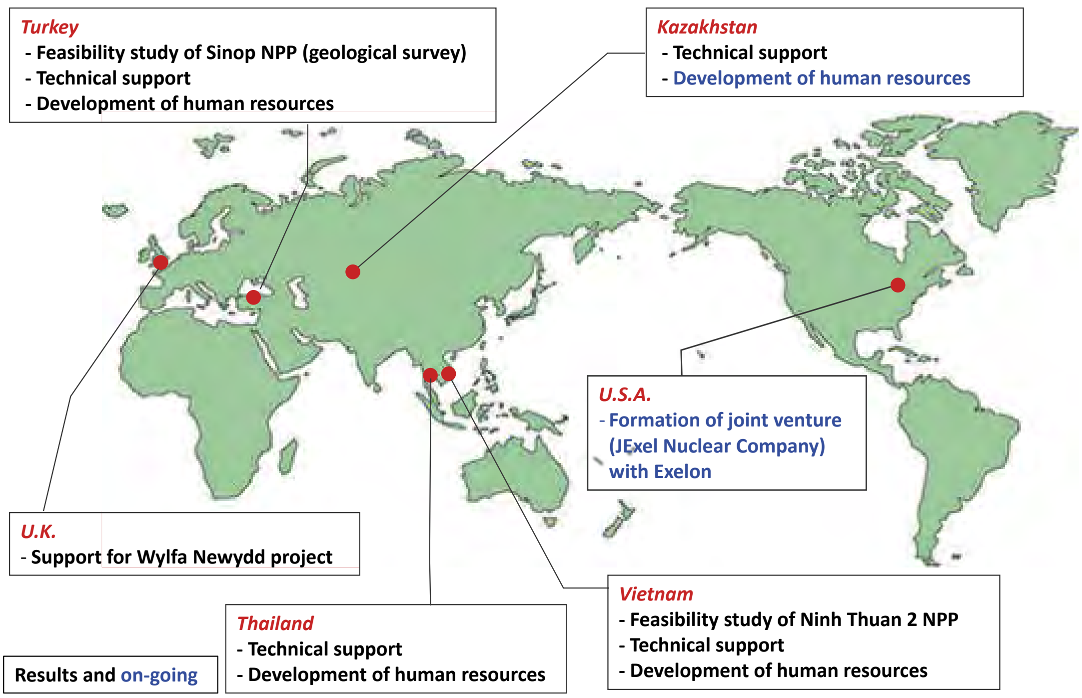
Westmoreland	
Location	Pennsylvania, USA
Start of operation	**Dec.2018**
Capacity	926 MW (231.5 MW owned)
Type	Combined cycle gas turbine
Stake	25%

Central Java	
Location	Java, Indonesia
Start of operation	**No. 1 June 2020** **No. 2 Dec. 2020**
Capacity	2,000 MW (680 MW owned)
Type	Coal (ultra-supercritical)
Stake	34%

Triton Knoll Offshore Wind	
Location	North Sea, UK
Start of operation	**2021**
Capacity	860 MW (215 MW owned)
Type	Offshore wind power
Stake	25%

Japan Atomic Power Co.

Major Projects



Development of human resources

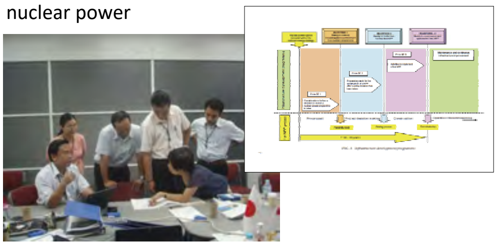
JAPC offers a comprehensive range of education and training support tailored to individual countries' needs.

So far, we have provided training for approximately 560 people in 23 countries.

We also use our experience to provide support for feasibility studies of nuclear power plants.

Tokai Training Center

Preparation of master plan for introduction of nuclear power



Nuclear power plant simulator

Pump disassembly and inspection

Radiation measurement

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Distribution Areas and Frequency of Electric Power Companies

(As of March 2020)

JEPIC's member companies include the 10 electric power companies indicated on the map and two wholesale electric utilities, J-POWER and The Japan Atomic Power Company.

Member Companies (As of March 2020)

Hokkaido Electric Power Co., Inc.
2, Higashi 1-chome, Odori, Chuo-ku, Sapporo, Hokkaido 060-8677, Japan
http://www.hepco.co.jp/english/index.html

Tohoku Electric Power Co., Inc.
1-7-1 Honcho, Aoba-ku, Sendai, Miyagi 980-8550, Japan
http://www.tohoku-epco.co.jp/english/index.html

Tokyo Electric Power Company Holdings, Inc.
1-1-3, Uchisaiwai-cho, Chiyoda-ku, Tokyo 100-8560, Japan
http://www.tepco.co.jp/en/index-e.html

Chubu Electric Power Co., Inc.
1, Higashi-shincho, Higashi-ku, Nagoya, Aichi 461-8680, Japan
http://www.chuden.co.jp/english/index.html

Hokuriku Electric Power Co.
15-1, Ushijima-cho, Toyama-shi, Toyama 930-8686, Japan
http://www.rikuden.co.jp/english/index.html

The Kansai Electric Power Co., Inc.
3-6-16, Nakanoshima, Kita-ku, Osaka 530-8270, Japan
http://www.kepco.co.jp/english/

The Chugoku Electric Power Co., Inc.
4-33, Komachi, Naka-ku, Hiroshima-shi, Hiroshima 730-8701, Japan
http://www.energia.co.jp/e/index.html

Shikoku Electric Power Co., Inc.
2-5, Marunouchi, Takamatsu, Kagawa 760-8573, Japan
https://www.yonden.co.jp/english/index.html

Kyushu Electric Power Co., Inc.
1-82, Watanabe-dori 2-chome, Chuo-ku, Fukuoka 810-8720, Japan
http://www.kyuden.co.jp/en_index.html

The Okinawa Electric Power Co., Inc.
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