THE ELECTRIC POWER INDUSTRY IN JAPAN 2021

JEPIC
JAPAN ELECTRIC POWER INFORMATION CENTER, INC.

JEPIC

Japan Electric Power Information Center, Inc. (JEPIC) was established in 1958 as a non-profit association of the electric utility industry in Japan. Our primary purpose is to meet the increasing need for a systematic and sustained exchange of information with the 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 facing the industry in Japan currently. 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.

International Exchange 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

EXECUTIVE SUMMARY

The information in this document, including the Executive Summary, was current as of the end of August 2020, unless otherwise specified.

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 liberalization of the electric power retailing and generation sectors was completed in April 2016. The legal separation of transmission and distribution from vertically integrated businesses was implemented in April 2020, resulting in the spin-off of new transmission and distribution companies from the former general electricity utilities. Meanwhile, plans to abolish regulated electricity rates in April 2020 have been deferred.

- Today, Japan's electrical power industry comprises three major sectors: electricity generation, transmission and distribution, and retailing. The number of operators in these sectors was 914, 13, and 670, respectively.

II. ENERGY AND ENVIRONMENTAL 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.

- Sixteen nuclear reactors have been granted the "permission for change to reactor installation" under the new regulatory standards, which verifies their compliance with those standards. Nine of these have already reentered commercial service. A number of other idled reactors are expected to restart, but 24 other units 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 Act on Special Measures Concerning Promotion of Utilization of Electricity from Renewable Energy Sources, enacted in June 2020, provides for a complete overhaul of the FIT scheme. Among other provisions, the law calls for the launch of a feed-in premium scheme in April 2022 to add premiums to the market prices of renewables.

- In March 2020, the Japanese government submitted to the United Nations its Nationally Determined Contribution (NDC) for reducing emissions. The target contribution remains the same as the one submitted in 2015, a 26% reduction compared to fiscal 2013.

- In a policy speech given in October 2020, Prime Minister Yoshihide Suga announced that Japan would seek to become carbon neutral by 2050.

III. SUPPLY AND DEMAND

- In fiscal 2019, electricity demand[1] in Japan was 877.1 TWh (down 2.1% YoY) and peak national demand came to 158.7 GW (down 0.6% YoY).

- In fiscal 2019, electric power generated[2] in Japan came to 863.2 TWh (down 3.2% YoY), of which 13.2 TWh was generated by solar power and 6.3 TWh by wind power.

IV. ELECTRIC POWER FACILITIES

- Total generating capacity in Japan came to 307 GW at the end of fiscal 2019. This consisted of 160 GW of thermal power, 49 GW of hydro power, 65 GW of renewables (excluding hydro), and 33 GW of nuclear power. Development of 32 GW of generating capacity is planned from fiscal 2020 to fiscal 2029. This consists of 14.5 GW of thermal power, 7.4 GW of renewables (excluding hydro), and 10.2 GW of nuclear power.

- As of the end of March 2020, smart meters had been installed at all extra-high voltage and high voltage customers and at 75.2% of low voltage customers (including households). All customers are expected to have smart meters by the end of March 2025.

- In response to the increased intensity of natural disasters in recent years, the Japanese government enacted the Energy Supply Resilience Act in June 2020 and amended the Electricity Business Act in the following month, and is leading efforts to improve the resilience of Japan's energy supply.

- Plans have been laid out for the enhancement of interregional interconnections in order to improve the resilience of electricity infrastructure and realize interregional utilization of distributed energy sources. Recently developed plans include increasing the capacity of frequency converters supporting the interconnections between Tokyo and the Chubu region, and the capacity of the interconnections between Tokyo and the Tohoku region.

1 Total of utilities' net system energy demand, specified service demand, and self-consumption demand.
2 Electric power generated by electricity utilities.

V. RETAIL BUSINESS AND TRADING MARKETS

- As of the end of March 2020, 13.14 million low voltage customers (including households) have switched suppliers, accounting for 21% of the total number of low voltage customers.

- The volume of trades on the JEPX spot market has been on the rise, reaching 292.5 TWh in fiscal 2019. This is a more than 40% increase year-on-year and means that about 30% of all electricity sold in Japan is sold through JEPX. The average system price has hovered around 7-9 yen/kWh since fiscal 2015 and stood at 7.93 yen/kWh in fiscal 2019.

- A baseload trading market was created in fiscal 2019. A total volume of 534 MW was sold for delivery in fiscal 2020, with clearing prices ranging from 8.47 to 12.47 yen/kWh.

- Trading in the capacity market began in 2020. Capacity contracts for 2024 totaled 167.69 GW in volume, and had a clearing price of 14,137 yen/kW.

- Details are being worked out for the planned launch of balancing market trading in fiscal 2021.

I. STRUCTURE OF THE ELECTRIC POWER INDUSTRY

1. History of 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 rate reduction competition engendered by the prolonged depression led to a series of mergers and acquisitions, and Japan's electric power industry ultimately developed into an oligopoly of 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, electricity generation and transmission facilities came under centralized control. The government also consolidated the electricity distribution business into nine separate regional blocks. Following World War II, the Japan Electric Generation and Transmission Company was dissolved in May 1951, 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 made focused investments 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 emphasizing the interests of shareholders. As a result, they contributed significantly to Japan's nearly 20-year period of rapid economic growth 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) Beginning of 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.

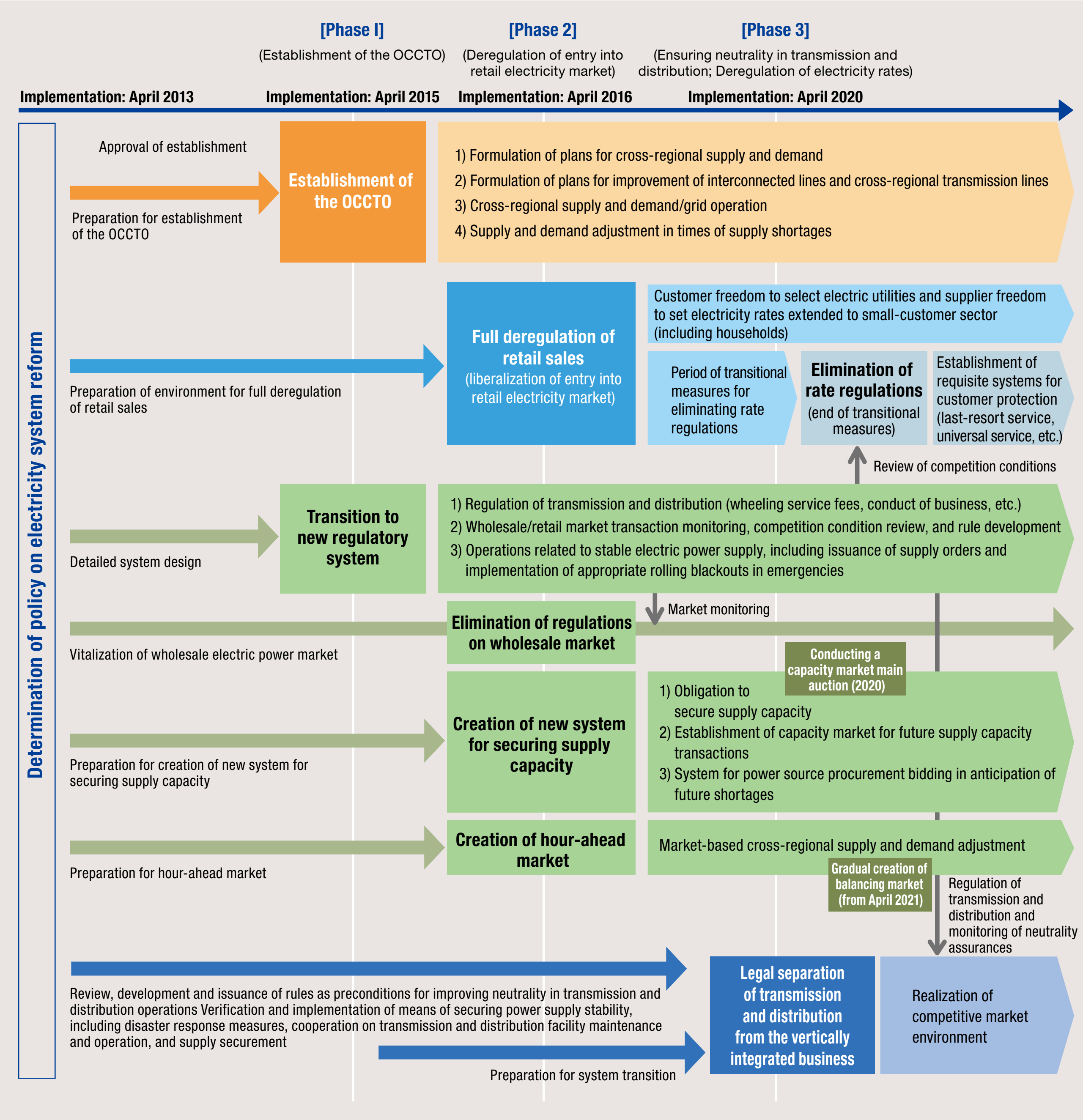
However, power shortages and other issues caused by the 2011 Great East Japan Earthquake prompted discussion of the ideal configuration of the nation's electric power system and its reform. Based on this discussion, reform of the electricity supply system has been pursued in three stages since 2015.

(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 unbundling of the transmission and distribution sector, and elimination of regulated retail rates by 2020.

Roadmap to Electricity System Reform

Figure 1.1



Source: Compiled 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, liberalization of the electric power retailing and generation sectors was completed. In the third phase, legal unbundling of the transmission and distribution sector was implemented in April 2020, and new spin-off transmission and distribution companies were established by eight former general electricity utilities other than Tokyo Electric Power Company Holdings, which was ahead on setting up new companies, and Okinawa Electric Co., which was not subject to legal unbundling. Meanwhile, plans to abolish regulated electricity rates scheduled for the end of March 2020 have been deferred due to insufficient competition (see Figure 1.1 and "Electricity Rates" in Section 1, Chapter V).

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.

(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 have been considered, including (1) a baseload power market, (2) a capacity market, (3) a balancing market, and (4) a non-fossil value trading market. Trading has commenced in markets (1), (2), and (4). (3) is scheduled to begin in phases from April 2021 onward (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. 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 1951 are now called "former general electricity utilities" (See Figures 1.2 and 1.3).

Data show that 914 entities had obtained power generation licenses in the electricity generation sector as of August 15, 2020, and generating capacity was 266 GW[1] as of March 2020. The group of former general electricity utilities, J-Power, and the Japan Atomic Power Co. accounted for 80% of generating capacity. In addition, power generation licenses have been obtained by firms from industries such as paper manufacturing, steel manufacturing, and gas and petroleum, as well as by some local governments.

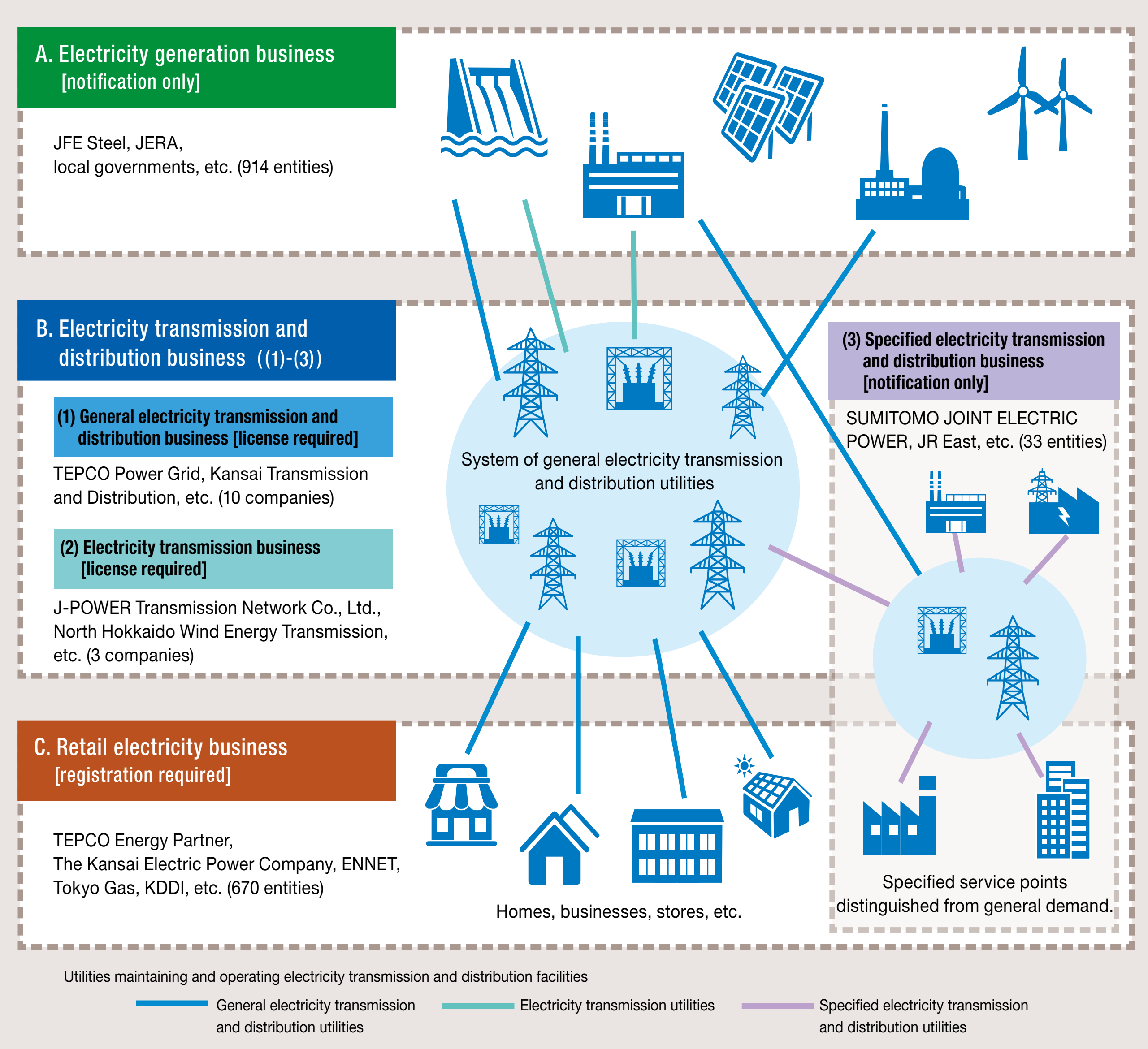
In the transmission and distribution sector, a total of 10 utilities (the 9 utilities spun out from the former general electricity utilities other than Okinawa Electric Co., and Okinawa Electric Co.) have been conducting business as general electricity transmission and distribution utilities. In addition, three other companies, including J-POWER Transmission Network Co., Ltd., are conducting business as electricity transmission utilities.

In the electricity retail sector, data released by METI's Agency for Natural Resources and Energy show that a total of 670 entities had obtained retail licenses (as of August 12, 2020). In addition to the former general electricity utilities, electricity retailers include telecommunications carriers, trading companies, gas and petroleum companies, steel manufacturers, and subsidiaries of former general electricity utilities. Net system energy demand in fiscal 2019 came

1 Figure represents the total of electricity utilities' generating capacity, and excludes that of non-electricity utilities.

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 836 TWh, of which former general electricity utilities accounted for about 85%.

(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.

General Electricity Transmission and Distribution Utilities Spun Off from Former General Electricity Utilities following Legal Unbundling (after April 1, 2020) Figure 1.3

Former general electricity utilities	General electricity transmission and distribution utilities	Electricity generation utilities and retailers
• Hokkaido Electric Co.	• Hokkaido Electric Power Network, Inc.	• Hokkaido Electric Power Co. (generation & retail)
• Tohoku Electric Co.	• Tohoku Electric Power Network, Co.	• Tohoku Electric Power Co. (generation & retail)
• Tokyo Electric Power Co.	• TEPCO Power Grid, Inc.*2	• Tokyo Electric Power Company Holdings, Inc., JERA*3, TEPCO Renewable Power, Inc. (generation), TEPCO Energy Partner, Inc. (retail)*2
• Chubu Electric Power Co.	• Chubu Electric Power Grid Co.	• Chubu Electric Power Co., JERA (generation), Chubu Electric Power Miraiz Co. (retail)
• Hokuriku Electric Power Co.	• Hokuriku Electric Power Transmission & Distribution Co.	• Hokuriku Electric Power Co. (generation & retail)
• Kansai Electric Power Co.	• Kansai Transmission and Distribution, Inc.	• Kansai Electric Power Co. (generation & retail)
• Chugoku Electric Power Co.	• Chugoku Electric Power Transmission & Distribution Co.	• Chugoku Electric Power Co. (generation & retail)
• Shikoku Electric Power Co.	• Shikoku Electric Power Transmission & Distribution Co.	• Shikoku Electric Power Co. (generation & retail)
• Kyushu Electric Power Co.	• Kyushu Electric Power Transmission and Distribution Co.	• Kyushu Electric Power Co. (generation & retail)
• Okinawa Electric Power Co.	• Okinawa Electric Power Co.	• Okinawa Electric Power Co. (generation & retail)

*1 Only major utilities are listed.
*2 TEPCO Power Grid, Inc. and TEPCO Energy Partner, Inc. were spun out in April 2016.
*3 JERA took over the thermal power generation business of TEPCO and Chubu Electric Power in April 2019.

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 AND ENVIRONMENTAL 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 power, giving top priority to its safety; and secondly, that in view of its lack of fossil fuel resources, Japan should leverage its energy technologies and play a leading role in the development of decarbonized energy.

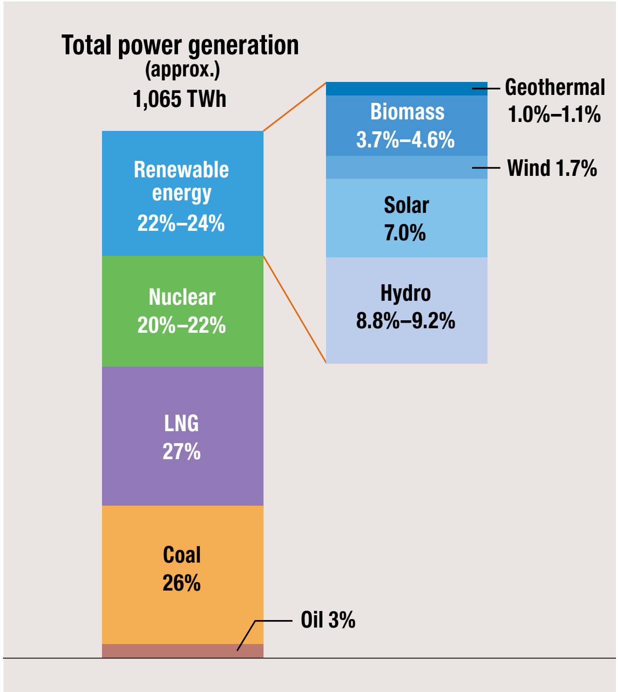
The plan lays down basic policies and measures towards 2030 and offers a scenario for energy transition and decarbonization in the years leading up to 2050.

(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.

The Fifth Strategic Energy Plan is grounded in part in the Long-term Energy Supply and Demand Outlook drafted by the government in July 2015. 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 approximately 30%

Power Generation Mix in Fiscal 2030 Figure 2.1



Source: METI, "Long-term Energy Supply and Demand Outlook 2015" 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).

In July 2020 the Minister of Economy, Trade and Industry repeated earlier expressions of the government's intention to phase out inefficient coal-fired power plants, and specific measures for achieving this goal are now being explored.

(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) Action on Nuclear Safety

a. Establishment of the Nuclear Regulation Authority

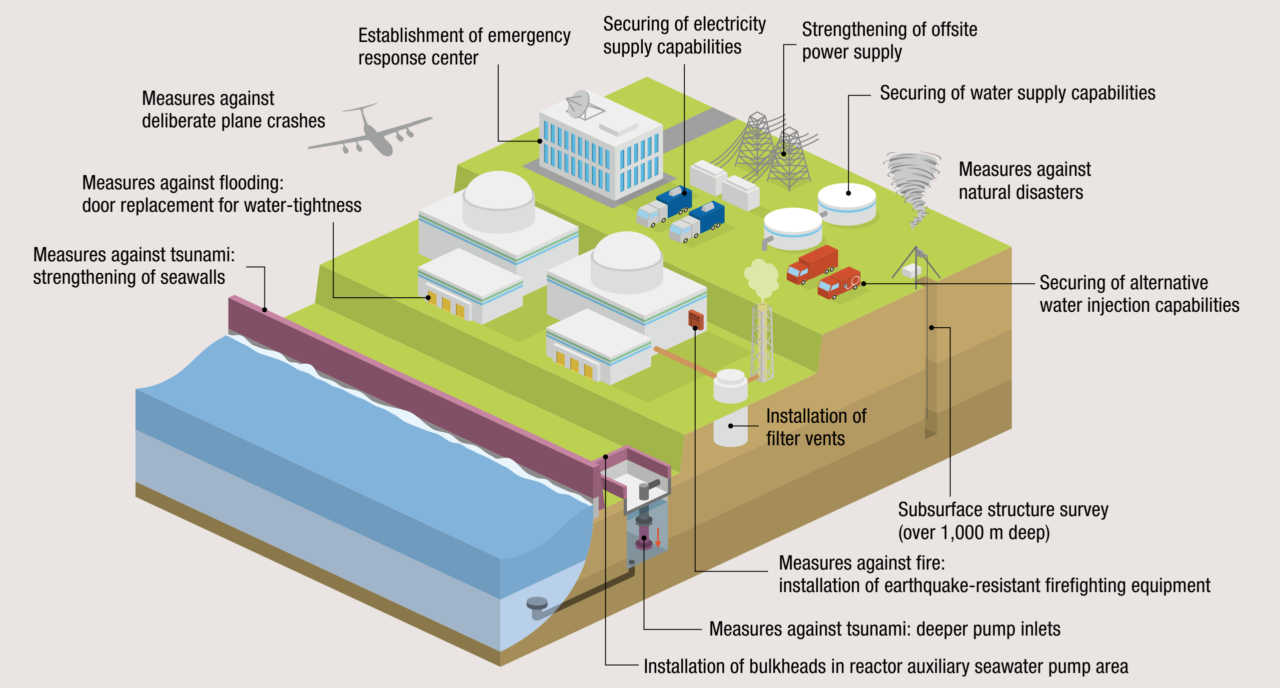
The Fukushima Daiichi accident led to an overhaul of the system of administration of nuclear power in order to separate safety regulation from use and to unify nuclear safety regulation work. The Nuclear Regulation Authority (NRA) was established in September 2012 as an affiliated agency of the Ministry of the Environment. As a result of this change, any future resumption of a nuclear power plant's operation will be predicated on a safety inspection by the NRA and on the local government's consent.

b. New Regulatory Requirements

Following the Fukushima Daiichi accident, the Act on the Regulation of Nuclear Source Material, Nuclear Fuel Material and Reactors was revised to incorporate a number of new provisions. These included:

- Reinforcement of strategies for severe accidents, etc. (Figure 2.2).

Safety Measures Required by New Safety Regulatory Requirements Figure 2.2



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

- Introduction of a "backfitting" program for existing nuclear power facilities.
- Setting the period of operation of nuclear reactors (setting the period of operation at 40 years, and allowing a one-time extension to this term not to exceed 20 years).
- Unification of regulation of nuclear power plants under the Nuclear Reactor Regulation Act.

The Nuclear Regulation Authority (NRA) checks the conformance of nuclear reactors to the New Regulatory Requirements through a 3-tier regulatory review process. Tier 1 grants permission for changes in reactor installation, Tier 2 approves the construction plan and requires pre-service inspections, and Tier 3 approves the operational safety program.

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 ATENA are working closely together to achieve high standards of safety.

(2) State of Nuclear Power Generation

Prior to the March 2011 Fukushima Daiichi accident, Japan had 57 nuclear reactors in operation and three under construction, and the nationwide capacity factor averaged 68.3%. Following the accident, all reactors were provisionally shut down due to changes in regulations. As a result of efforts to bring plants into conformance with the new safety regulatory requirements, nine reactors had restarted (three reactors in operation as of the end of 2020) achieving a capacity factor of more than 15% (Table 2.1).

The lifetime value of nuclear power plants became limited by the government's capping of reactor service life and the expected additional costs of safety measures mandated by the New Regulatory Requirements. After weighing the wishes of local governments and other considerations, plant operators applied for permission for changes in reactor installation for 27 units (including two under construction) and selected 24 aging small and medium-sized reactors for decommissioning:

Of those 27 reactors, 16 were granted permission for changes in reactor installation under the first tier of regulatory review, and eventually nine of them were brought back into operation after passing the second- and third-tier reviews and receiving the local government's consent. Subsequently, however, six reactors were taken out of service—three because of delays in the completion of their specialized safety facilities,[1] one due to a temporary court injunction (under litigation), and two due to equipment trouble—thus effectively reducing the number of operable reactors to three.

The situation regarding restarts and decommissioning is summarized in Table 2.2 below.

Nuclear Power Plant Capacity Factor Table 2.1

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Capacity factor [%]	68.3	38.0	4.4	3.6	0.0	1.2	5.0	8.4	15.0	21.4	15.5

Source: Compiled from Japan Atomic Industrial Forum, Inc., "Current Status of Nuclear Power Plants" (2020)

1 Specialized safety facilities: As part of major accident countermeasures mandated by the New Regulatory Requirements, nuclear plant operators are required to construct bunkered back-up control centers designed to withstand deliberate aircraft crashes and similar threats.

Compliance with New Regulatory Standards

Table 2.2

Tier 1 review completed (installation license granted) (16 units)	Restarted	9 units
	Pending completion of Tier 2 and 3 reviews (construction approval, safety regulations, pre-service inspections), and consent of local government	7 units
Under Tier 1 review (including 2 units under construction)		11 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

Company	Plant	Restart date	Operation resuspended
Kansai Electric Power Co.	Takahama Unit 3	Feb. 26, 2016	Aug. 2, 2020
	Takahama Unit 4	Jun. 16, 2017	Oct. 7, 2020
	Ohi Unit 3	Apr. 10, 2018	(Aug. 24, 2022)
	Ohi Unit 4	Jun. 5, 2018	(Aug. 24, 2022)
Shikoku Electric Power Co.	Ikata Unit 3	Sep.7, 2016	(Mar. 22, 2021)
Kyushu Electric Power Co.	Genkai Unit 3	May 16, 2018	(Aug. 24, 2022)
	Genkai Unit 4	Jul. 19, 2018	(Sep. 13, 2022)
	Sendai Unit 1	Sep. 10, 2015	Mar. 16, 2020
	Sendai Unit 2	Nov. 17, 2015	May 20, 2020

Note: Not including the three JPDR, Fugen, and Monju reactors.

Source: Compiled from Japan Atomic Industrial Forum, Inc., "Current Status of Nuclear Power Plants in Japan" (2020).

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

(3) 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 pursuing greater use of MOX fuel in thermal reactors and managing and using plutonium appropriately under the principle of not possessing any plutonium that does not have a use.

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 with 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 regulations, and was granted permission 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 2022, and was granted official approval in July 2020 for modifications needed to conform with the new regulations. 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 and improve the reprocessing environment in terms of the financing system. 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.

With regard to interim storage of spent fuel, Tokyo Electric Power Company Holdings and The Japan Atomic Power Company are currently building a facility in Mutsu City, Aomori Prefecture, for dry-cask storage of spent fuel until it is transported to a reprocessing plant (the application for approval of modifications complying with the new regulations was filed in January 2014, and the NRA compiled a report in September 2020 that deemed the application to be approvable). The facility is scheduled to enter operation with an initial storage capacity of 3,000 tons, which will later 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, the Nuclear Waste Management Organization of Japan (NUMO) was established in 2000 by mainly electric power companies to implement final disposal of the waste, and METI published in July 2017 the Nationwide Map of Scientific Features for Geological Disposal showing potential candidate sites as a preparatory step toward final disposal. The government plans to narrow down the number of candidate sites based on this map, and a number of local governments in Hokkaido are considering allowing surveys for selection of the final disposal site.

e. Development of Fast Reactors, etc.

In line with the Japanese government's basic policy for dealing with the country's limited energy resources, the Japan Atomic Energy Agency (JAEA) constructed the Joyo experimental fast breeder reactor, and later the Monju prototype fast breeder reactor, which reached its first criticality in April 1994. However, in December 2016, the government decided to decommission Monju for several reasons, including a series of accidents that began with a sodium leak in 1995, concerns over the JAEA's competence to operate the reactor, and poor economic viability. Fast reactor research and development using the Joyo experimental reactor will continue to be pursued in partnership with other countries following the roadmap developed in accordance with the new policy on fast reactor development adopted by the Inter-Ministerial Council for Nuclear Power in December 2016.

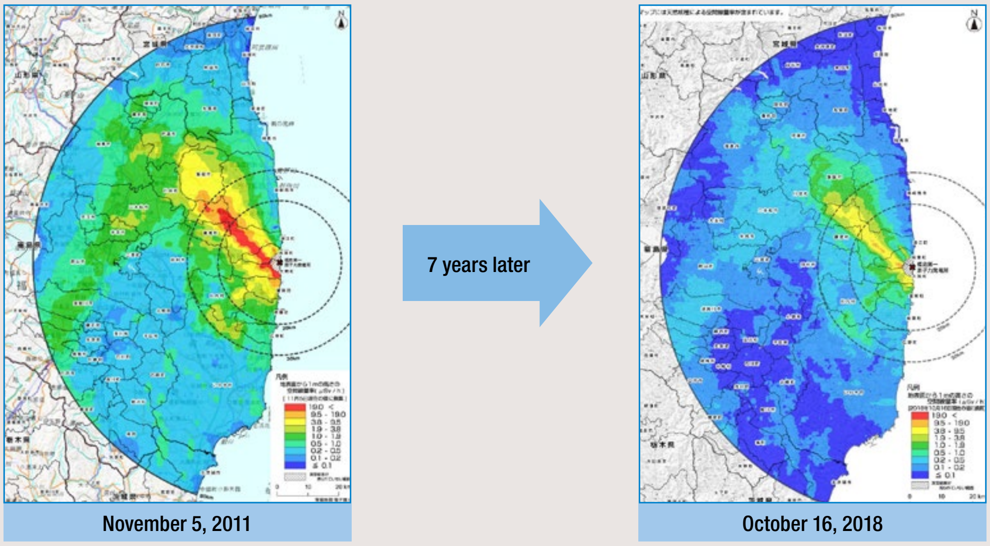
(4) Decommissioning Work at Fukushima Daiichi Nuclear Power Plant

Efforts to decommission the Fukushima Daiichi Nuclear Power Plant's reactors are being carried out under the supervision of the government's Nuclear Emergency Response Headquarters, which is led by the Prime Minister.

a. Decommissioning Roadmap

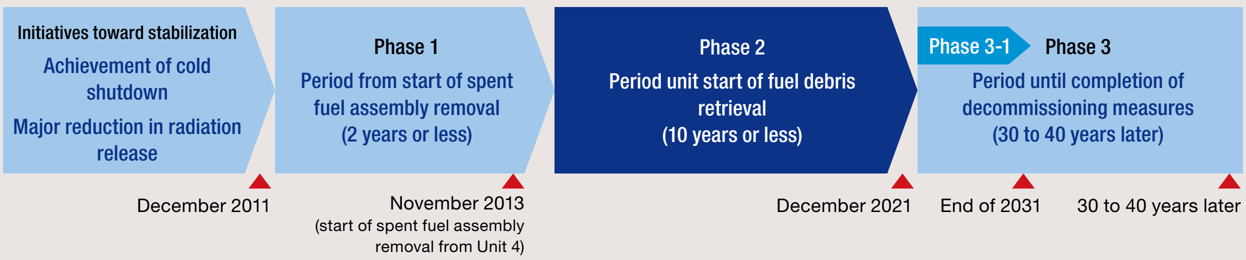
In December 2011, Fukushima Daiichi's reactors were declared to be in cold shutdown and TEPCO released a roadmap for decommissioning Units 1–4 and dealing with radioactive contaminated water resulting from the decommissioning process. A fifth revision of the roadmap was issued in December 2019, by which time radiation levels

Changes in Air Dose Rate Figure 2.3



Source: Reconstruction Agency, "Acceleration of Reconstruction Efforts"

Milestones on the Mid- to Long-Term Roadmap Figure 2.4



Source: TEPCO website (https://www.tepco.co.jp/en/hd/decommission/project/roadmap/index-e.html) in the surrounding area had decreased by 77% (Figure 2.3) and gradual progress was being made in reconstruction and the return of displaced residents. The fifth revised edition gives top priority to safety and early reduction of risk and is premised on a commitment to simultaneously advance reconstruction and decommissioning work. The roadmap lays out several key tasks, including removal of spent fuel from the reactor buildings' spent fuel pools, retrieval of melted fuel debris, and implementation of contaminated water measures. The entire decommissioning project is divided into three phases expected to span 30 to 40 years (Figure 2.4). Phase 1, which began with the completion of the reactors' cold shutdown in December 2011 and ended in November 2013, laid the groundwork for the commencement of operations to remove the spent fuel. Phase 2, scheduled to last until December 2021, initiated the process of spent fuel removal and is advancing preparations for the start of debris retrieval. Phase 3 will launch debris retrieval work and end with the completion of all decommissioning operations.

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 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.

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

The amount of radioactive contaminated water has increased in Units 1–3 as a result of the mixing of inflowing groundwater with water pumped into the reactor buildings to cool the fuel debris. In response, a multilayered approach for controlling the radioactive contaminated water is being implemented under three strategies: treatment of the contaminated water, prevention of groundwater intrusion, and prevention of leakage of the contaminated water. The radioactive contaminated water is being treated to a level below the discharge standards using a Multi-nuclide Removal Facility (Advanced Liquid Processing System: ALPS) and other equipment, and the treated water is stored on site. 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. In line with a report issued by the advisory committee in February 2020, the discussions are focusing on either evaporating the water or discharging it into the ocean.

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 52 GW between the launch of the FIT scheme and the end of December 2019. Including pre-FIT capacity, total installed renewables capacity reached approximately 73 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). This act led to implementation of the FIT scheme for renewable energy on July 1, 2012.

Installed Capacity of Renewable Energy (as of end December 2019)

Table 2.3

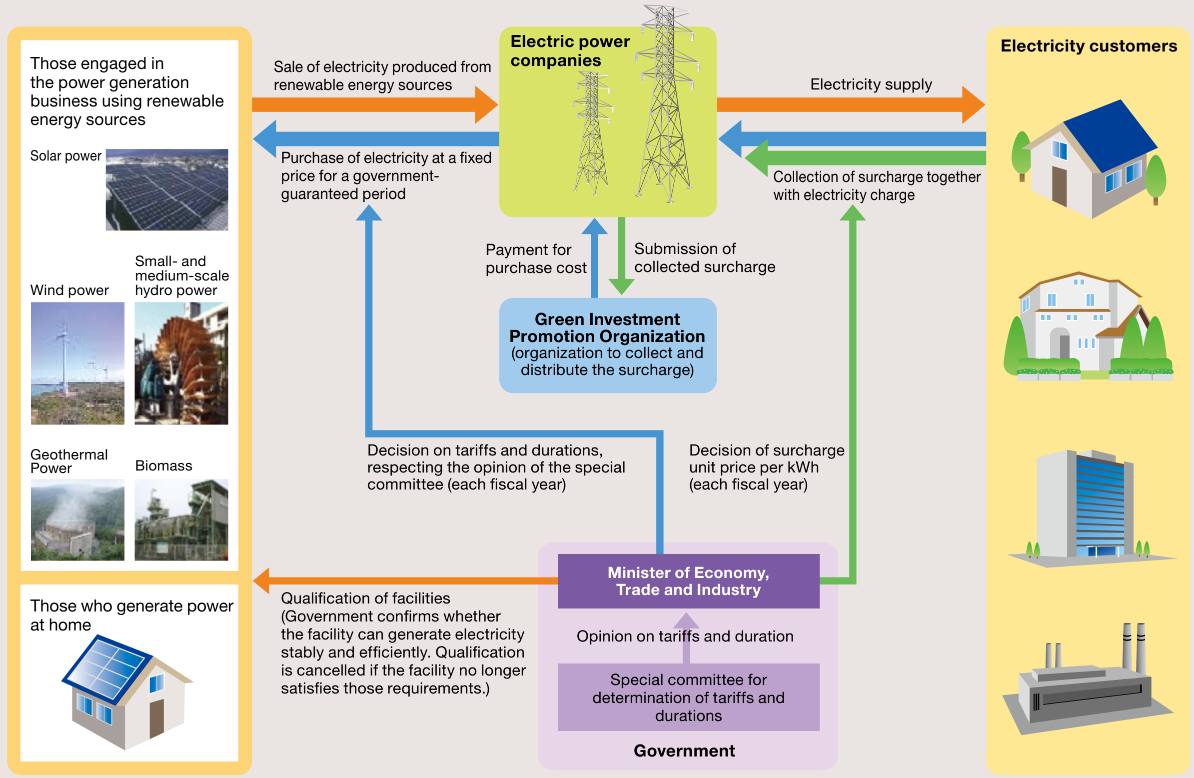
[Unit: MW]

Type	Combined total by end June 2012	Combined capacity installed under FIT	Total
Solar power (residential)	4,700	6,730	11,430
Solar power (non-residential)	900	41,557	42,457
Wind power	2,600	1,367	3,967
Small/medium hydropower	9,600	497	10,097
Biomass	2,300	2,114	4,414
Geothermal power	500	78	578
Total	20,600	52,343	72,943

Source: FIT scheme public information website: https://www.fit-portal.go.jp/PublicInfoSummary

Outline of the FIT Scheme

Figure 2.5



Source: Green Investment Promotion Organization website

Purchase Prices and Durations under the FIT Scheme

Table 2.4

<table>
<tr><th colspan="3" rowspan="2">Purchase category</th><th colspan="5">Purchase price [yen/kWh]</th><th rowspan="2">Duration [years]</th></tr>
<tr><th>FY2017</th><th>FY2018</th><th>FY2019</th><th>FY2020</th><th>FY2021</th></tr>
<tr><td rowspan="9">Solar</td><td rowspan="4">Less than 10 kW</td><td>Output controller not required</td><td>28</td><td>26</td><td>24</td><td>21</td><td>–</td><td rowspan="4">10</td></tr>
<tr><td>Output controller required*1</td><td>30</td><td>28</td><td>26</td><td>21</td><td>–</td></tr>
<tr><td>Output controller not required, dual generation</td><td colspan="2">25</td><td>24</td><td>21</td><td>–</td></tr>
<tr><td>Output controller required, dual generation*1</td><td colspan="2">27</td><td>26</td><td>21</td><td>–</td></tr>
<tr><td colspan="2">10 kW–50 kW</td><td rowspan="4">21</td><td rowspan="4">18</td><td rowspan="3">14</td><td>13</td><td>–</td><td rowspan="5">20</td></tr>
<tr><td colspan="2">50 kW–250 kW</td><td>12</td><td>–</td></tr>
<tr><td colspan="2">250 kW–500 kW</td><td colspan="2">Bidding system</td></tr>
<tr><td colspan="2">500 kW–2,000 kW</td><td colspan="3">Bidding system</td></tr>
<tr><td colspan="2">2,000 kW or above</td><td colspan="5">Bidding system</td></tr>
<tr><td rowspan="3">Onshore wind power</td><td>20 kW or above</td><td rowspan="2">Newly installed</td><td>21</td><td>20</td><td>19</td><td>18</td><td>–</td><td rowspan="5">20</td></tr>
<tr><td>Less than 20 kW</td><td>55</td><td>20</td><td>19</td><td>18</td><td>–</td></tr>
<tr><td>All capacities</td><td>Replacement capacity</td><td>18</td><td>17</td><td>16</td><td>16</td><td>–</td></tr>
<tr><td rowspan="2">Offshore wind power</td><td colspan="2">Bottom-fixed offshore wind power</td><td>36</td><td>36</td><td>36</td><td>Bidding system</td><td>–</td></tr>
<tr><td colspan="2">Floating offshore wind power</td><td>36</td><td>36</td><td>36</td><td>36</td><td>–</td></tr>
<tr><td rowspan="2">Geothermal</td><td colspan="2">Less than 15,000 kW</td><td>40</td><td>40</td><td>40</td><td>40</td><td>40</td><td rowspan="6">15</td></tr>
<tr><td colspan="2">15,000 kW or above</td><td>26</td><td>26</td><td>26</td><td>26</td><td>26</td></tr>
<tr><td rowspan="2">Geothermal (replacement of all equipment)</td><td colspan="2">Less than 15,000 kW</td><td>30</td><td>30</td><td>30</td><td>30</td><td>30</td></tr>
<tr><td colspan="2">15,000 kW or above</td><td>20</td><td>20</td><td>20</td><td>20</td><td>20</td></tr>
<tr><td rowspan="2">Geothermal (replacement of equipment excepting underground equipment)</td><td colspan="2">Less than 15,000 kW</td><td>19</td><td>19</td><td>19</td><td>19</td><td>19</td></tr>
<tr><td colspan="2">15,000 kW or above</td><td>12</td><td>12</td><td>12</td><td>12</td><td>12</td></tr>
<tr><td rowspan="4">Hydro</td><td colspan="2">Less than 200 kW</td><td>34</td><td>34</td><td>34</td><td>34</td><td>34</td><td rowspan="8">20</td></tr>
<tr><td colspan="2">200 kW–1,000 kW</td><td>29</td><td>29</td><td>29</td><td>29</td><td>29</td></tr>
<tr><td colspan="2">1,000 kW–5,000 kW</td><td>27</td><td>27</td><td>27</td><td>27</td><td>27</td></tr>
<tr><td colspan="2">5,000 kW–30,000 kW</td><td>20</td><td>20</td><td>20</td><td>20</td><td>20</td></tr>
<tr><td rowspan="4">Hydro using existing conduits*2</td><td colspan="2">Less than 200 kW</td><td>25</td><td>25</td><td>25</td><td>25</td><td>25</td></tr>
<tr><td colspan="2">200 kW–1,000 kW</td><td>21</td><td>21</td><td>21</td><td>21</td><td>21</td></tr>
<tr><td colspan="2">1,000 kW–5,000 kW</td><td>15</td><td>15</td><td>15</td><td>15</td><td>15</td></tr>
<tr><td colspan="2">5,000 kW–30,000 kW</td><td>12</td><td>12</td><td>12</td><td>12</td><td>12</td></tr>
<tr><td rowspan="5">Biomass</td><td colspan="2">Methane fermentation gasification (biomass-derived)</td><td>39</td><td>39</td><td>39</td><td>39</td><td>39</td><td rowspan="5">20</td></tr>
<tr><td rowspan="2">Woody biomass (thinnings, etc.)</td><td>Less than 2,000 kW</td><td>40</td><td>40</td><td>40</td><td>40</td><td>40</td></tr>
<tr><td>2,000 kW or above</td><td>32</td><td>32</td><td>32</td><td>32</td><td>32</td></tr>
<tr><td>Construction material waste</td><td>All capacities</td><td>13</td><td>13</td><td>13</td><td>13</td><td>13</td></tr>
<tr><td>General waste and other biomass</td><td>All capacities</td><td>17</td><td>17</td><td>17</td><td>17</td><td>17</td></tr>
</table>

*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

Results of Tenders for Solar Power Generation

Table 2.5

	Outline of tenders	Successful bids
First tender (November 2017)	Eligible facilities: 2 MW or above Target volume: 500 MW	Successful bids: 9 Total output: 141.366 MW Successful bid price: 17.20–21.00 yen/kWh
Second tender (September 2018)	Eligible facilities: 2 MW or above Target volume: 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 Target volume: 196.96 MW	Successful bids: 7 Total output: 196.96 MW Successful bid price: 14.25–15.45 yen/kWh
Fourth tender (September 2019)	Eligible facilities: 500 kW or above Target volume: 300 MW	Successful bids: 63 Total output: 195.883 MW Successful bid prices: 10.50–13.99 yen/kWh
Fifth tender (January 2020)	Eligible facilities: 500 kW or above Target volume: 416 MW	Successful bids: 27 Total output: 39.818 MW Successful bid prices: 10.99–13.00 yen/kWh

Source: Compiled from Green Investment Promotion Organization website

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 2020 are as shown in Table 2.4. Under the FIT scheme, 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 2020 is 2.98 yen per kWh (2.3707 trillion yen for Japan as a whole), or 9,288 yen per year for the standard model household. Under this system, electricity utilities collect the surcharge from customers based on electricity sales volume 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 2.5).

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.

As the investment in renewable energies has increased and FIT-approved capacity has grown 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 power generation, the pricing system was changed to allow purchase prices to be set for multiple years. A tender scheme for solar power generation above a certain level has also been introduced to bring down purchase prices. Results of tenders are shown in Table 2.5.

Yokkaichi Biomass Power Plant (Chubu Electric Power Co.)
The Yokkaichi Biomass Power Plant is a woody biomass-fired power plant with an output of 49MW. Commercial operation started in May, 2020

(3) Complete Overhaul of the FIT Scheme

As adoption of renewables has spread, a number of problems with FIT have emerged, including rising renewable surcharges on electricity rates and difficulties with receiving power generated by renewables on the grid side. The government has decided to overhaul the FIT system in order to make renewables an economically self-sustaining core element of the power generation mix. In June 2020, the government revised the Act on Special Measures Concerning Procurement of Electricity from Renewable Energy Sources by Electricity Utilities through the enactment of the Act on Special Measures Concerning Promotion of Utilization of Electricity from Renewable Energy Sources. The amended act prescribes, among other things, the rollout of a feed-in premium scheme in April 2022 to add premiums to the market price of renewables expected to evolve into competitive power sources, such as large commercial solar power generation and wind power generation. The details of this scheme are now under study. It also provides for the creation of a nationwide surcharge scheme to partially offset the costs of interregional interconnection development and other grid expansions needed to support the introduction and spread of renewable energy. Moreover, it requires electricity generation utilities to pay monies into an external fund for covering the future cost of dismantling photovoltaic power generation facilities when decommissioned.

(4) Development of Legal Framework for Advancing Offshore Wind Farm Projects

Expectations for the potential of offshore wind power continued to rise as efforts to expand onshore wind power, mired by locational constraints and other issues, progressed more slowly than the installation of solar power systems after the launch of the FIT scheme in 2012. Accordingly, the government enacted the Act on Promoting Utilization of Sea Areas for Development of Power Generation Facilities Using Maritime Renewable Energy Resources to lay out, among other things, rules for ownership of maritime areas and the process for coordinating the interests of stakeholders such as members of the fishing industry. Under this act, which went into effect in April 2019, the government designates certain offshore areas suited for wind power generation as targeted promotional areas and selects operators by tender to carry out projects in those areas. As of July 2020, four areas had been designated (one each off Nagasaki and Chiba Prefectures, and two off Akita Prefecture), and preparations were advancing toward the designation of 20 other areas. Many of the Japanese utilities seeking to advance these projects are doing so through collaboration with various partners, particularly European utilities experienced in operating offshore wind farms.

Sakai Solar Power Station (Kansai Electric Power Co.)

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 developed nations to reduce their emissions, the Paris Agreement requires all signatories 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 Intended Nationally Determined Contribution (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, regulatory, and economic measures, exploiting their respective characteristics in an 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.

Furthermore, the government formulated the Fifth Strategic Energy Plan in July 2018, and the cabinet adopted in June 2019 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

Government Action on GHG Reduction Targets Table 2.6

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.
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.
March 2020	The Japanese government submits its NDC to the United Nations as required by the Paris Agreement.
October 2020	Prime Minister Suga announced that Japan would become carbon neutral by 2050.

Source: Compiled from Agency for Natural Resources and Energy website, etc.

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.

In March 2020, the Japanese government submitted to the United Nations its Nationally Determined Contribution (NDC) for reducing emissions, as required by the Paris Agreement. The target contribution remains the same as that stated in the INDC. In a policy speech given in the following October, Prime Minister Yoshihide Suga announced that Japan would do its utmost to transform into a green society, and become carbon neutral by 2050 by achieving net-zero greenhouse gas emissions.

Table 2.6 shows the government's initiatives relating to GHG reduction targets since adoption of the Kyoto Protocol in 1997.

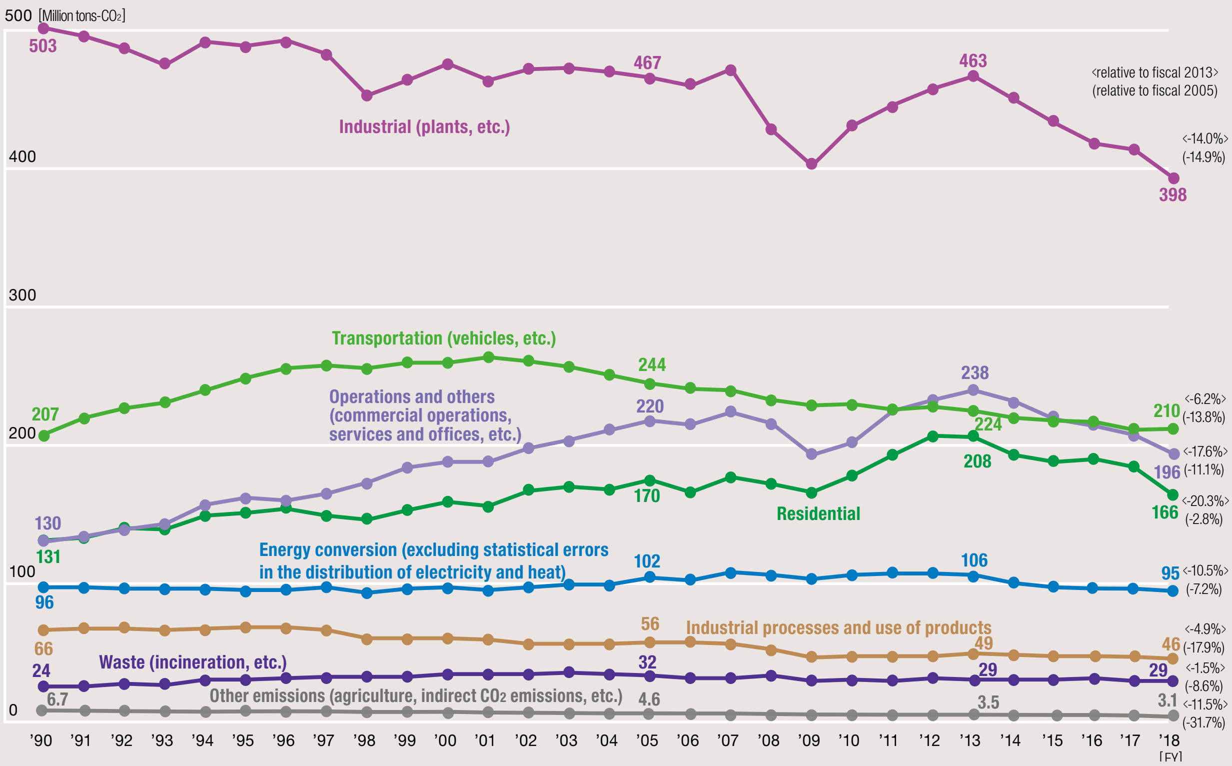
b. Joint Crediting Mechanism

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.

Changes in CO_2 Emissions by Sector Figure 2.6



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 2018 (Final Figures)" (2020)

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 2018, Japan's GHG emissions measured 1,240 million tons (CO_2 equivalent), and emissions of CO_2 accounted for 91.7% (1,138 million tons) of this total. CO_2 emissions showed 13.6% decrease from fiscal 2013 and a 12.0% decrease from fiscal 2005 (Figure 2.6).

CO_2 emissions in individual sectors have been decreasing since 2013, and declining by 14.0%, 17.6%, and 20.3% respectively in the industrial sector, the commercial sector, and the residential sector between fiscal 2013 and fiscal 2018. 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.

In June 2020, more than 130 corporate members of the Japan Business Federation endorsed the "Declaration on Challenge Zero" initiative for boldly pursuing innovation toward the realization of a decarbonized society, and announced over 300 innovation challenges in areas such as development of net-zero emission technologies, active deployment and diffusion of those technologies, and financing for the projects.

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, 10 members of FEPC, J-POWER, The Japan Atomic Power Co. 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 2019 (preliminary figures) came to 345 million tons-CO_2 and the CO_2 emission factor was 0.444 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, feeding electricity derived from renewable energy sources into the grid based on the FIT scheme for renewable energy, and improving the efficiency of thermal power plants.

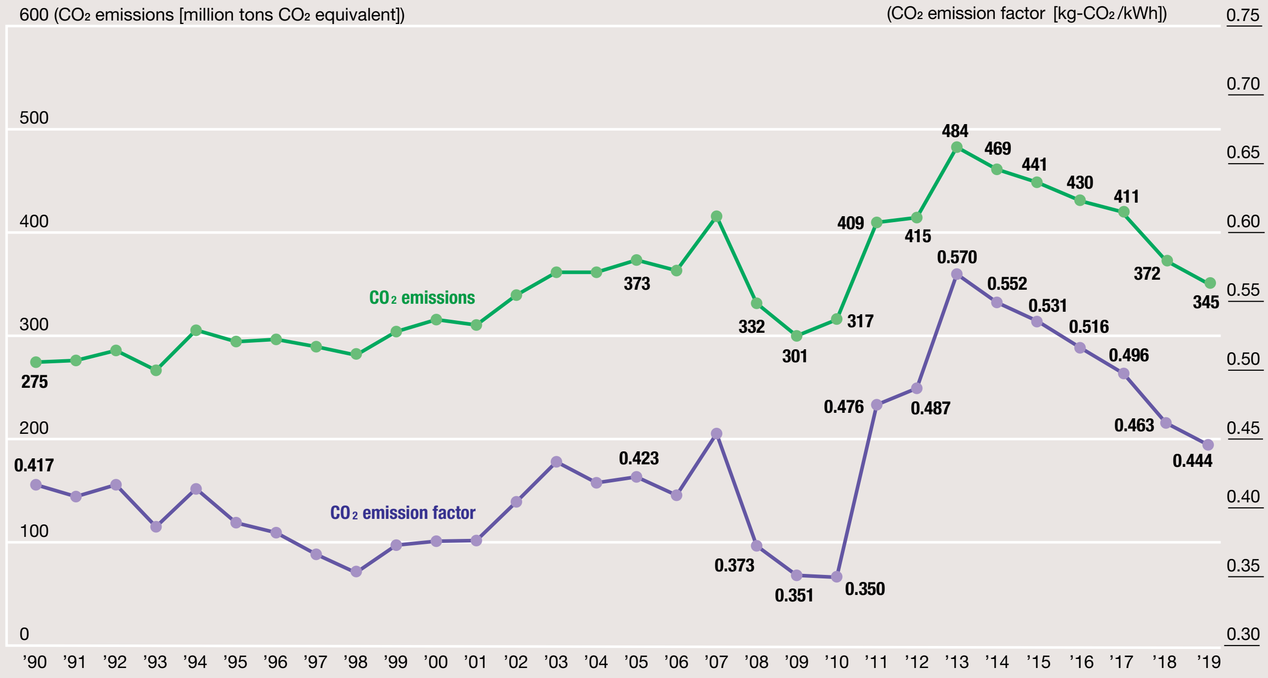
On the demand side, they are actively promoting energy conservation, providing information to realize more efficient electricity use, and pursuing the widespread installation of smart meters.

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 2.7 shows CO_2 emission trends in the electric power industry.

CO_2 Emissions in the Electric Power Industry

Figure 2.7



Note: Reflected adjustments made for Kyoto Mechanism credits

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

III. SUPPLY AND DEMAND

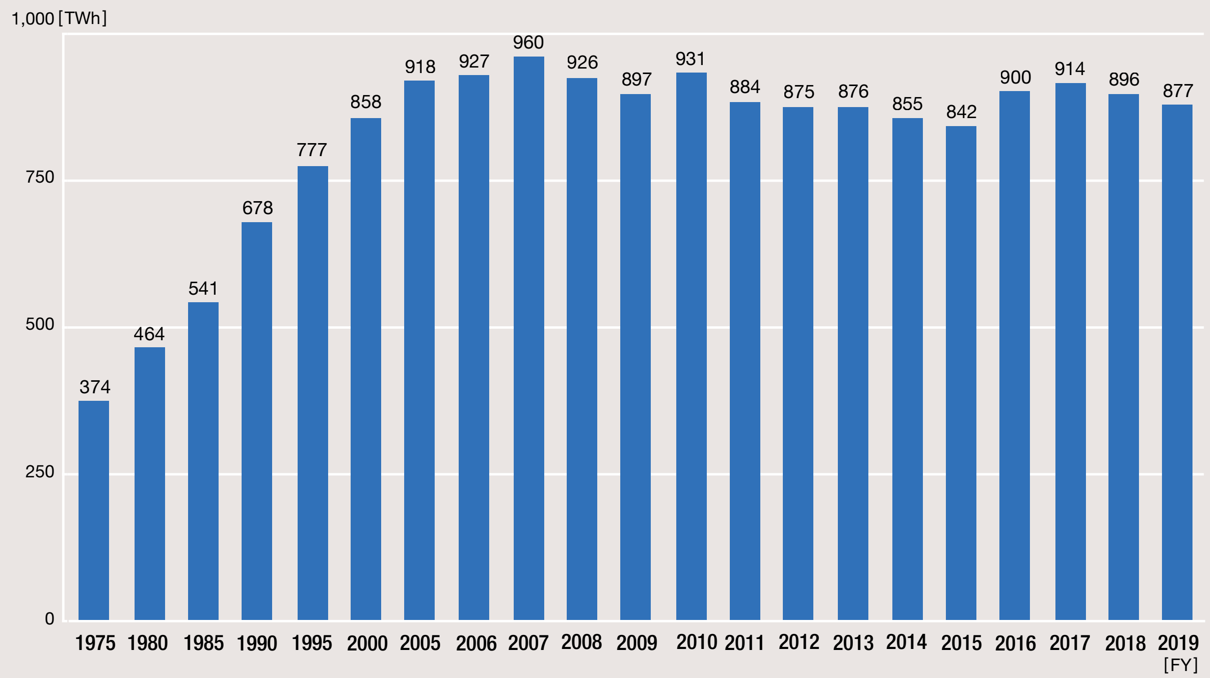
1. Electricity Demand and Peak Load

Japan's electricity demand increased for the most part until the early 2000s. The real GDP growth rate in fiscal 2019 was 0.0% compared to fiscal 2018, when it rose 0.3% from a year earlier. The unemployment rate in fiscal 2019 stood at 2.4%, which was the same as fiscal 2018. Annual electricity demand has either declined or remained unchanged since reaching 959.7 TWh in fiscal 2007, and in fiscal 2019 came to 877.1 TWh[1] (2.1% decrease from previous fiscal year) **(Figure 3.1)**. 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 fiscal 2011 and the average of the three highest daily loads in fiscal 2019 came to 158.7 GW (0.6% decrease from previous fiscal year).

Demand in April and May 2020 decreased by 3.2% and 8.7%, respectively, versus the same period in the previous year due to the impact of the COVID-19 pandemic.

Power consumption breaks down by use as follows: 28% residential demand, 34% commercial demand, and 37% industrial demand **(Figure 3.2)**. 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

Changes in Electricity Demand, 1975–2019 Figure 3.1

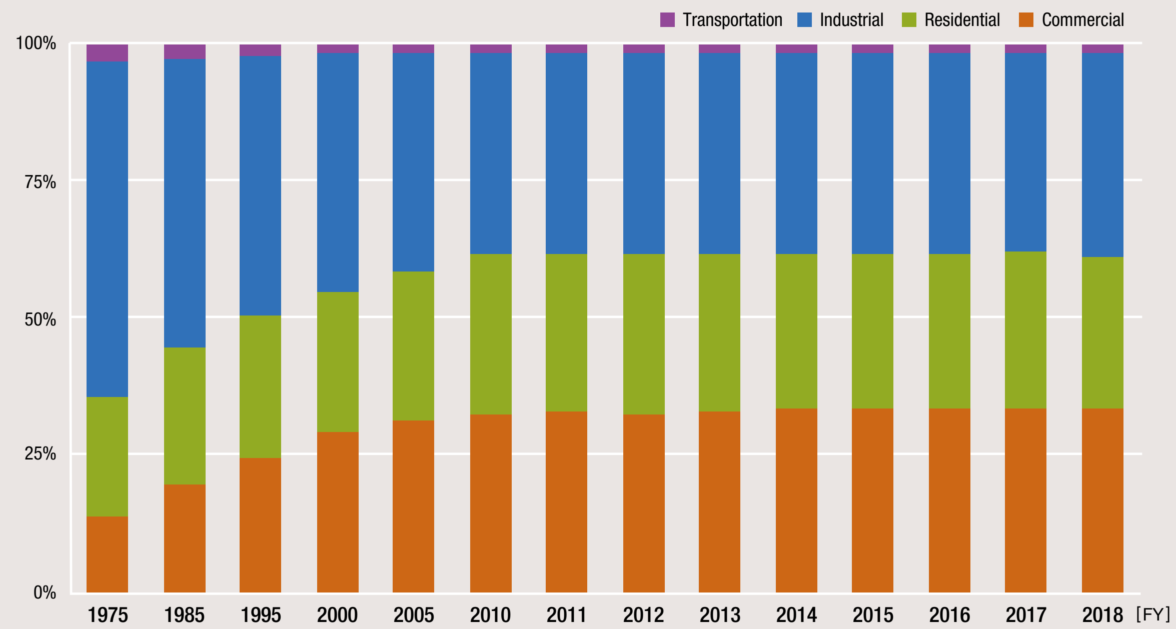


Source: Compiled from Agency for Natural Resources and Energy, "Handbook of Electric Power Industry" (2019) and "Surveys and Statistics of Electricity" (2020)

1 Total of utilities' net system energy demand, specified service demand, and self-consumption demand.

Breakdown of Power Consumption by Sector, 1975–2018

Figure 3.2



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

Source: Agency for Natural Resources and Energy, "Energy Balance in Japan" (2020)

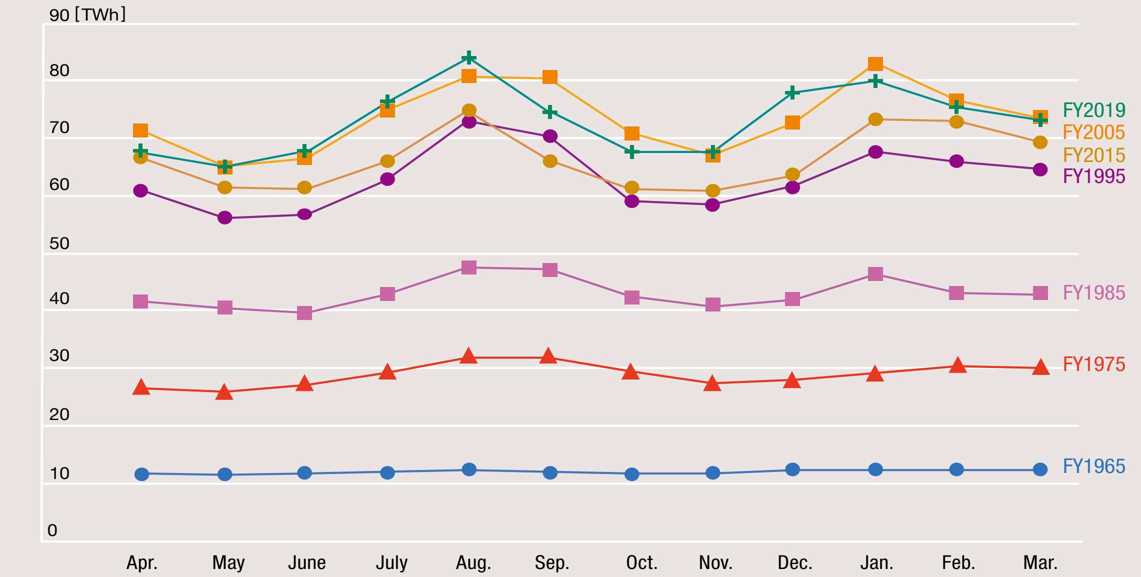
sectors, namely the residential and commercial sectors. Growth in consumption in the commercial sector has been propelled by growth in offices and commercial facilities triggered by development of a service economy and the accompanying use of air conditioners and other appliances. In the residential 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 the population continued to decline, 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 2018, non-industrial consumption accounted for 62% of final power consumption.

In the years preceding the March 2011 Great East Japan Earthquake, the rise in the non-industrial share of demand widened the gap between summer/winter demand and spring/fall demand (Figure 3.3), and between daytime and nighttime hours (Figure 3.4) due to the use of electricity for heating and cooling. Since the disaster, however, power conservation, wider adoption of solar power generation, and other measures have curbed daytime grid power demand during the summer, thus shrinking the disparities between the summer and other seasons, and between daytime and nighttime hours during the summer.

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 and nighttime electricity use (Figure 3.5).

Electric Power Consumption over the Course of a Year

Figure 3.3

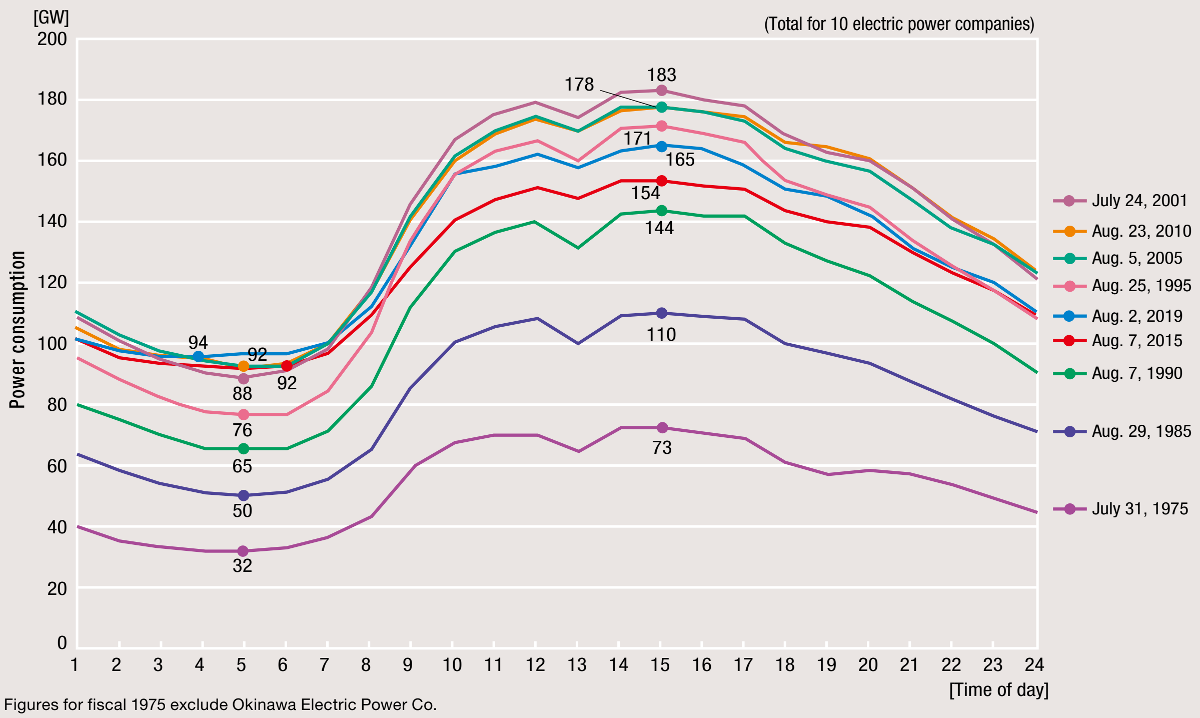


Note 1: Figures for fiscal 1975 and 1985 exclude Okinawa Electric Power Co.
Note 2: Figures are totals for 10 electric power companies through fiscal 2015, and for 10 areas in fiscal 2016.

Source: Compiled from FEPC, "Electricity Demand" up to fiscal 2015, and OCCTO, "Information on Electricity Supply and Demand" from fiscal 2016

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

Figure 3.4

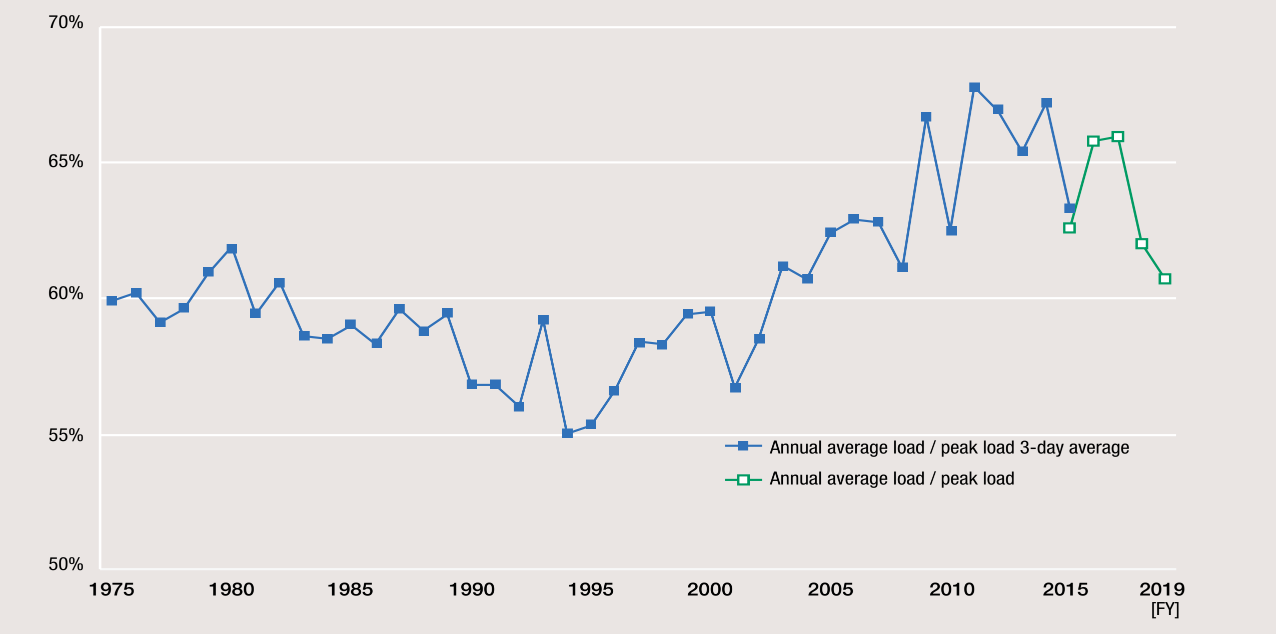


Note: Figures for fiscal 1975 exclude Okinawa Electric Power Co.

Source: Japan Atomic Energy Relations Organization, "Graphical Flip-chart of Nuclear & Energy Related Topics" (2020)

Annual Load Factor, 1975–2019

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[2] came to 863.2 TWh in fiscal 2019 (3.2% decrease from previous fiscal year). 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 79.1% in fiscal 2010 to 80.7% in fiscal 2019 (Figure 3.6). While nuclear power's share stood at 31.4% 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 90.8%. 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 2019 was still only 7.1%.

On the other hand, the construction of renewable energy installations such as wind and solar power plants has increased. In fiscal 2019, 6.3 TWh of electric power was generated by wind power, and 13.2 TWh by solar power (Figure 3.7). As an effect of the FIT scheme launched in July 2012, the use of solar power has saliently increased since then, and solar power installations have been growing with each passing year, not only for business use, but also for self-consumption.

3. Electricity Supply and Demand Balance

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

a. Recent Developments

Nine 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.

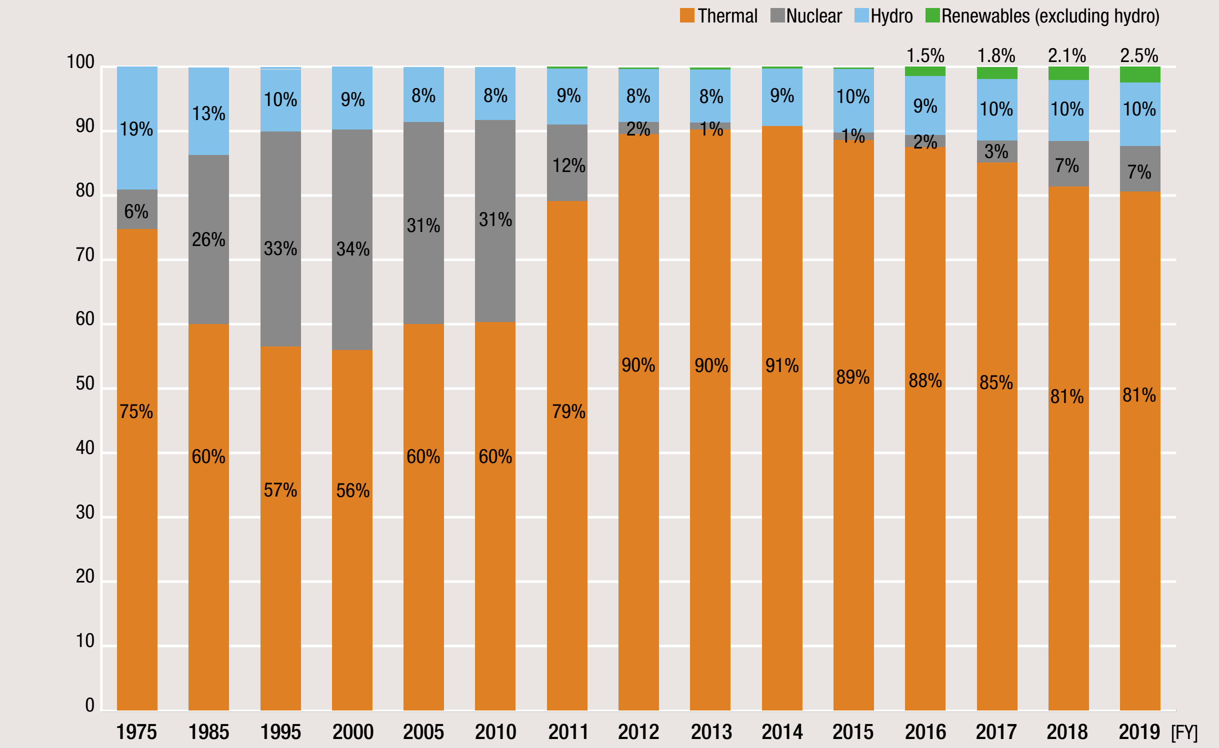
b. Supply and Demand Projections

As for the electricity supply and demand situation, it has remained possible in recent years to maintain the minimum

2 Electric power generated by electricity utilities.

Power Generation Mix, 1975–2019

Figure 3.6

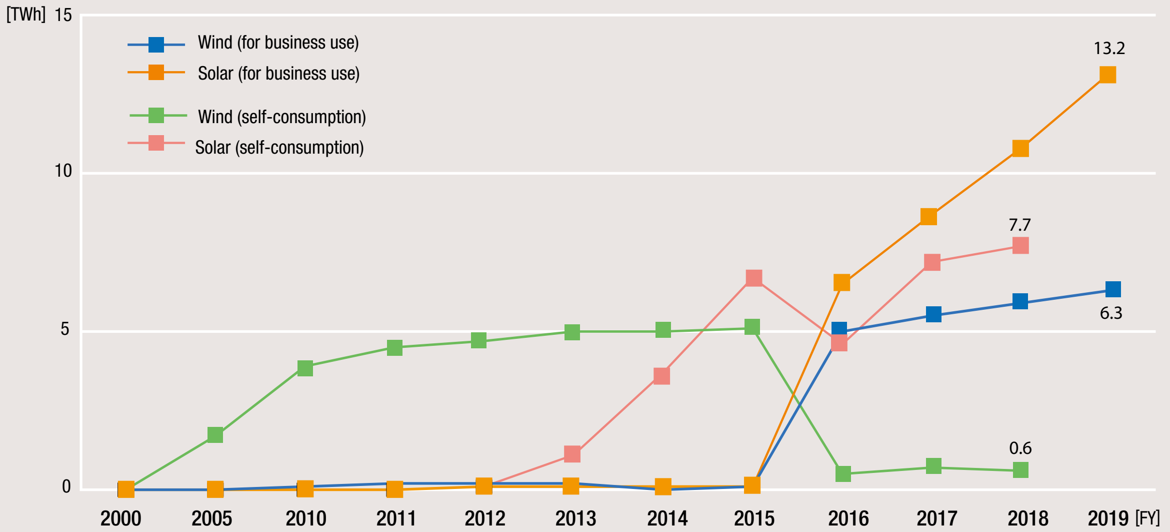


Note: Figures on electric power generated for electric utilities are generation-end figures through fiscal 2015, and transmission-end figures from fiscal 2016.

Source: Compiled from Agency for Natural Resources and Energy, "Handbook of Electric Power Industry" (2019) and "Surveys and Statistics of Electricity" (2020)

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: Compiled from Agency for Natural Resources and Energy, "Handbook of Electric Power Industry" (2019) and "Surveys and Statistics of Electricity" (2020)

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 2020 to fiscal 2029 will be almost 0%, and electricity demand and supply capacity are expected to remain at current levels (Figure 3.8).

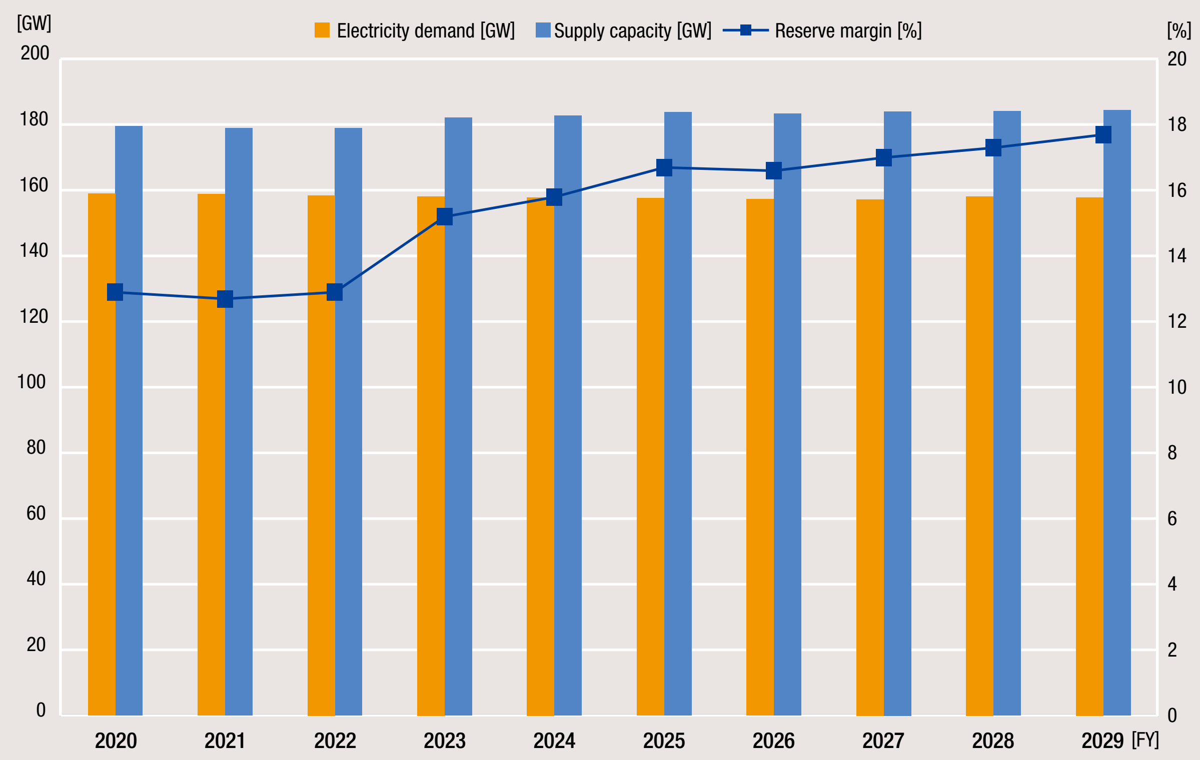
(2) Securing Balancing Capacity

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.

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 2020, 11,410 MW of power source I and 135,520 MW of power source II were procured. In addition, 4,270 MW of power source I' was procured, of which 1,290 MW of demand was met by demand response.

Projected Electricity Demand and Supply Capacity Figure 3.8



Source: OCCTO, "Aggregation of Electricity Supply Plans for FY2020"

IV. ELECTRIC POWER FACILITIES

1. Power Generation Facilities[1]

Total generating capacity in Japan was 306.7 GW at the end of fiscal 2019. This consisted of 52.0% thermal power (15.0% coal, 27.3% LNG, and 9.7% oil), 10.8% nuclear power, 16.0% hydro, and 21.1% renewables (excluding hydro). Figure 4.1 shows the breakdown of total generating capacity by power source at the end of fiscal 2019.

(1) Power Generation Facilities for Electric Utilities

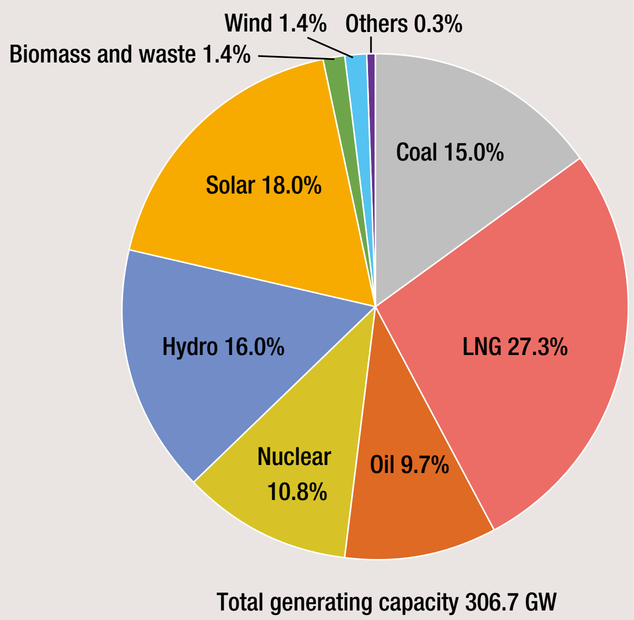
a. Thermal Power

The total installed capacity of thermal power plants was 159.5 GW as of the end of fiscal 2019. This accounts for 52.0% of Japan's total generating capacity, making thermal power the predominant source of electricity. In recent years, the increasing deployment of variable renewable energy (solar power) has spurred greater need to leverage the balancing capacity of thermal power to match supply with demand. The average power generation efficiency (gross efficiency) of all thermal plants in Japan was maintained at a world-class level (Figure 4.2).

Coal-fired generating capacity came to 46.0 GW. Coal generates higher CO_2 emissions than other fuels, but offers superb supply stability and economy. Inefficient coal power plants are being gradually phased out toward 2030, meanwhile high efficiency coal power plants are being developed to further lessen its environmental impact. The past 20 years have seen emissions reduced by the introduction of ultra-supercritical (USC) coal power plants.

LNG-fired generating capacity totaled 83.7 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-

Breakdown of Commercial Power Generation Facilities by Power Source (FY2019) Figure 4.1

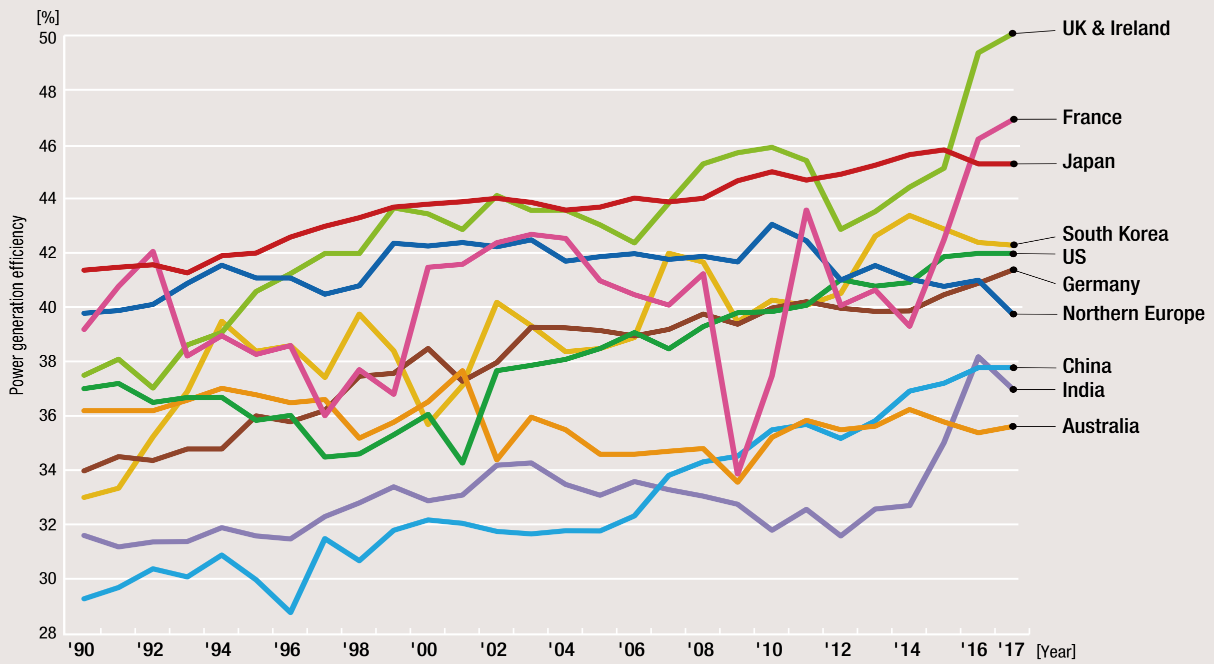


Source: OCCTO, "Aggregation of Electricity Supply Plans for FY2020"

1 The data on power generation facilities are for facilities owned by electricity generation utilities and those procured by electricity retailers and general electricity transmission and distribution utilities from entities other than electricity generation utilities (such as facilities generating electricity under the FIT scheme).

Average Power Generation Efficiency of Thermal Power Plants in Japan Compared with Other Countries

Figure 4.2



Note: 1. Power generation efficiency is weighted average of gross efficiencies of coal, oil, and gas (based on Lower Heating Value).
2. Excludes self-consumption power generation facilities.
3. Figures for Japan are for the Japanese fiscal year (April–March).

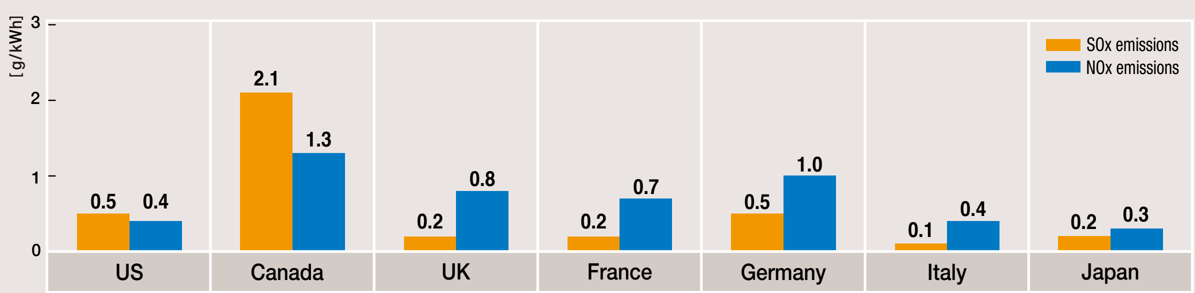
Source: FEPC, "INFOBASE 2019" (2019)

cycle technologies is underway to further reduce emissions of these substances. A new plant[2] added to the grid in 2018 exhibits significant improvements in performance, with gas turbine inlet temperatures of 1,600℃ and power generation efficiency of approximately 63.08%.

Oil-fired generating capacity was 29.9 GW. Oil plays a measurable role in peak power supply and balancing but accounted for just 1.6% of all power generated in fiscal 2019, representing a considerably smaller contribution versus other thermal power generation methods (coal, 32.7%; LNG, 41.0%).

Comparison of SOx and NOx Emissions per Unit of Power Generated at Thermal Power Plants of Major Countries (2017)

Figure 4.3



Source: FEPC, "INFOBASE 2019" (2019)

2 Chubu Electric Power Co.'s Nishi-Nagoya Thermal Plant Unit 7-2 (operation started in March 2018)

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

Takehara Power Plant (J-POWER)

b. Hydro Power

Hydro power generating capacity stood at 49.2 GW at the end of fiscal 2019. Hydro power plants have been promoted in Japan to take advantage of the country's high levels of rainfall. Conventional hydro accounted for 21.7 GW and pumped storage for 27.5 GW. Variable speed pumped storage systems have also been adopted for a portion of pumped storage power generation. These systems provide a means of addressing fluctuations in output from variable renewable energy as they allow power output to be flexibly adjusted.

c. Renewable Energy

• Solar

Installed solar power generating capacity at the end of fiscal 2019 was 55.4 GW. The deployment of renewable energies, mainly solar power, has been progressing in Japan. Solar power makes up approximately 87% of total FIT-certified renewable power generating capacity. As a result, the morning decrease in net demand[3] and the evening increase in net demand have become more extreme than before. This has become a grid operation issue for some regions. Since it started becoming difficult to adjust supply and demand

3 Total of demand, less solar power output. Represents demand for grid power.


Fukuyama Solar Power Station (Chugoku Electric Power Co.)

versus the fluctuating output of solar power using only the balancing capacity of thermal power and pumped storage hydro power, the output of solar power has been curtailed in Kyushu and its remote islands since 2018. Resolution of this fluctuating output challenge is a critical task for advancing the further deployment of solar power.

• Wind

Wind power generating capacity was 4.3 GW as of the end of fiscal 2019. The installation of wind power facilities has lagged behind that of solar power facilities, due to factors such as the longer time needed to assess environmental impacts, and constraints on grid capacity. The majority of installed wind power generation facilities are onshore, and only around 20 MW of capacity is offshore. However, the FIT-certified capacity of offshore installations has trended upward, reaching 668 MW at the end of fiscal 2019.

• Biomass and waste

Biomass and waste generating capacity at the end of fiscal 2019 came to 4.4 GW. In Japan, this form of power generation has centered upon municipal waste incineration and the direct combustion of black liquor from paper-making and wood waste from lumber production. Biomass and waste power, low environmental load type thermal power is a renewable that, unlike variable renewable energy (solar and wind), can stably generate power with minimal fluctuation. This means that it can be used to reliably generate electricity in the wake of disasters, and thus is being increasingly introduced as a power source that can help to strengthen disaster resilience, even when compared with other renewables.

d. Nuclear Power Generation

Total nuclear power generating capacity at the end of fiscal 2019 was 33.1 GW (33 units that have operated in the past, and excluding three under construction). Nine nuclear reactors (all PWRs) are in commercial operation (see "Nuclear Power Generation" in Section 2, Chapter II).

(2) Future Plans

a. Transition of Power Generating Capacity and Power Development Plans

In March 2020, OCCTO published the "Aggregation of Electricity Supply Plans for FY2020."[4] Figure 4.4 shows generating capacity by power source, and Table 4.1 shows the breakdown of power development plans up to fiscal 2029[5] (new installation, uprating/derating, and retirement plans).

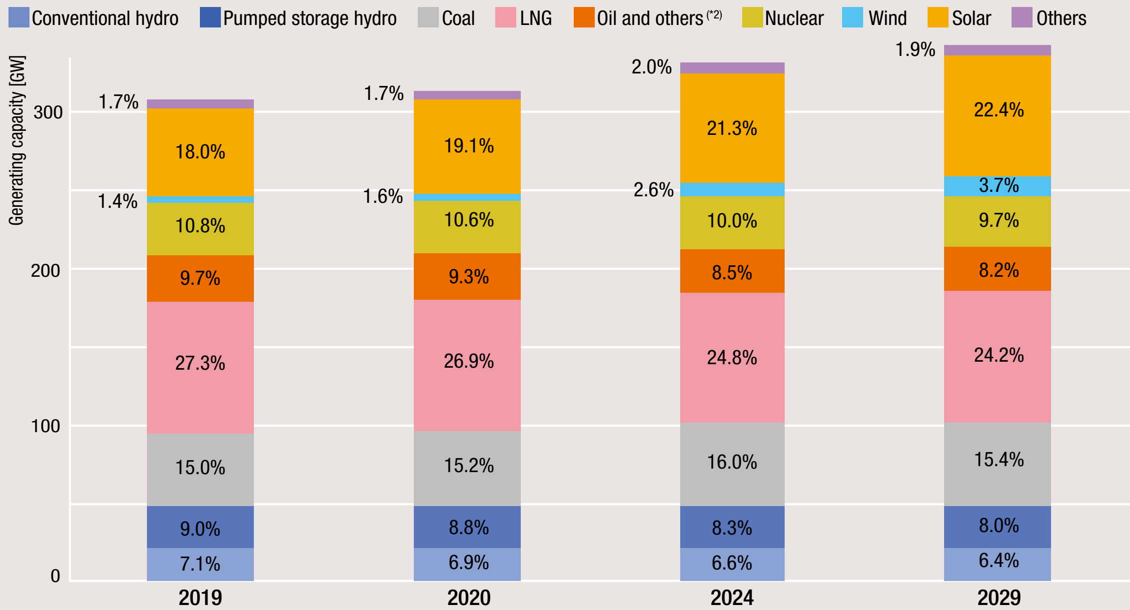
Looking forward, coal-fired generating capacity will trend upward overall as construction of new capacity will outweigh ongoing decommissioning. As the global trend to reduce GHG emissions continues, however, the withdrawal of plans for new coal-fired power plants and the shift to gas-fired power plants are observed in Japan.

4 All electricity utilities are annually required to submit to the national government (via OCCTO) a supply plan that maps out their supply of electricity and development of power sources and transmission lines over the ensuing 10 years.

5 Aggregated including facilities for which the date of commercial operation is "uncertain."

Trends in Generating Capacity by Power Source, 2019–2029 (*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 for FY2020"

Power Development Plans up to FY 2029 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		379	51	68	46	-222	32	225
	Conventional	379	51	68	46	-222	32	225
	Pumped storage	–	–	–	–	–	–	–
Thermal		14,476	34	52	1	-9,586	42	4,942
	Coal	6,851	10	–	–	-518	3	6,333
	LNG	7,574	15	52	1	-7,635	16	-9
	Oil	51	9	–	–	-1,433	23	-1,382
Nuclear		10,180	7	152	1	–	–	10,332
Renewables		7,353	345	8	3	-311	49	7,050
	Wind	1,792	54	–	–	-147	36	1,645
	Solar	4,040	253	–	–	-2	1	4,038
	Geothermal	44	3	6	2	-24	1	26
	Biomass	1,405	30	–	–	-84	6	1,321
	Waste	72	5	2	1	-56	5	18
Total		32,387	437	280	51	-10,120	123	22,549

Note: Decimals have been rounded off, so the figures for some items may not add up to the total listed.

Source: OCCTO, "Aggregation of Electricity Supply Plans, FY2020"

Decommissioning of oil-fired power plants will continue and generating capacity will shrink. Note that net generating capacity will decrease because the number of new gas-fired power plant construction projects is less than the number of decommissionings. 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

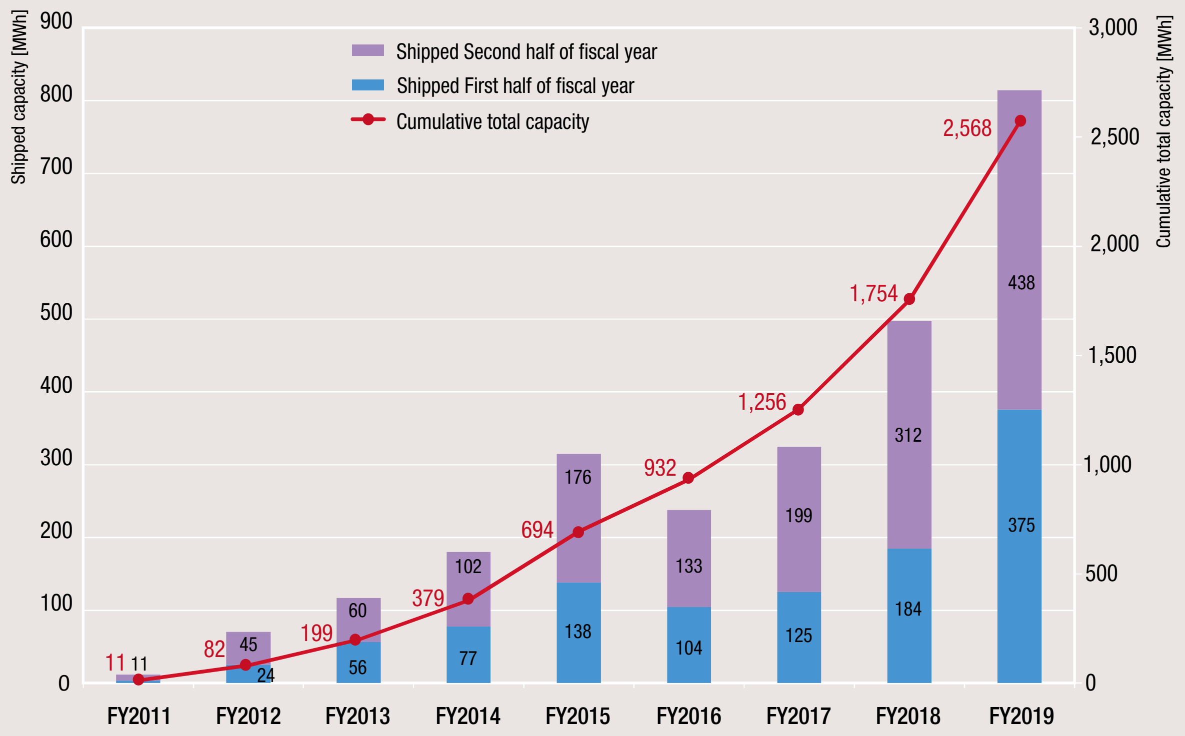
In June 2016, the government published its "Technology Roadmap for Next-Generation Thermal Power Generation." Among other things, this aims to reduce CO_2 emissions from thermal power plants by improving the efficiency of gas- and coal-fired power generation.

More specifically, the aim regarding gas-fired plants is to develop ultra-high temperature (1,700°C class) gas turbines[6] and fuel cell combined cycle (GTFC)[7] 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 (IGCC)[8] and integrated coal gasification fuel combined cycle (IGFC)[9] systems.

In the area of next-generation coal power, New Energy and Industrial Technology Development Organization (NEDO) and Osaki CoolGen Corporation[10] conducted a demonstration test of a 170 MW-class IGCC plant in fiscal 2017–2018, attaining results indicating the potential for net efficiency[11] of around 46%. In December 2019, they launched an IGFC demonstration test project, slated for completion in fiscal 2022.

Looking at carbon capture and storage (CCS) technologies, a government-led project has been carrying out large-scale demonstration testing toward commercialization of CCS.

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



Source: The Japan Electrical Manufacturers' Association, "Shipments of Stationary Lithium-Ion Battery Storage Systems" (2020).

6 Development will be completed by around 2020 (approx. 57% power-generation efficiency and CO_2 emission intensity of 310 kg/MWh).
7 Development will be completed by around 2025 (approx. 63% power-generation efficiency and CO_2 emission intensity of 280 kg/MWh).
8 Development will be completed by around 2020 (approx. 46%-50% power-generation efficiency and CO_2 emission intensity of 650 kg/MWh).
9 Development will be completed by around 2025 (approx. 55% power-generation efficiency and CO_2 emission intensity of 590 kg/MWh).

Testing began in 2016 with a CO_2 injection rate of 100,000 t/year, reaching a total of 300,000 t in 2019.

• Renewable Energy

METI aims to expand adoption of renewables by solving the problem of fluctuations in output by making use of battery storage system, hydrogen, and other technologies.

Use of battery storage system is rising. Over 360,000 stationary lithium-ion battery storage systems with a capacity in excess of 2.5 GWh were in use in fiscal 2019 (Figure 4.5). METI is conducting experimental projects using battery storage system. Themes selected for these projects include the adoption of large grid stabilization systems for storing power generated from variable renewable energy and the development of virtual power plants using customer-side energy resources (such as battery storage system and demand response). An example of the kinds of projects underway is that being conducted at the Buzen 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 solar power curtailment up to 300 MWh per day.

Regarding hydrogen, METI formulated a "Strategic Roadmap for Hydrogen and Fuel Cells" in March 2019. Among other goals, this plan aims to commercialize hydrogen power generation by around 2030, and calls for efforts to establish the technologies needed and to reduce the production cost of hydrogen. It also seeks to make hydrogen power generation as cost competitive as existing LNG-fired power generation, including with regard to environmental value.[12]

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. Capturing CO_2 from the exhaust gas generated by power plants and other emission sources and combining it with "clean" hydrogen produced by surplus variable renewable energy 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.

(3) Digitalization in the Power Generation Sector

The power generation sector is developing digital technology-driven methods of data analysis and forecasting to answer various challenges and needs, including reduction of the power generation costs and environmental impact of facility operation, and labor-saving approaches to equipment maintenance. For example, a former general electricity utility teamed up with an IT firm and a power plant builder to create an AI-enhanced combustion adjustment model at a thermal power plant. The model achieved reductions in NOx emissions and fuel costs compared with human operation.

Buzen Battery Electrical Substation (Kyushu Electric Power Co.)
Output: 50MW, Capacity: 300MW (operation started in March 2016)

10 Established through joint investment by Chugoku Electric Power Co. and J-POWER.
11 Based on Higher Heating Value.
12 The plan aims to reduce the cost of hydrogen delivered for plants to 30 yen/Nm³ in around 2030 and to 20 yen/Nm³ thereafter.

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 Okinawa Electric Power Co. (132 kV). As of the end of March 2020, these transmission lines had a 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, TEPCO Power Grid, Inc. has constructed transmission lines designed to handle up to 1,000 kV as a third outer ring, which is currently operating at 500 kV, in order to accommodate the large-scale grid expansions expected to accompany the future decentralization or centralization of power source locations. Ultra-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 2020, Japanese 10 general electricity transmission and distribution utilities have 6,788 substations with a total installed capacity of approximately 850,000 MVA (Table 4.2). Almost all substations are now unmanned, with remote monitoring and control.

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

Transmission and Distribution Facilities — Table 4.2

	1975	1985	1995	2005	2010	2015	2016	2017	2018	2019
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	36,986	37,021
110kV Under 220kV	28,913	35,106	36,952	35,962	35,696	35,588	35,709	35,459	35,390	35,441
Under 110kV	69,361	78,660	88,648	95,176	104,618	106,167	106,238	106,341	106,494	106,784
Total	112,441	137,252	154,707	166,347	176,105	178,704	178,792	178,665	178,870	179,246
Transformation facility capacities										
Substation output capacity (MVA)	234,748	447,866	657,536	778,740	810,924	833,112	842,084	843,886	846,638	850,313
Total Number of substations	3,466	5,152	5,814	6,570	6,686	6,718	6,766	6,774	6,783	6,788
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	4,031,278	4,038,426
Underground	14,358	25,348	50,371	65,287	66,896	70,733	71,360	72,096	72,735	73,420
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	4,104,013	4,111,846

Source: FEPC, "Electricity Statistics Information"

Assist Arms (Hokuriku Electric Power T&D)
Hokuriku Electric Power T&D 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 Network)

(3) Distribution Facilities

Distribution lines are classified into extra-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 extra-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 100/200 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 2020, the total length of distribution lines in Japan was approximately 4,112,000 km. Of this, approximately 73,000 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.

Smart meters for low voltage customers have also been installed in order to (1) facilitate meter reading by general electricity transmission and distribution utilities, (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 extra-high voltage and high voltage customers and 75.2% of low voltage customers (including households) had been provided with smart meters as of March 2020. All customers should have smart meters by the end of March 2025.

Power distribution equipment (Okinawa Electric Power Co.)
Maintenance work in preparation for a typhoon

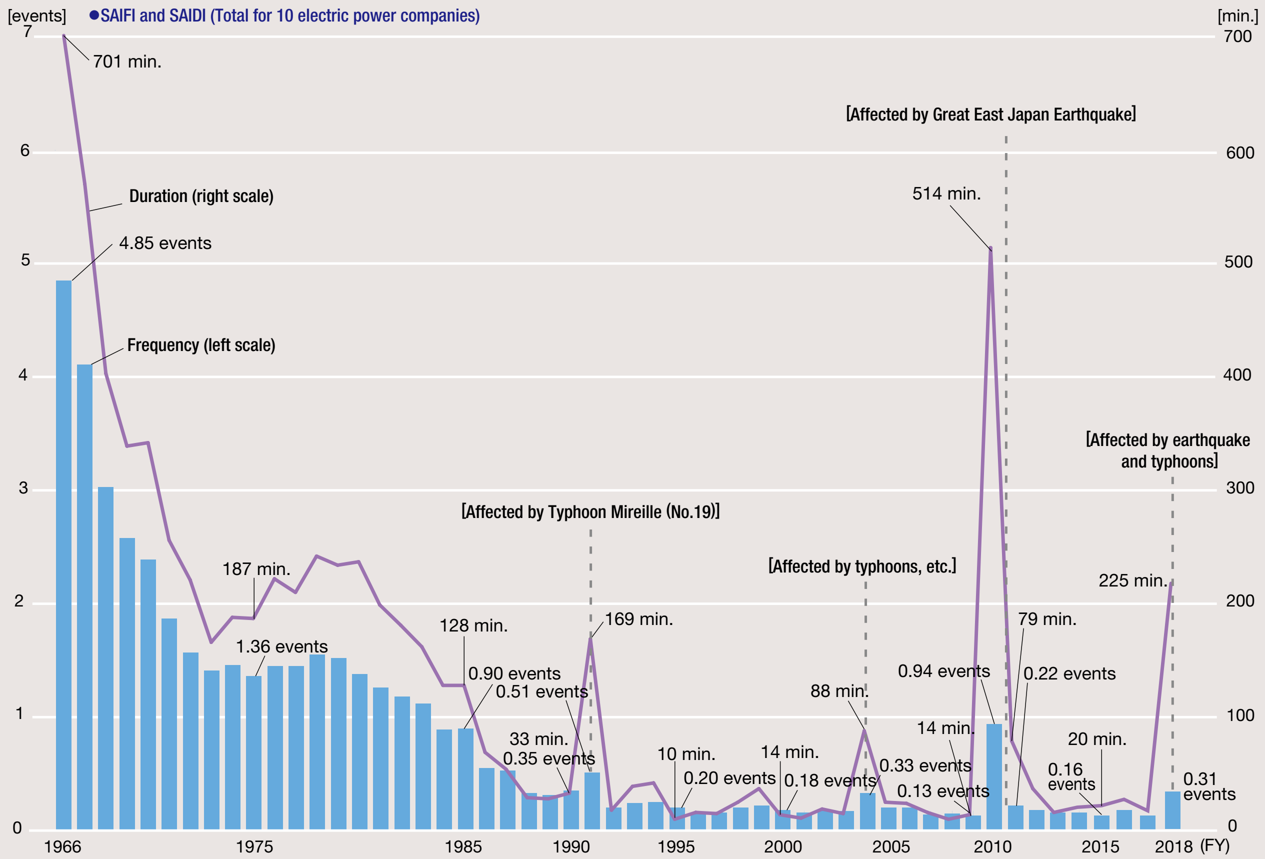
(4) Supply Reliability (SAIDI, SAIFI)

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 2018, the System Average Interruption Frequency Index (SAIFI) was 0.31 interruptions and the System Average Interruption Duration Index (SAIDI) was 225 minutes (Figure 4.6). These figures were higher than those for fiscal 2017 (SAIFI, 0.14 interruptions; SAIDI, 16 minutes) due to large-scale power outages resulting from Typhoon Jebi (No. 21), Typhoon Trami (No. 24), and the Hokkaido Eastern Iburi Earthquake, all of which occurred in September 2018.

Boat patrol (Tohoku Electric Power Network)
Utility employees in boats inspected the extent of damage in areas flooded by Typhoon Hagibis (No.19). (October 2019, Osaki, Miyagi Prefecture)

SAIFI and SAIDI

Figure 4.6



Note: 9 electric power companies up to FY1988

Source: FEPC, "INFOBASE 2019" (2019)

(5) Efforts to Improve Resilience and Increase Use of Renewables in Power Transmission and Distribution Sector

It has become imperative to secure an electrical power supply system that is tailored to the expanded use of renewables and is capable of swift recovery from typhoons, torrential rains, and other natural disasters that have become more frequent in recent years. To address this need, the government drafted a bill for establishing an energy supply resilience legislation for securing a resilient and sustainable power supply system through measures supporting rapid disaster recovery, facilitated investment in transmission/distribution grids, increased introduction of renewables, and other enhancements.

Specifically, the bill contains measures such as the following. (1) Enhancing inter-business collaboration in disaster responses: Require general electricity transmission and distribution utilities to formulate action plans for collaborating with one another during disasters, and to update local governments and other authorities on the status of power supply service during disaster recovery. (2) Enhancement of transmission/distribution grid resilience: Add to OCCTO's functions the duty to formulate forward-looking plans for development of cross-regional networks; and establish a wheeling rate system that would encourage electricity transmission and distribution utilities to pursue cost efficiencies that would keep them below the revenue caps based on their investment plans and approved by the Minister of the Economy, Trade and Industry. (3) Establishment of disaster-resilient distributed power supply systems: Redefine the legal standing of distribution utilities so that they can operate their services as independent networks during emergencies while continuing the operation of distribution grids, including small distributed energy resources, in specific service areas.

This bill was passed by the Diet in June 2020. Certain provisions came into effect in October 2020, and the remainder will go into effect in April 2022.

(6) Digitalization in the Transmission and Distribution Sector

To address challenges such as aging equipment and reduced maintenance staffing, the power transmission and distribution sector is using digital technologies to streamline maintenance and inspections. For example, general transmission/distribution utilities are seeking to shrink manpower needs and improve maintenance techniques through demonstration projects that use drones to inspect transmission facilities, or use imaging analysis and AI tools to automatically detect failures from photographs of facilities.

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. 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[13]. The neighboring grids of nine of the general electricity transmission and distribution utilities' service areas are connected to one another (Okinawa area is the exception). Japan has no international interconnections.

The individual electric power companies have 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, OCCTO administers the use of the interconnections that span the service areas of different general electricity transmission and distribution utilities.

Traditionally, electricity generation utilities have been allowed to use these interconnections on a first-come, first-served basis. However, this model was abandoned in October 2018, 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 power generation based on 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.

Prior to the legal separation of electricity generation and transmission into different sectors, the principle was for electricity utilities to independently operate their own grids, and they essentially balanced supply and demand fluctuations in their grids with their own electricity. Following the separation, it also has been the rule for general electricity transmission and distribution utilities to adjust the supply and demand fluctuations in their service areas, with load fluctuations in their grids balanced using electricity acquired from their service areas, in principle.

OCCTO plans to create a balancing market in 2021, and general electricity transmission and distribution utilities will be able to use this market to procure balancing capacity from outside their areas. Several companies are already preparing for this change by carrying out pilot programs in cross-regional transmission of balancing capacity.

(2) Interregional Interconnections

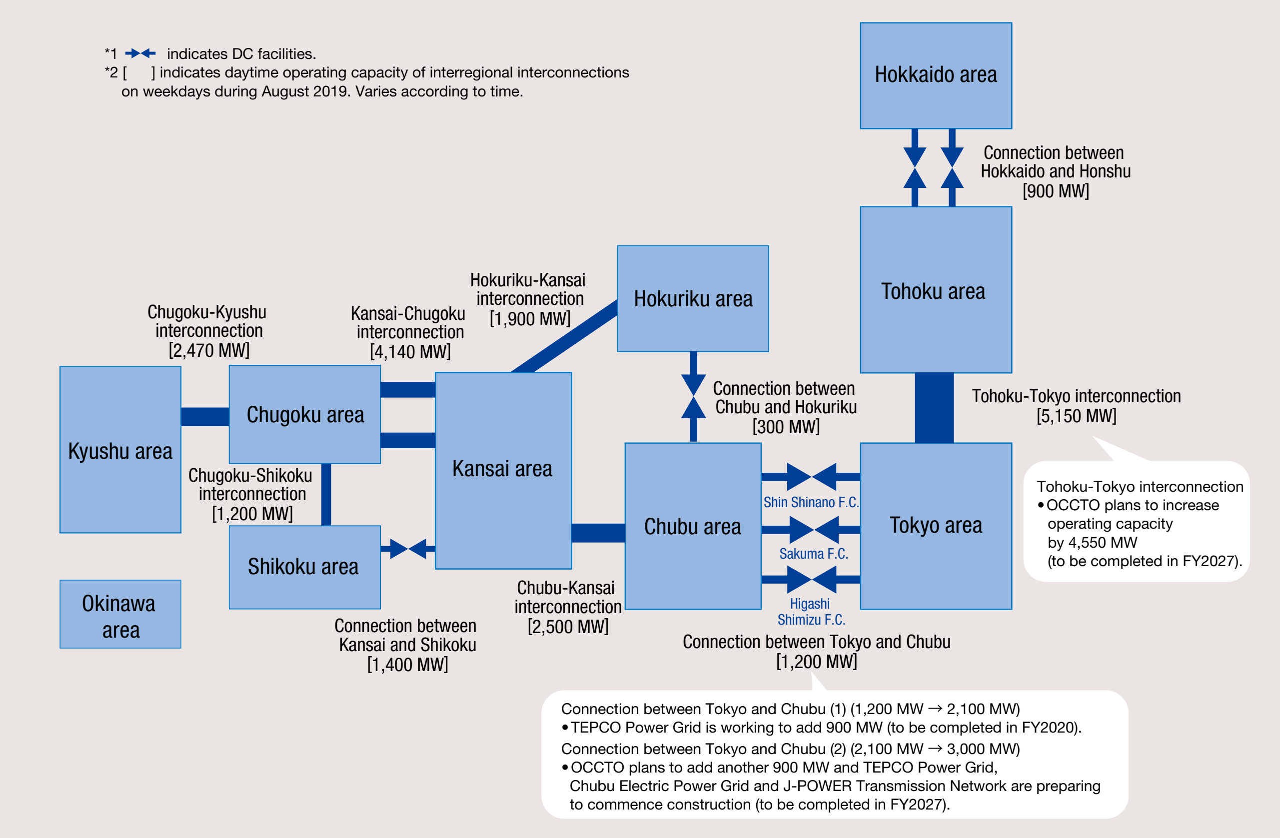
As of 2020, the interregional interconnections in operation are mainly AC transmission lines. In the 50 Hz eastern region, Tokyo area and Tohoku area are linked by 500 kV AC transmission lines, while Tohoku area and Hokkaido area are linked by DC submarine cables that span the approximately 20 km strait between Honshu and Hokkaido. Tohoku area and Hokkaido area are connected via two ±250 kV links (600 MW, 300 MW).

In the 60 Hz western region, Chubu area, Hokuriku area, Kansai area, Chugoku area, Shikoku area and Kyushu area are linked by 500 kV AC transmission lines. Okinawa is not connected with other regions of Japan. DC lines are used by Chubu area and Hokuriku area, which are connected by back-to-back DC linkage facilities (300 MW), and by Kansai area and Shikoku area, which are linked by ±500 kV DC submarine cables (currently operated at ±250 kV) that span the Kii Channel. The 50 Hz and 60 Hz systems are linked by the interconnections between the Tokyo area and Chubu area 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).

Along with the increasing large-scale adoption of distributed energy sources in recent years, OCCTO has been considering plans to enhance these interconnections, taking into account the individual utilities' views. As part of those plans, the Shin-Shinano Frequency Converter at the Tokyo-Chubu interconnection will be upgraded by 900 MW by the end of fiscal 2020, and the Sakuma and Higashi-Shimizu frequency converters' capacity will be expanded by a total of 900 MW by the end of fiscal 2027 (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.

13 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: Compiled from Agency for Natural Resources and Energy, "Formation and Sharing of Cost of Electric Power Networks" (2019)

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.[14] This has been partially deployed 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. This has already been put into practice in certain areas since September 2019.

14 A single fault affecting one transmission or distribution line, one transformer, one generator, A 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 to customers covered by rate regulations 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 2020, 55.03 million low voltage customers (74% of the total) paid regulated rates.

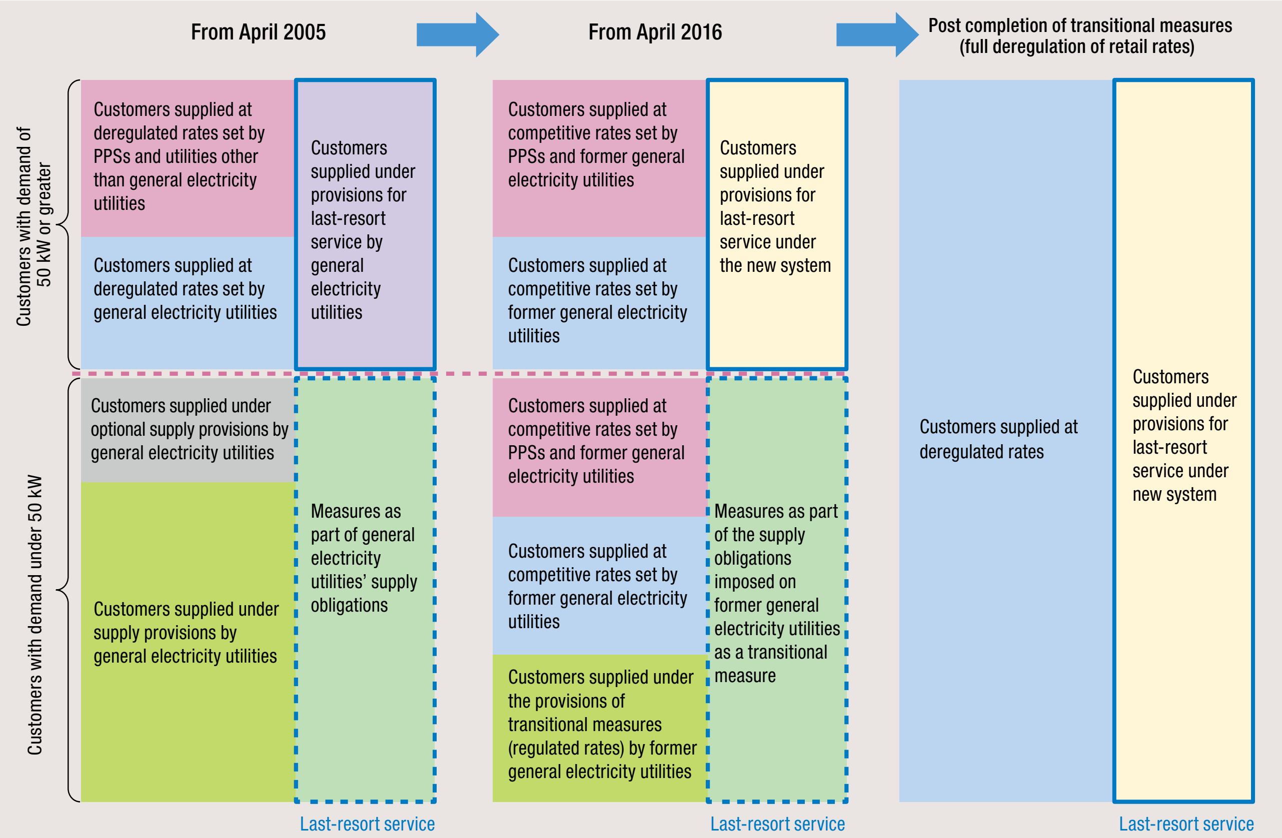
Regulated rates were originally to be discontinued at the end of March 2020. However, as competition had not developed sufficiently, METI decided in July 2019 to maintain regulated rates from April 2020 onwards. Discontinuation of regulated rates will continue to be considered, while paying close attention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

a. Two-Component Rates

The electricity rates charged when former general electricity utilities supply electricity to customers that selected regulated rates consist of two components: a basic

Arrangements to Bridge the Transition to Competitive Rates

Figure 5.1



Source: Agency for Natural Resources and Energy website

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

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

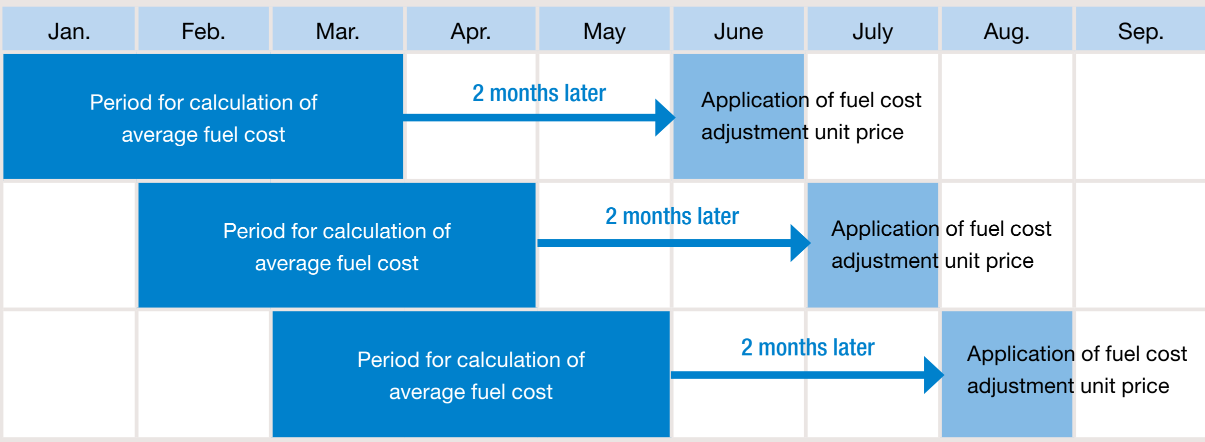
A fuel-cost adjustment scheme was introduced in January 1996 in order to externalize the effects of fuel prices and exchange rates, which are beyond the control of general electricity utilities in their efforts to enhance efficiency, and thus reflect the changes in rates as expediently as possible and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

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

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



Source: Compiled from FEPC materials

certain period (under the current system, general electricity transmission and distribution utilities do the purchasing). 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 extra-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 (newly entered electricity retailers). 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

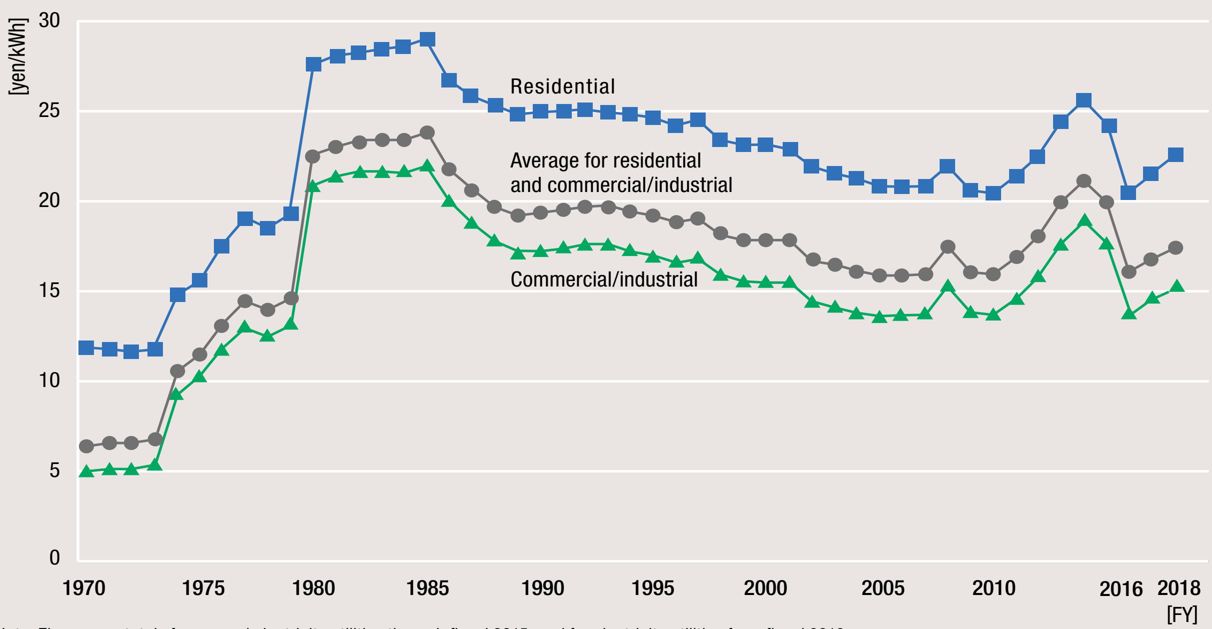
Electricity rates in Japan climbed sharply in the 1970s and early 1980s due to the oil crises, but subsequently entered a long-term decline, owing in part to operational streamlining efforts by the former general electricity utilities. Since the Great East Japan Earthquake in 2011, however, rates have 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 began rising again in 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

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, "FY2019 Annual Report on Energy" (2020)

Average Unit Wheeling Charges of General Electricity Transmission and Distribution Utilities (As of October 2020)

Table 5.2

Average unit wheeling charges of general electricity transmission and distribution utilities [yen/kWh] (excluding tax)			
	Low voltage	High voltage	Extra-high voltage
Hokkaido	8.75	4.16	1.83
Tohoku	9.71	4.50	1.98
Tokyo	8.57	3.77	1.98
Chubu	8.98	3.51	1.83
Hokuriku	7.80	3.76	1.81
Kansai	7.81	4.01	2.02
Chugoku	8.28	3.98	1.61
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); general electricity transmission and distribution utilities' websites

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."

Currently, plans are being studied for revising the wheeling charge system by around 2023. The discussions include detailed design of a new scheme that would set revenue caps at certain intervals on general electricity transmission and distribution utilities based on their investment plans and other considerations, with the aim of encouraging them to make the operational efficiency improvements needed to keep their business sustainable under the revenue caps.

(5) Basic Charge on the Power Generation Side

Under the current system, the expenses associated with power transmission and distribution equipment are, as a rule, borne by electricity retailers as part of the wheeling charges. However, the government has been considering introducing a new scheme that would seek to realize fair and appropriate cost sharing and to encourage efficient use of transmission and distribution networks by also having power generation-side operators, as grid users, bear some of the costs, with their share based on their level of revenue. Based on this review, the Fifth Strategic Energy Plan (approved by the Cabinet on July 3, 2018) included a plan to introduce a basic charge to be levied on the power generation side. The details of this scheme are being worked out, with an eye on launching it in fiscal 2023.

2. Efforts to Acquire Customers

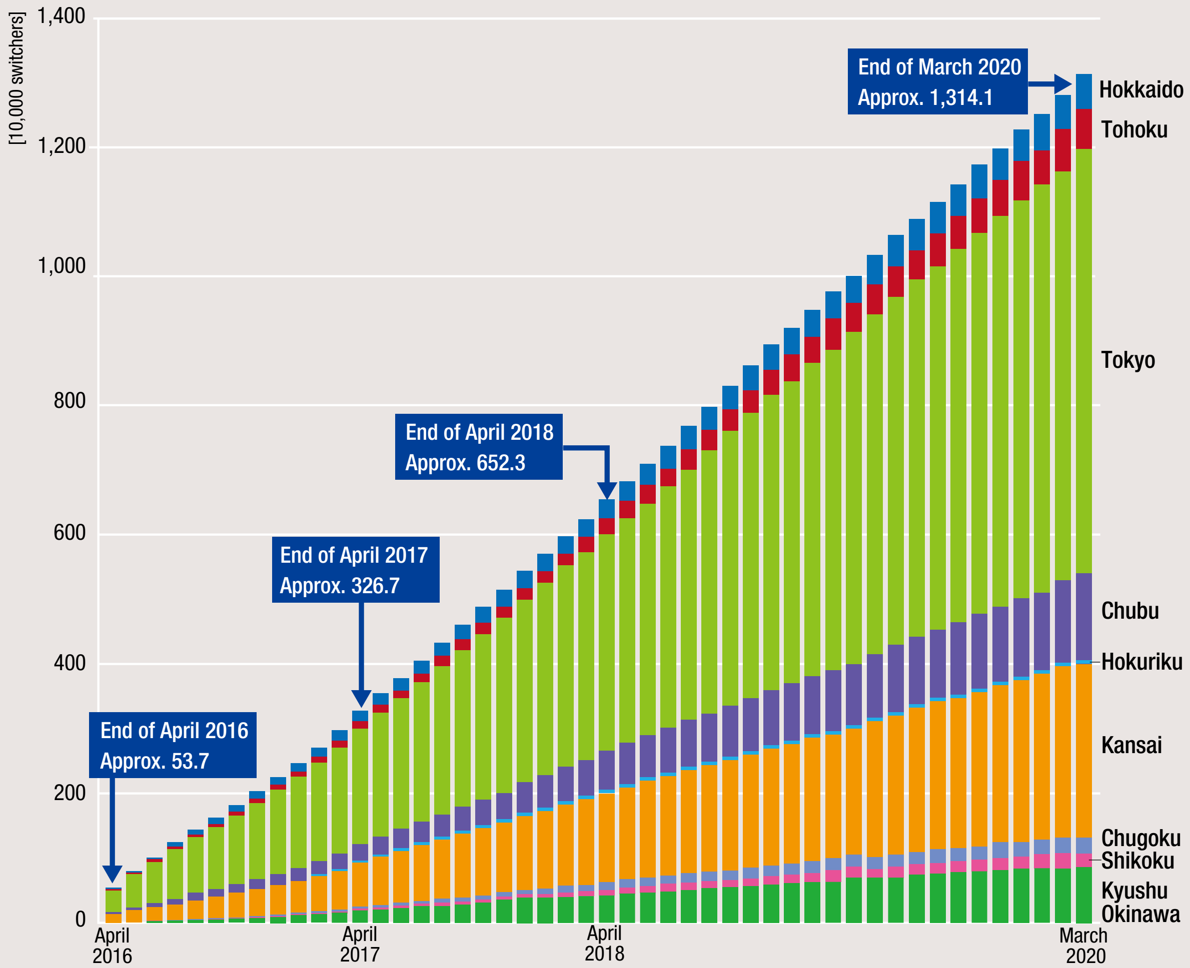
(1) State of Customer Switching of Retail Service Agreements

As of the end of March 2020, there had been a cumulative total of approximately 13.14 million cases of retail service agreement switching since March 2016, when applications for switching were first accepted. Among general households, some 21% of the regular contracts in effect immediately prior to liberalization (approximately 62.53 million) had been switched (Figure 5.4).

(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

Trends in Number of Low Voltage Switchers by Service Area (As of end of March 2020) 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" (2020) 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.

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.

Meanwhile, PPSs are seeking to acquire new customers through diverse approaches, including offering lower rates to families with heavy electricity usage.

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 more than 1,000 types of plans were available as of the end of July 2020. Rate comparison websites have therefore been launched by service providers to help customers choose the plans that best meet their needs. These websites are playing an increasingly important role as plans become more diversified with the rise in the number of electricity retailers.

(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.

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 under the feed-in tariff scheme, 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. Business operators 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 May 25, 2020, there were 191 trading members and 10 special 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.
- Intra-day market: A market for correcting unexpected

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" (2019), and JEPX data 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 292.5 TWh in fiscal 2019. This is more than a 40% increase in year-on-year terms and means that about 30% of all electricity sold in Japan is sold through JEPX. PPSs procure more than 80% of their electricity from the spot market. The average system price has hovered around the 7–9 yen/kWh mark since fiscal 2015, and stood at 7.93 yen/kWh in fiscal 2019 (Figure 5.5). However, prices fell in April 2020 as demand dropped from the impact of Covid-19. In that month, trading occurred at the lowest possible system price of 0.01 yen/kWh, with the average system price falling to 5.24 yen/kWh.

(2) New Markets

New markets have been developed to encourage further competition in the electricity sector, secure stable power supply, and actualize environmental value. 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 new markets are mainly the following: (a) a baseload power market, (b) a capacity market, (c) a balancing market, and (d) a non-fossil value trading market. In addition, trading has begun in the electricity futures 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 baseload power market was established in 2019, and three auctions for delivery in fiscal 2020 have been conducted, for a total volume of 534 MW, with clearing prices ranging from 8.47 to 12.47 yen/kWh.

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, 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 was studied 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 supply capacity (installed capacity) through market mechanisms.

Trading in the capacity market began in 2020. Capacity contracts for 2024 totaled 167.69 GW in volume, and had a clearing price of 14,137 yen/kW.

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 system 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.
The first auction for balancing capacity was held by general electricity transmission and distribution utilities at the end of fiscal 2016 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 April 2021.

d. Non-Fossil Value Trading Market

The wholesale electricity market 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 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 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 achieve the targeted level of reductions in greenhouse gas emissions by fostering use of a power generation mix consistent with its most suitable energy mix.

Ten auctions of non-fossil certificates for electricity under the FIT scheme had been held as of September 15, 2020. The first for fiscal 2020 was held in August 2020, with a trade volume of 151 GWh and a weighted average trade volume price of 1.30 yen/kWh. Trading of electricity generated by non-fossil fuel sources not covered by FIT scheme is scheduled to commence in fiscal 2020.

In addition, an electricity futures market run by Tokyo Commodity Exchange, Inc. was established on September 17, 2020 to reduce electricity price fluctuation risks. The market is operating on a three-year trial basis, and the decision on approval for full listing will be made based on its trial performance.

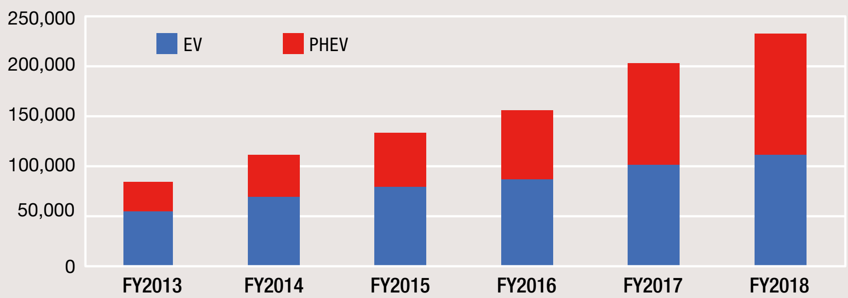
TOPICS: Electric Vehicle Initiatives

Since the Great East Japan Earthquake in March 2011, Japan has been working on the issue of how to achieve distributed energy systems that are efficient and reliable, moving away from energy supply systems reliant on large-scale power plants. This is one of the reasons why METI provided grants from fiscal 2016 to 2020 to support demonstration projects for a virtual power plant (VPP) that uses demand-side energy resources. The use of electric vehicles (EV) and plug-in hybrid electric vehicles (PHEV) has been steadily growing (Figures 1.1, 1.2), and EV batteries now have higher capacities and lower cost per unit of energy stored than home batteries. Consequently, they are seen as key energy resources for VPPs. V2G (vehicle to grid) demonstration projects were conducted from fiscal2018 to 2019, and projects to trial shifting the EV charging peak by using dynamic pricing linked to the wholesale price of electric power began in fiscal 2020 (Figure 2). Japan's electricity utilities have individual initiatives, including VPP demonstration projects, predicated on growing EV usage.

(1) VPP Demonstration Project (V2G, Battery Reuse)

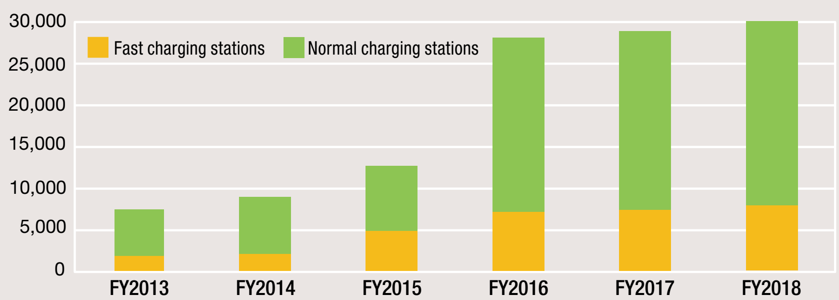
Tokyo Electric Power Company, Tohoku Electric Power Company, Chubu Electric Power Company, and Kyushu Electric Power Company individually conducted V2G demonstration projects from fiscal 2018 to 2019.

Total EV and PHEV Usage in Japan Figure 1.1



Source: Compiled from Next Generation Vehicle Promotion Center data

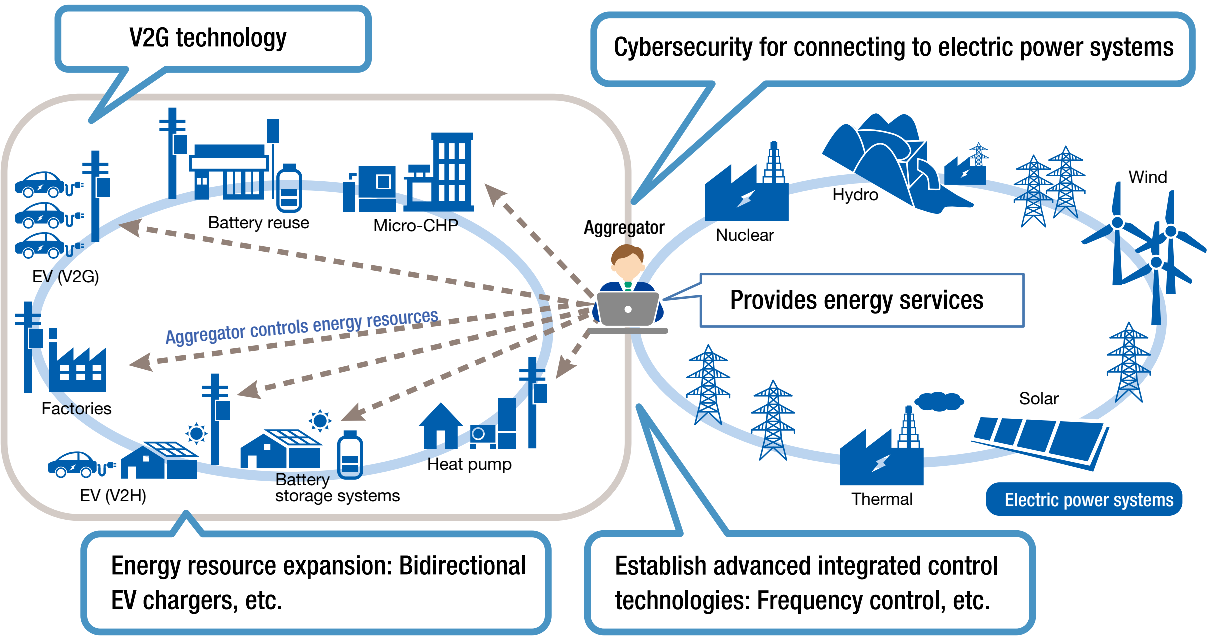
Number of EV Charging Stations Installed in Japan Figure 1.2



Source: Ministry of Land, Infrastructure, Transport and Tourism (MLIT)/METI report on EV/PHEV usage

Virtual Power Plant Demonstration Project (FY2020) Figure 2

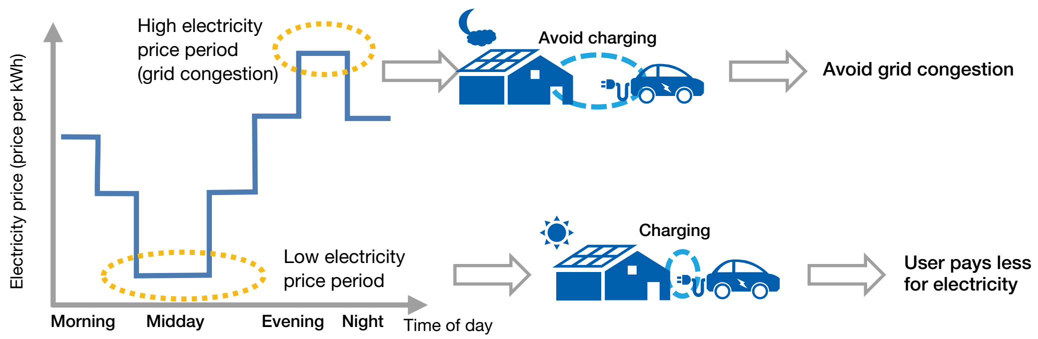
(1) Using VPPs to Facilitate Advanced Energy Business



(2) Trials Using Dynamic Pricing to Shift EV Charging demand

- Dynamic pricing linked to the wholesale electricity price encourages a shift in the EV charging demand from times of higher electricity prices to times when the price is lower.
- This approach is beneficial for increasing the adoption of renewable energy, securing balancing capacity, and mitigating grid reinforcement needs.

Charging based on dynamic pricing



Source: METI report on initiatives for constructing energy systems using distributed energy resources (2020)

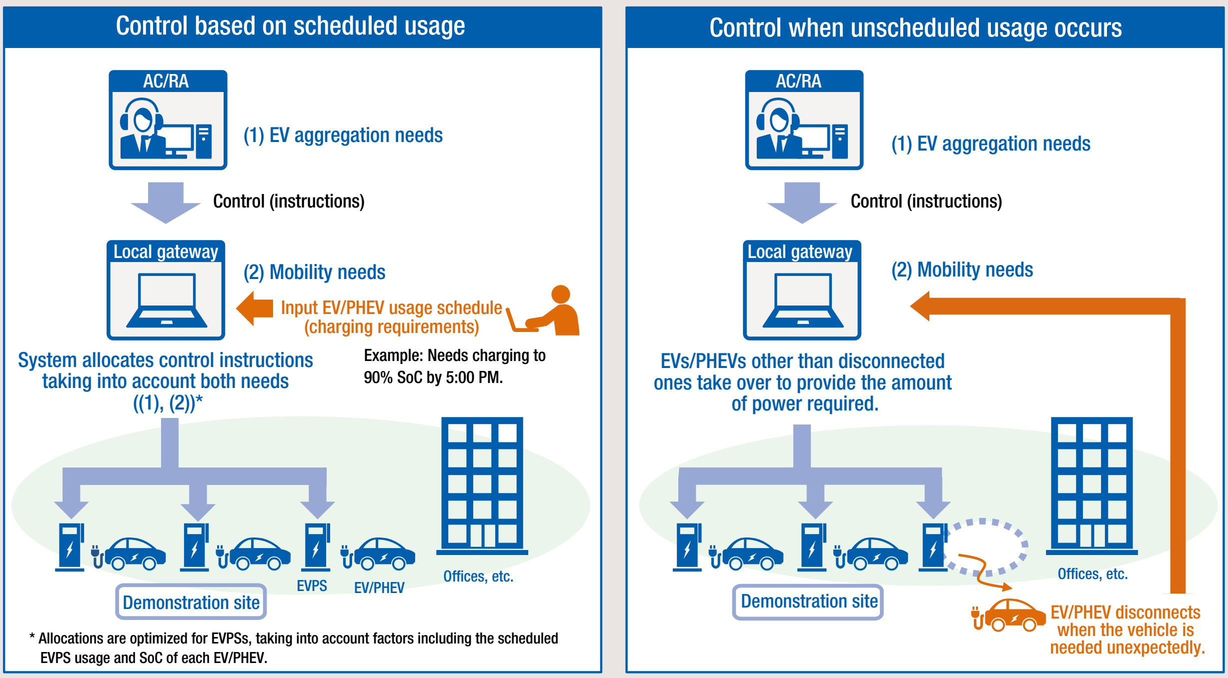
- Tokyo Electric Power Co. constructed an online system that can control simultaneously EV charging and discharging at five charging stations (354 kW total), and that can optimize balancing capacity so that when unscheduled EV usage occurs, the system can dispatch power from other EVs based on their usage schedules and states of charge (Figure 3).
- Tohoku Electric Power Co. installed charging stations at four locations (33.6 kW total) and assessed the grid response when using EVs to provide balancing capacity, and also investigated the potential for voltage improvement by using V2G in areas identified as having large fluctuations in distribution grid voltage due to wind power or other variable output power sources that also had potential for growth in EV usage due to having a large number of houses (Figure 4).
- Chubu Electric Power Co. used a single charging station (20 kW total) and four PHEVs, introducing a system where scheduled vehicle activity is input using a smartphone app, and assessed the grid response when using a combination of private and commercial vehicles to provide balancing capacity (Figure 5).
- In fiscal 2019, Kyushu Electric Power Co. completed its multi-year verification of a control system for distributing commands to obtain balancing capacity from EVs using charging stations at six locations (95.4 kW total). In fiscal 2020, it is constructing a VPP linked with other resources such as electric water heaters (Figure 6).

Other projects include verification tests being conducted by Chugoku Electric Power Co. to evaluate second-life battery response and degradation characteristics when reusing EV batteries as a VPP resource, controlled in combination with distributed energy resources (Figure 7).

(2) EV Charging Infrastructure

At the end of fiscal 2018, Japan had a cumulative total of about 240,000 EVs and PHEVs, and about 30,000 EV charging facilities. Urban areas are covered by the charging infrastructure, but the presence of areas with congestion due to insufficient charging facilities and areas without charging facilities is becoming a problem (Figure 8). Tokyo

Optimum Allocation Control When Using EVs to Provide Balancing Capacity Figure 3



AC: Aggregate Coordinator / RA: Resource Aggregator

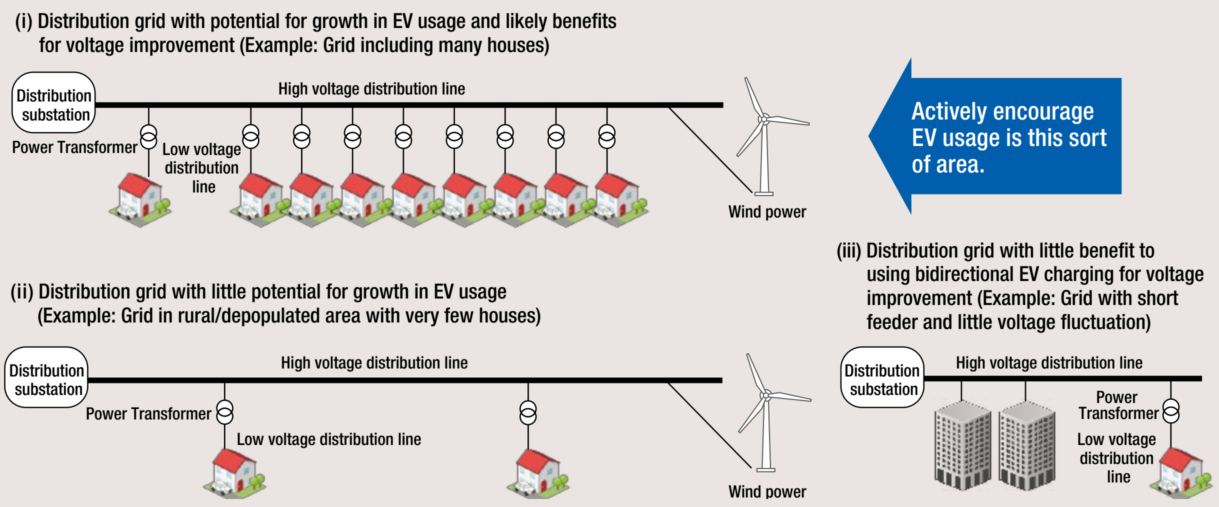
Source: Tokyo Electric Power Company Holdings

Electric Power Co. and Chubu Electric Power Co. jointly established e-Mobility Power Co., Inc. in 2019 to address this issue. This company is now active throughout Japan. In addition to boosting the infrastructure through charging stations at public sector facilities and for commercial vehicles, it is also, providing convenient charging services that meet user needs, such as V2H (vehicle to home) equipment enabling EVs to act as emergency power sources for homes (Figure 9).

To boost the charging infrastructure in Hokkaido, which is sparse compared to other regions of Japan, Hokkaido Electric Power Co. is researching the construction of an EV charging business platform using blockchain technology to make charging facilities more convenient for both owners and users. The platform connects multiple EV charging stations together in a blockchain network, enabling owners to use the network to check charger occupancy and set prices, and enabling users to find charging stations and check charger availability, reserve a charger, and make payment online (Figure 10).

Concept for Actively Boosting EV Usage

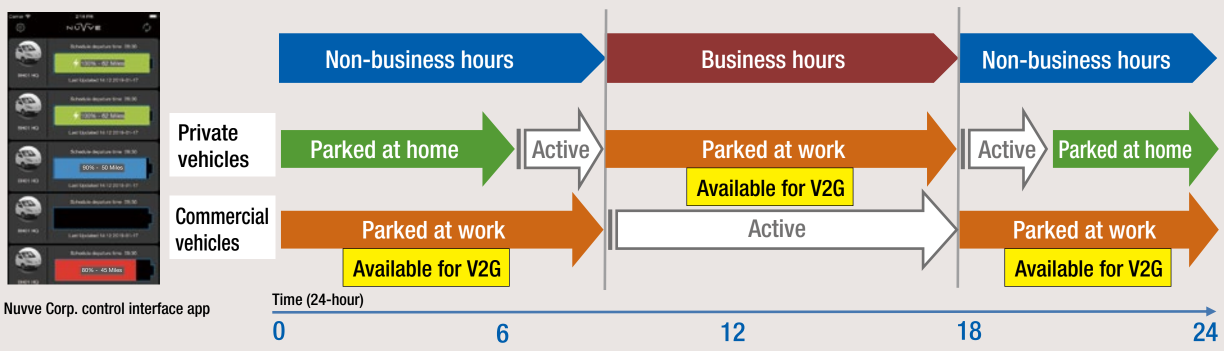
Figure 4



Source: Tohoku Electric Power Co.

Bidirectional Charging Control for Combination of Private and Commercial Vehicles

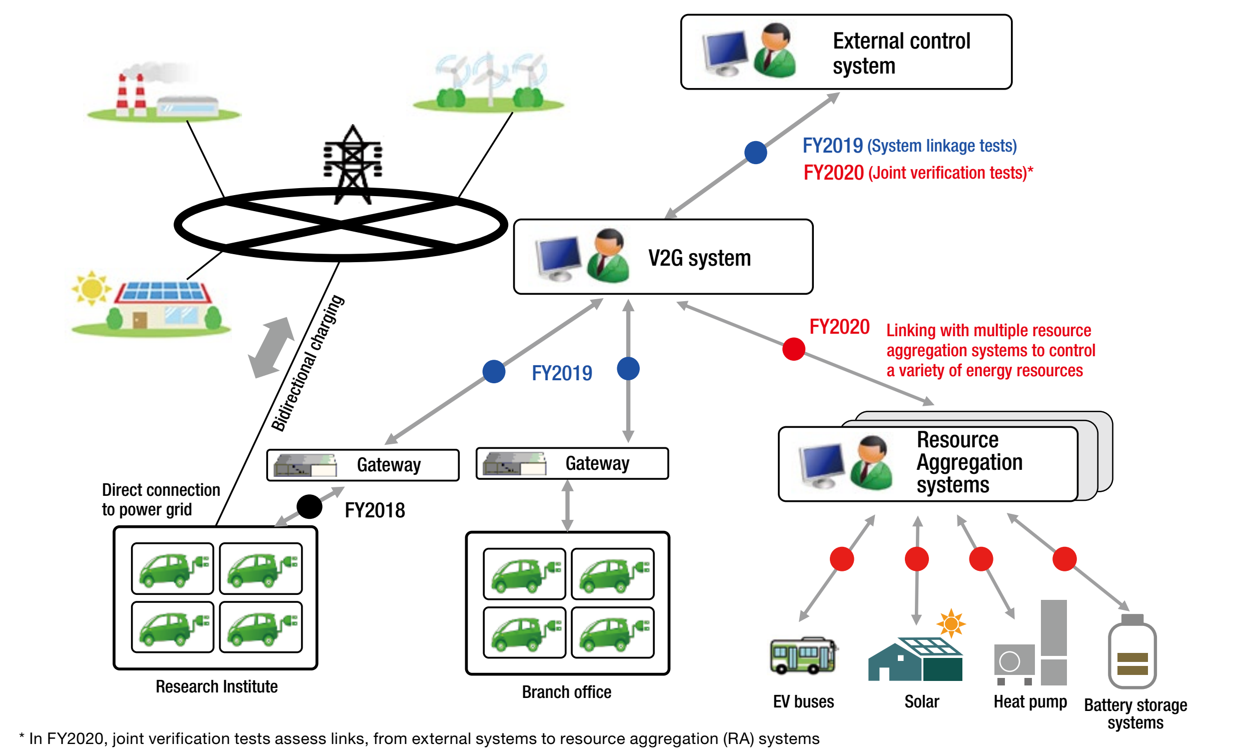
Figure 5



Source: Toyota Tsusho Corporation, Chubu Electric Power Co.

Construction of VPP Incorporating V2G System

Figure6

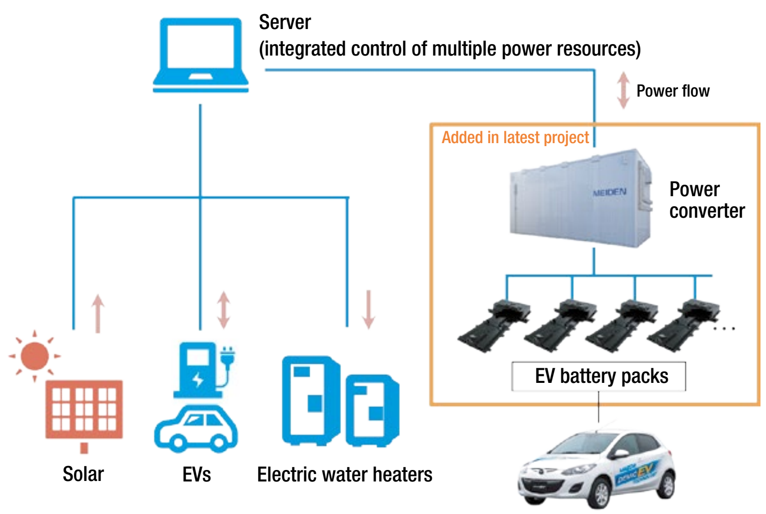


* In FY2020, joint verification tests assess links, from external systems to resource aggregation (RA) systems

Source: Kyushu Electric Power Co.

EV Battery Reuse Verification Tests

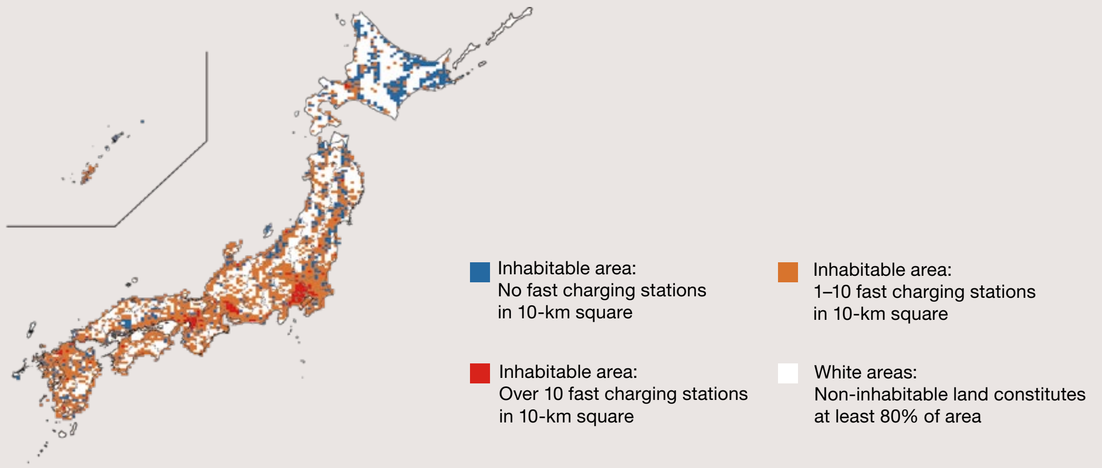
Figure 7



Source: Chugoku Electric Power Co.

EV Charging Station Deployment in Japan

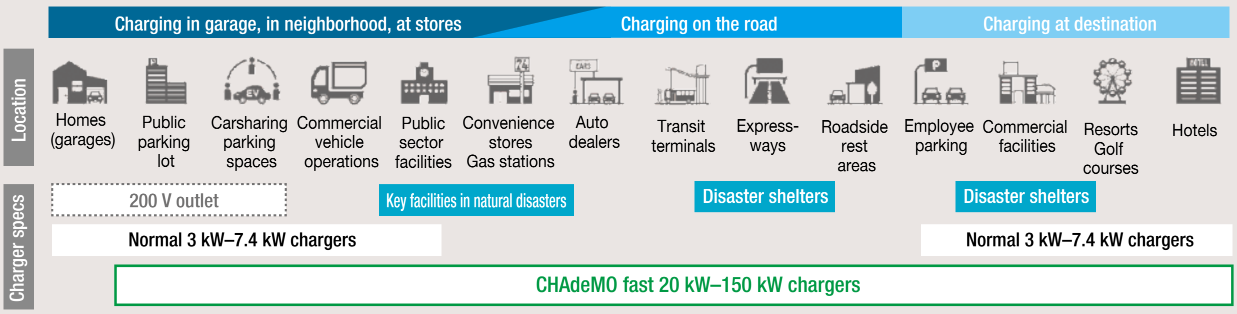
Figure 8



Source: e-Mobility Power Co., Inc. website

EV Charging Service Locations

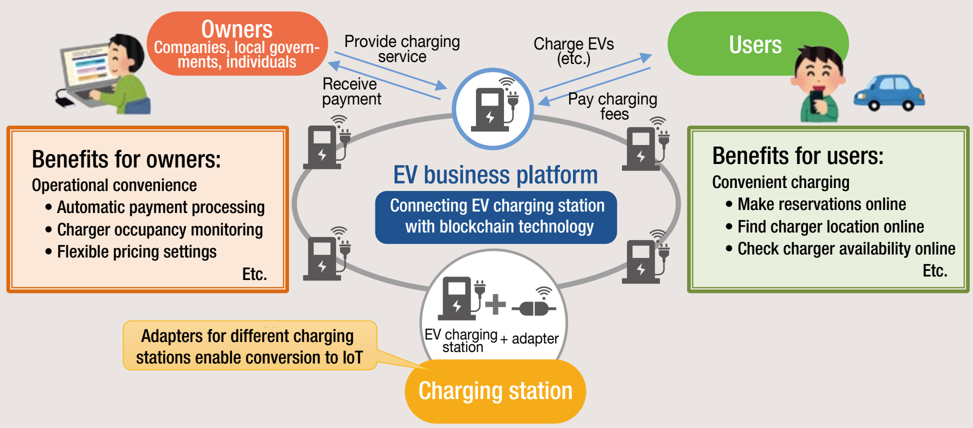
Figure 9



Source: e-Mobility Power., Inc. website

EV Charging Business Platform

Figure 10



Source: Hokkaido Electric Power Co.

STATISTICAL DATA

Electric Power Generation*

[TWh]

FY	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Hydroelectric	90.7	91.7	83.6	84.9	86.9	91.4	84.6	90.1	87.4	86.3
Electric Utilities	74.2	74.4	67.4	68.6	70.3	74.9	81.9	87.9	85.0	84.3
Industry-owned	16.5	17.3	16.3	16.3	16.7	16.5	2.7	2.3	2.4	2.0
Thermal**	771.3	906.9	986.8	987.3	955.4	908.8	877.0	861.4	823.6	792.9
Electric Utilities	553.3	678.5	735.9	743.1	717.8	675.7	794.4	777.5	726.2	696.2
Industry-owned	218.0	228.4	250.8	244.2	237.6	233.1	82.6	83.9	97.4	96.7
Nuclear	288.2	101.8	15.9	9.3	–	9.4	17.3	31.3	62.1	61.0
Electric Utilities	288.2	101.8	15.9	9.3	–	9.4	17.3	31.3	62.1	61.0
Industry-owned	–	–	–	–	–	–	–	–	–	–
Wind Power	4.0	4.7	4.8	5.2	5.0	5.2	5.5	6.1	6.5	6.9
Electric Utilities	0.1	0.2	0.2	0.2	0.0	0.1	5.0	5.5	5.9	6.3
Industry-owned	3.9	4.5	4.7	5.0	5.0	5.1	0.5	0.7	0.6	0.6
Solar	0.0	0.1	0.2	1.2	3.8	6.8	11.1	15.9	18.5	21.4
Electric Utilities	0.0	0.0	0.1	0.1	0.1	0.1	6.5	8.7	10.8	13.2
Industry-owned	0.0	0.0	0.1	1.1	3.7	6.7	4.6	7.2	7.7	8.2
Geothermal	2.6	2.7	2.6	2.6	2.6	2.6	2.2	2.1	2.1	2.1
Electric Utilities	2.5	2.5	2.5	2.4	2.4	2.4	2.2	2.1	2.1	2.0
Industry-owned	0.2	0.2	0.1	0.2	0.2	0.2	0.1	0.1	0.1	0.1
Others	–	–	–	–	–	–	0.3	0.3	0.2	0.2
Electric Utilities	–	–	–	–	–	–	0.3	0.3	0.2	0.2
Industry-owned	–	–	–	–	–	–	–	–	–	–
Total	1,156.9	1,107.8	1,094.0	1,090.5	1,053.7	1,024.2	997.9	1,007.3	1,000.4	970.8
Electric Utilities	918.2	857.4	822.0	823.7	790.6	762.6	907.6	913.2	892.2	863.2
Industry-owned	238.6	250.4	272.0	266.8	263.2	261.6	90.4	94.1	108.2	107.6

*Figures for industry-owned generation represent the total amount generated by power plants with a generating capacity of 1,000kW or above.
*Due to the launch of the licensing system in FY2016, certain operators' electric power generation that had theretofore been counted as for self-consumption has instead been counted as for electricity utilities since FY2016. **Including biomass and waste-to-energy. Source : METI (2010-2019)

Electric Power Consumption

[TWh]

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

FY		2016	2017	2018
Low Voltage	Residential	272.9	280.4	271.4
	Commercial and Industrial	37.9	38.4	37.1
Specified-Scale Demand*	High Voltage	308.3	310.6	307.8
	Extra-High Voltage	231.4	233.8	236.3
Specified Supply**		6.0	6.1	6.3
Self-Consumption		43.2	45.1	37.4
Supplied by Electric Utilities		899.8	914.4	896.2
Power Generated and Consumed by Privately-owend Power Facilities		70.8	70.0	77.2
Total Consumption		970.6	984.3	973.4
Others (Last Resort Supply and Isolated Area Supply)		2.3	2.3	2.3

*This refers to contracted demand supplied by general electricity utilities or specified-scale electricity suppliers at, in principle, 50 kW or more.
**This is a system whereby an electricity supplier directly supplies a recipient with whom it shares a close association in production, capital, etc., without obtaining an electricity retailing license. Source: METI

Installed Generating Capacity*

[MW]

FY	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Hydroelectric	48,111	48,419	48,934	48,932	49,597	50,035	50,058	50,014	50,037	50,033
Electric Utilities	43,849	44,168	44,651	44,676	45,403	45,786	49,521	49,562	49,582	49,635
Industry-owned	4,262	4,250	4,282	4,256	4,194	4,248	536	452	455	398
Thermal**	182,381	185,309	188,903	191,258	193,356	190,805	193,910	193,462	193,026	189,784
Electric Utilities	135,070	136,132	139,794	141,901	143,777	143,040	174,392	173,261	171,469	168,760
Industry-owned	47,312	49,177	49,109	49,357	49,579	47,765	19,517	20,201	21,557	21,024
Nuclear	48,960	48,960	46,148	44,264	44,264	42,048	41,482	39,132	38,042	33,083
Electric Utilities	48,960	48,960	46,148	44,264	44,264	42,048	41,482	39,132	38,042	33,083
Industry-owned	–	–	–	–	–	–	–	–	–	–
Wind Power	2,294	2,419	2,562	2,646	2,750	2,808	3,203	3,483	3,498	3,951
Electric Utilities	85	85	83	82	30	50	2,893	3,091	3,165	3,580
Industry-owned	2,209	2,334	2,479	2,563	2,720	2,758	310	391	332	371
Solar	32	85	267	1,559	4,085	5,624	9,110	12,592	14,974	16,522
Electric Utilities	13	61	65	67	81	87	5,655	7,318	8,922	10,549
Industry-owned	19	24	202	1,492	4,005	5,536	3,455	5,274	6,052	5,973
Geothermal	537	537	512	512	508	517	526	471	473	481
Electric Utilities	502	502	477	477	473	473	511	466	463	463
Industry-owned	35	35	35	35	35	43	15	5	11	18
Others	–	–	–	–	–	–	64	54	43	43
Electric Utilities	–	–	–	–	–	–	64	54	43	43
Industry-owned	–	–	–	–	–	–	0	0	0	0
Total	282,315	285,729	287,327	289,171	294,560	291,836	298,352	299,209	300,093	293,897
Electric Utilities	228,479	229,908	231,219	231,468	234,028	231,484	274,519	272,885	271,685	266,112
Industry-owned	53,836	55,821	56,107	57,703	60,532	60,352	23,834	26,324	28,407	27,785

*Figures represent the total amount generated by power plants with a generating capacity of 1,000kW or above. *Due to the launch of the licensing system in FY2016, certain operators' power generation facilities that had theretofore been counted as for self-consumption have instead been counted as for electric utilities since FY2016.
**Including biomass and waste-to-energy.
Source : FEPC (2010-2015), METI (2016-2019)

Transmission, Substations and Distribution Facilities of General Electricity Transmission and Distribution Utilities (As of March 31, 2020)

Voltage [kV]	Transmission Lines [km]				Substations	
	Route length		Circuit length		Number	Output Capacity [MVA]
	Overhead	Underground	Overhead	Underground		
500	7,954	113	15,423	201	84	225,650
275	7,444	605	14,724	1,512	160	175,705
220	2,617	61	5,027	134	63	39,910
187	2,686	15	5,227	35	39	17,019
110–154	15,516	1,037	28,194	1,985	680	156,756
66–77	38,296	7,418	68,483	13,355	4,470	225,435
≦55	13,545	6,164	14,785	10,161	1,290	9,839
Total	88,059	15,415	151,862	27,385	6,786	850,313

Distribution Lines [km]				Transformers	
Route length		Circuit length		Output Capacity [MVA]	
Overhead	Underground	Overhead	Underground	Overhead	Underground
952,760	43,734	4,038,426	73,420	343,669	35,207

Source : FEPC

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

FY	2011	2012	2013	2014	2015	2016	2017	2018	2019
Peak Load [GW]	156.4	157.2	161.6	154.3	161.2	156.2	157.1	159.7	158.7
Supply Capability [GW]	175.9	176.9	179.5	179.8	184.2	180.4	185.2	178.9	178.4
Annual Electricity Demand [TWh]	926.8	914.7	917.5	898.9	888.2	887.1	892.6	886.9	879.9
Reserve [GW]*	19.5	19.7	17.9	25.6	23.0	24.2	28.1	19.2	19.7
Reserve Margin [%]*	12.5	12.6	11.1	16.6	14.3	15.5	17.9	12.0	12.4
Load Factor [%]**	67.4	66.4	64.8	66.5	62.9	64.8	64.9	63.4	63.3

* 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 (2011-2014), OCCTO (2015-2019)

Summarized Comparative Table Classified by Country for the Year 2018

	USA	UK	France	Germany	Russia	China	India*	Japan
Total Installed Capacity [MW]	1,202,093	82,909	132,889	215,046	271,600	1,900,120	400,701	300,093
Hydroelectric	100,315	4,363	25,510	10,342	51,300	352,590	45,358	50,037
Thermal	834,581	50,274	18,588	83,170	190,200	1,144,080	276,294	193,026
Nuclear	107,816	9,261	63,130	9,516	29,100	44,660	6,780	38,042
Renewables and others	159,380	19,010	25,661	112,019	–	358,790	72,269	18,988
Total Energy Production [GWh]	4,176,489	332,776	548,600	643,450	1,115,000	6,994,700	1,490,293	1,000,409
Hydroelectric	286,596	7,942	68,300	17,975	193,000	1,232,100	126,271	87,398
Thermal	2,636,575	155,164	39,400	315,839	716,000	4,924,900	1,217,575	823,589
Nuclear	806,752	65,064	393,200	76,005	205,000	295,000	38,346	62,109
Renewables and others	446,565	104,605	47,700	233,631	1,400	542,820	108,101	27,311
Capacity Factor [%]	–	36.7	47.0	34.2	–	44.3	61.1	–
Total Energy Production per Capita [kWh]	12,766	5,022	8,470	7,772	7,591	5,013	1,161	7,906
Domestic Energy Supplies [GWh]	4,207,154	333,078	478,450	–	1,108,100	5,950,800	–	–
Energy Sales [GWh]	3,859,186	278,835	–	445,188	–	5,577,700	1,123,427	852,560
Number of Customers [At year-end; thousand]	153,339	31,012	–	–	–	589,449	277,922	87,620
Maximum Demand [MW]	779,578	50,411	96,600	79,074	151,900	–	177,022	164,820
Annual Load Factor [%]	60.0	68.8	56.4	–	79.3	–	–	62.1
Thermal Efficiency [%]	–	34.1	–	44.3	40.1	39.9	–	–
Loss Factor (Transmission and Distribution) [%]	5.2	8.0	7.6	–	–	6.3	21.0	–
Total Consumption per capita [kWh]	–	4,533	6,827	6,305	6,842	4,945	875	7,693

*Figures other than Capacity Factor and Maximum Demand are the actual values for 2017. 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.

Recent Overseas Activities of Member Companies

North and South America

Company	Project	Location	Type	Capacity [MW]	Equity [%]	COD
Hokkaido	PV project in Mexico	Mexico	PV	290	12	2018
Kansai	Aviator	USA	Onshore Wind	525	48.5	2020
Chugoku	South Field Energy	USA	CCGT	1,182	10	2021
Shikoku	Huatacondo	Chile	PV	98	30	2019
Shikoku	South Field Energy	USA	CCGT	1,182	9	2021
Kyushu	Westmoreland Gas-fired Power Plant	USA	CCGT	940	12.5	2018
J-POWER	Wharton	USA	PV	350	25	2022
J-POWER	Refugio	USA	PV	400	25	2023

Europe

Company	Project	Location	Type	Capacity [MW]	Equity [%]	COD
Tokyo	Zenobe	UK	Battery Storage	73	5	2019
Tokyo	Dariali Hydro Power Plant	Georgia	Hydro	108	31	2020
Chubu	Offshore Transmission Business	Germany	Transmission	2,810	12	2017
Chubu	Offshore Transmission Business (Walney Extension)	UK	Transmission	–	20	2020
Chubu	Acquisition of 20% shares of Eneco Group	Netherlands	Integrated Energy Business	–	20	2020
Kansai	Moray East	UK	Offshore Wind	952	10	2022
Kansai	Electricity North West	UK	Distribution	–	22	–
Kansai	Piiparinmaki	Finland	Onshore Wind	211	15	2021
Kyushu	Data Collection Survey of Energy Sector for Decarbonization	Serbia	Consultation	–	–	2019

Asia

Company	Project	Location	Type	Capacity [MW]	Equity [%]	COD
Tohoku	Rantau Dedap Geothermal Power Plant Project	Indonesia	Geothermal	98	10	2021
Tohoku	Nghi Son 2 BOT Thermal Power Plant Project	Vietnam	Coal (SC)	1,200	10	2022
Tokyo	Coc San Hydro Power Plant	Vietnam	Hydro	30	33	2018
Tokyo	Deep C Industrial Park	Vietnam	Distribution and Retail	–	50	2018
Tokyo	TEPCO Energy Partner International (Thailand)	Thailand	Proposal of saving energy and CO_2	–	49	2019
Chubu	Power Distribution and Retail Sales business for New Clark City	Philippines	Distribution and Retail	–	9	2019
Kansai	New Clark City	Philippines	Distribution and Retail	–	9	2019
Chugoku	Ahlone	Myanmar	CCGT	121	28.5	2013
Chugoku	Revision of Power Development Master Plan	Cambodia	Consultation	–	–	2019–2020
Chugoku	Yunlin	Taiwan	Offshore wind	640	3.375	2021
Shikoku	Batang Toru 3	Indonesia	Hydro	10	15	2020
Shikoku	Yunlin	Taiwan	Offshore Wind	640	4.4	2021
Shikoku	Hamriyah	UAE	CCGT	1,800	15	2023
Kyushu	Sarulla/Geothermal IPP	Indonesia	Geothermal	330	25	2017
Kyushu	Taweelah B IWPP	United Alab Emirates	IWPP	2,000	6	2020
J-POWER	CBK (3 projects)	Philippines	Hydro	728	50	2001–2004
J-POWER	Nong Seang	Thailand	CCGT	1,600	60	2014
J-POWER	U-Thai	Thailand	CCGT	1,600	60	2015

Others

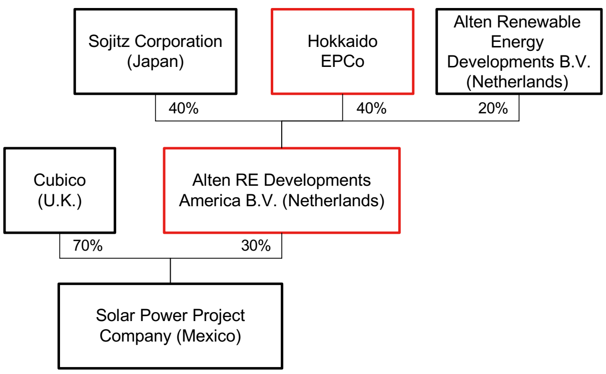
Company	Project	Location	Type	Capacity [MW]	Equity [%]	COD
Chubu	Project for Improvement of Energy Loss Reduction on Distribution Network	Mozambique	Technical Cooperation	–	–	2020
Okinawa	Project for Introduction of Hybrid Power Generation System in Pacific Island Countries	Fiji, Tuvalu, Kiribati, Federated States of Micronesia (FSM) and Republic of the Marshall Islands (RMI)	ODA	–	–	2017-2022

Participation in Solar Power Project in Mexico (2020-)

Hokkaido Electric Power Co., Inc. (HEPCO) is participating in the operation of solar power plant in Mexico through an equity stake in Alten RE Developments America B.V., which invests in soar power businesses.

- **Project Summary**
  Power generated by a 290MW solar power plant in Aguascalientes in western-central Mexico is sold mainly to a wholly owned subsidiary of Comisión Federal de Electricidad under a long term power purchase agreement.

- **HEPCO's Role**
  Contribute to project by leveraging strengths such as experience in overseas technical consultation, insights gained from renewable energy power plant maintenance/operation in Hokkaido, and technical expertise cultivated from self-developed remote monitoring system.



- **Solar Power Project Companies**
  Cubico Alten Aguascalientes Uno (Project 1)
  Cubico Alten Aguascalientes Dos (Project 2)

- **Capacity**
  290MW
  - Project 1 : 150MW
  - Project 2 : 140MW

- **HEPCO's equity**
  HEPCO, through its equity stake in Alten RE Developments America B.V., owns a 12% stale in the solar power project company, which is partially owned by Alten RE Developments America B.V.

Tohoku Electric Power Co.

Rantau Dedap Geothermal Power Plant Project

Conceptional Drawing

➢ Purpose

Expecting stable long term revenue by dispatching electricity to PLN based on 30-years' PPA.

➢ Facilities

Location	South Sumatera, Indonesia
Type	Geothermal
Capacity	98MW (49MW×2units)
Equity	10%
COD	2021

➢ Special Notes

We have dispatched our engineer to contribute to stable operations using more than 40 years O&M experience on our domestic geothermal power plants.

Nghi Son 2 BOT* Thermal Power Plant Project

* BOT :Build Operate and Transfer

Note) Plan to cover the coal yard with shades entirely

Conceptional Drawing

➢ Purpose

Expecting stable long term revenue by dispatching electricity to EVN based on 25-years' PPA.

➢ Facilities

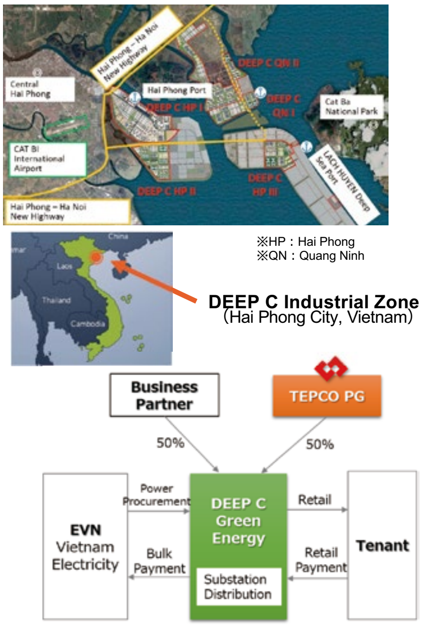
Location	Thanh Hoa province, Vietnam
Type	Coal (Supercritical)
Capacity (net)	1,200MW (600MW×2units)
Equity	10%
COD	2022

➢ Special Notes

We contribute to stable operations and reduction of environmental load using more than 60 years O&M experience on our domestic coal-fired power plants.

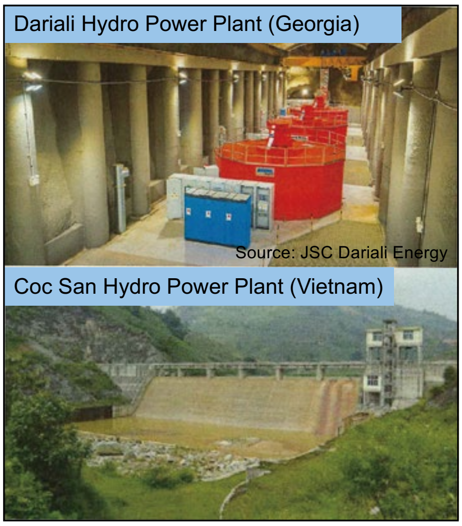
Tokyo Electric Power Company Holdings

TEPCO PG's first investment in the Distribution/ Retail business in Vietnam (2018)



- **Purpose**
  - TEPCO PG is pursuing global business expansion, by leveraging technologies and Know-How for facility planning, operation and maintenance
- **Business Summary**
  - Power Distribution and Retail in DEEP C Industrial Zone.
  - TEPCO PG will be mainly in charge of engineering and facility (Substation, Distribution) construction.
- **Investment Ratio**
  - TEPCO PG 50%
  - Infra Asia Investment 50%
- **Other Features**
  - DEEP C Industrial Zone is first established in 1997, located in Hai Phong City, Vietnam, with a total area of 3,400ha

Investment for the Hydro power plant (2018, 2020)

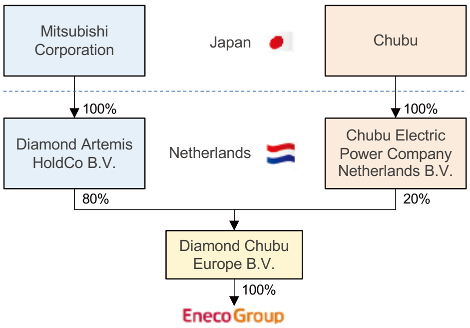


- **Purpose**
  - Improve operation and maintenance, utilizing TEPCO's expertise of plant operation
- **Dariali HPP Features**
  - 108MW
  - COD: December 2016
  - 15 years PPA
- **Coc San HPP Features**
  - 29.7MW
  - COD: April 2016
  - 20 years PPA

Chubu Electric Power Co.

Integrated Energy Company “Eneco” in Netherlands

Chubu Electric Power Co., Inc. (Chubu) acquired 20% of shares in the integrated energy company “Eneco” in March 2020.



➢ Basic data for Eneco

	As of the end of 2019
Total assets	720 billion yen
Amount of sales	510 billion yen
Profit after tax	9.6 billion yen
ROA, ROE	1.3%, 2.7%
Number of employees	About 3,000 FTE※

※ full time equivalent　　120 JPY/EUR

➢ Purpose of investment
- Chubu regards Eneco as a platform for electric power business in Europe.
- Chubu will expand its business domain in renewables, retail sales and new services by combining its accumulated expertise in energy sector with Eneco’s unique strengths.

JICA Technical Cooperation Project in Mozambique

JICA Project for Improvement of Energy Loss Reduction on Distribution Network
(March 2020 to March 2023)

Site survey* on power distribution facilities with EDM engineers

*conducted in the Project for "Integrated Master Plan on Mozambique Power System Development" in the Republic of Mozambique (2016 to 2018)

➢ Overall Goal/ Project Purpose
Electricidade de Moçambique (EDM) will implement planning, design and O&M for technical and non-technical power distribution losses reduction including human resource development based on the improved capabilities of EDM staff.

➢ Activities on this Project
To achieve the above, Chubu Electric Power Co., Inc. conducts following activities with EDM engineers;
(1) Trainings to EDM staff so as to acquire necessary knowledge for planning, design and O&M for distribution loss reduction,
(2) Pilot projects to improve practical capacities to reduce power distribution losses, and
(3) Creation of guidelines, standards and manuals on practical works related to distribution loss reduction/ Formulation of an action plan to proceed power distribution loss reduction approaches.

Kansai Electric Power Co.

Aviator Onshore Wind Farm Project

- Location
  - Coke County, Texas, USA
- Facilities
  - Onshore Wind Power Generation
  - Name: Aviator Wind Farm
  - Number of Turbines: 191
  - Total Power Output: 525MW
- Partners
  - The Kansai Electric Power CO., Inc. (KPIC USA, LLC) : 48.5%
  - AIP (Ares Infrastructure and Power) Funds : 0.5%
  - CMS Energy Corporation : 51%

Chugoku Electric Power Co.

Participation in hydroelectric power generation in Indonesia (March 2019)

- Purpose
  - Contribute to achieving a low-carbon society.
  - Achieve stable profitability through a long-term electric sales contract.
  - Utilize our knowledge and experience of hydroelectric power generation.
- Features
  - Project: Pakkat hydropower plant
  - Location: Humbang Hasundutan Regency, North Sumatra Province
  - Capacity: 18MW (Run-of–river type)
  - COD: April 2016
  - Off-taker / Period: PT. PLN (PERSERO) (Indonesian state-owned electric power company) / 30 years
  - Chugoku EPCO's Equity Share: 25%

Participation in natural gas fired power generation in the US (May 2018)

- Purpose
  - Secure stable profits by the combination of fixed revenue under a capacity contract with a local electricity company and merchant energy revenue from the sale of energy in the wholesale power market.
- Features
  - Project: Kleen Energy Systems, LLC
  - Location: Middletown, Connecticut
  - Capacity: 620MW (CCGT: Combined Cycle Gas Turbine)
  - COD: July 2011
  - Market: ISO New England
  - Chugoku EPCO's Equity Share: 16.2%

Kyushu Electric Power Co.

Westmoreland Gas-Fired Power Project in USA

Supplying electricity to the north-eastern part of the United States through PJM since 2018

- Purpose
  - Achieving equity ownership of 5,000MW
- Facilities
  - Project Site
    Westmoreland, Pennsylvania (USA)
  - Commercial Operation
    Since 2018
  - Generation Capacity
    940MW
  - Generation Type
    Natural gas combined cycle
  - Key Equipment
    MHPS gas turbine (501J)
  - Fuel Supply
    Shale gas from gas fields in USA

Microgrid project in the Philippines

Implementing renewable energy sources and providing technical support since 2020

- Purpose
  - Supply of environmental-friendly energy
  - Expansion of PowerSource's microgrid business
- Features
  - Project Site
    Rio Tuba, Liminangcong, Rizal Port Barton, Manamoc, Poblacion Malapascua
  - Commercial Operation
    Since 2005
  - Generation Capacity
    100kW - 2,100kW
  - Generation Type
    Diesel generation (PV + Battery will be implemented in the future)

Okinawa Electric Power Co.

JICA Technical Cooperation Project in Pacific Island Countries

JICA Project for Introduction of Hybrid Power Generation System in Pacific Island Countries

- Objectives
  - To promote introduction of hybrid power generation system
- Period
  - From 2017 to 2022
- Countries
  - Fiji, Tuvalu, Kiribati, Federated States of Micronesia (FSM) and Republic of the Marshall Islands (RMI)
- Trainees
  - Engineers of utility companies
  - Government officers (Energy sector)
- Content
  - Training on O&M of diesel engine generators and RE generation systems
  - Lectures on grid integration of RE generation systems
- Background of the project
  - The project is commissioned by JICA to a consortium comprised of Okinawa Enetech and OEPC.

J-POWER

Jackson CCGT Project in US

Development of high efficiency CCGT plant close to Chicago, Illinois

Location of the Jackson power plant

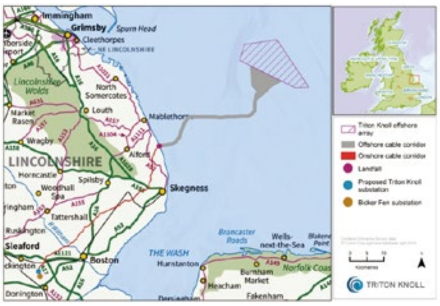
Rendering of the Jackson power plant

- Features
  - Second greenfield development project in US by J-POWER
  - J-POWER's 12th project in US, 5th in PJM
  - Located close to high power demand area, Chicago
  - Scheduled to sell power through PJM market
- Overview
  - Capacity: 1,200 MW (600 MW x 2 units)
  - Fuel: Natural Gas
  - Technology: CCGT
  - Equity Owner: J-POWER 100%
  - Status: Under Construction
  - Construction Start: 2019
  - Commercial Operation: 2022

Triton Knoll Offshore Wind Farm Project in UK

Development of a large scale offshore wind farm off North Sea, east of England

Location of the Triton Knoll Offshore Wind Farm



- Features
  - First overseas offshore wind project among Japanese Power Utilities
  - Participated in September 2018
  - Located in the North Sea region east of England, known as area with optimum wind conditions for wind power generation
  - Qualified for CfD (Contracts for Difference) regime of UK, which guarantees 15 years of stable revenue after commencement of operation
- Overview
  - Capacity: 857 MW (approx.9.5 MW x 90 units)
    *Owned Capacity: 214 MW
  - Equity Ownership: J-POWER 25%
  - Status: Under Construction
  - Construction Start: 2018
  - Commercial Operation: 2021

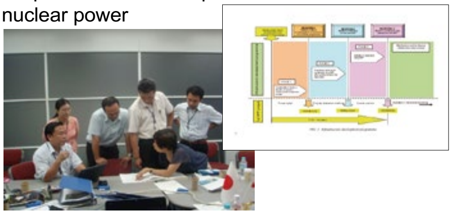
The Japan Atomic Power Co.

Fostering of human resources

JAPC can offer a comprehensive range of education and training depending on each country's need.
So far, we have provided education for approximately 23 countries, 560 people.
In addition, we can support FS for NPP introducing based on our experiences.

Tokai Training Center

Preparation of master plan for introduction of nuclear power



Nuclear power plant simulator

Pump disassembly and inspection

Radiation measurement

Member Companies Data (As of March 31,2020) *

	FY 2019			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 EPCo	114,291	748,468	23,701	1,651	4,469	2,070	–	8,191
Tohoku EPCo	251,441	2,246,369	67,167	2,556	11,949	2,750	243	17,498
TEPCO HD	1,400,975	6,241,422	222,277	9,874	–	8,212	51	18,137
Chubu EPCo	430,777	3,065,954	122,542	5,459	–	3,617	39	9,115
Hokuriku EPCo	117,641	628,039	25,054	1,961	4,565	1,746	–	8,272
Kansai EPCo	489,320	3,184,259	112,992	8,234	15,766	6,578	11	30,590
Chugoku EPCo	197,024	1,347,352	50,208	2,905	7,801	820	6	11,532
Shikoku EPCo	145,551	733,187	22,396	1,152	3,395	890	2	5,439
Kyushu EPCo	237,304	2,013,050	70,398	3,580	9,985	4,140	208	17,913
Okinawa EPCo	7,586	204,296	7,316	–	2,145	–	2	2,147
J-POWER	180,502	913,775	–	8,560	8,173	–	535	17,269
JAPC	120,000	99,617	–	–	–	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

Note: The existing thermal power generation businesses of Tepco Fuel & Power, Inc. (a subsidiary of TEPCO HD) and Chubu Electric Power Co., Ltd. were integrated into JERA Co., Inc. on April 1, 2019.

JERA	5,000	3,280,000	–	–	65,476	–	–	65,476

Source: Compiled from JERA's website and financial results briefing handouts, and the Agency for Natural Resources and Energy's electrical power survey statistics

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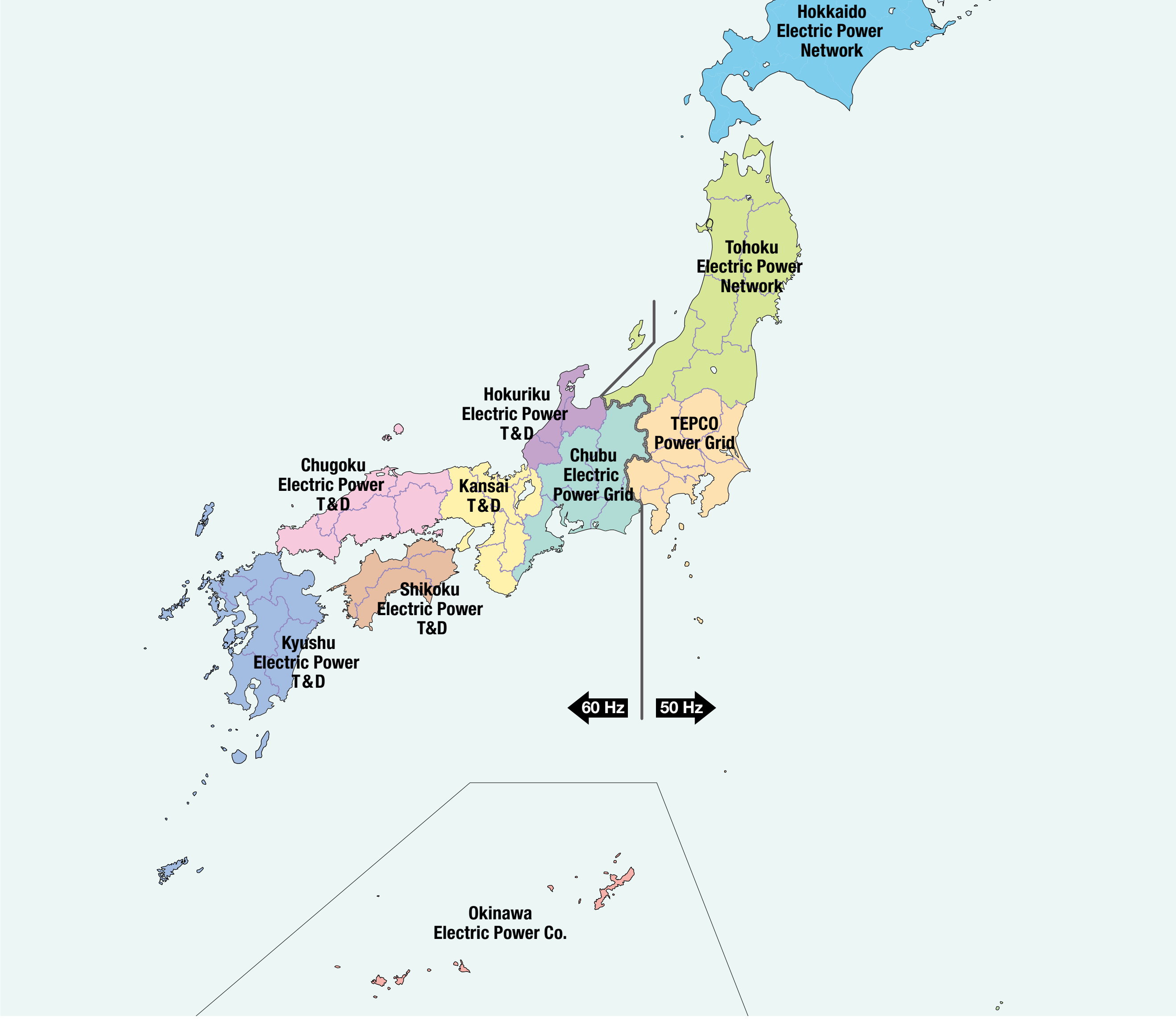
Distribution Areas and Frequency of General Electricity T&D Utilities
(As of February 2021)



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