The Electric Power Industry in JAPAN 2022

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 September 17, 2021, 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 986 (as of June 30, 2021), 49 (August 26), and 730 (August 25), respectively.

- The government agency responsible for overseeing Japan's electric utilities is the Agency for Natural Resources and Energy. The Organization for Cross-regional Coordination of Transmission Operators (OCCTO) nationally monitors conditions such as the supply/demand situation and grid operational status, and formulates cross-regional grid development plans.

II. ENERGY AND ENVIRONMENTAL POLICY

- The Prime Minister announced in October 2020 the goal of making Japan carbon neutral by 2050. In April 2021, the Prime Minister also declared that Japan would seek to reduce its greenhouse gas emissions by 46 percent in fiscal 2030 from its fiscal 2013 levels, and would thereafter further strive toward 50%.

- To lay out the path to realizing these goals, the Cabinet approved the Sixth Strategic Energy Plan in October 2021. Under the philosophy of S+3E (safety, energy security, economic efficiency, and environment), the electricity sector will strive toward its 2030 commitments by working to make renewable energy the main source of power generation, restart nuclear power plants with top priority placed on safety, and reduce dependence on thermal power generation as much as possible, including by phasing out inefficient thermal power generation.

- Prior to the March 2011 Fukushima Daiichi Nuclear Power Plant accident, Japan had 57 nuclear reactors in operation. All were provisionally shut down in 2014. While there is anticipation for their return to service, 24 have been selected for decommissioning. Of the remaining 36 (including three under construction), 17 have received approval of their applications for change of installation under the New Regulatory Requirements (i.e., have been confirmed as compliant with those requirements). Ten are currently back in operation.

- 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. As part of the changes, a feed-in premium scheme that adds premiums to the market prices of large-scale commercial solar and certain other power sources will go into effect in April 2022.

- In fiscal 2019, Japan's GHG emissions measured 1,212 million tons (CO_2 equivalent), and emissions of CO_2 accounted for 91.4% of this total, down 15.9% from the fiscal 2013 level. In December 2020, the government released the Green Growth Strategy as a roadmap toward achieving carbon neutrality in 2050.

III. SUPPLY AND DEMAND

- In fiscal 2020, electricity demand[1] in Japan was 863.2 TWh (down 1.6% YoY) and peak national demand came to 159.2 GW (up 0.3 YoY).

- In fiscal 2020, electric power generated[2] in Japan came to 845.4 TWh (down 2.1% YoY), of which 16.2 TWh was generated by solar power and 7.6 TWh by wind power.

IV. ELECTRIC POWER FACILITIES

- Total generating capacity in Japan came to 312.8 GW at the end of fiscal 2020. This consisted of 51.1% thermal power (14.7% coal, 26.9% LNG, and 9.5% oil), 10.6% nuclear power, 15.7% hydro, and 22.5% renewables (excluding hydro). Development of 20.9 GW of generating capacity is planned to be completed by fiscal 2030. This consists of 5.05 GW of thermal power, 5.3 GW of renewables (excluding hydro), and 10.3 GW of nuclear power.

- As of the end of March 2021, smart meters had been installed at all extra-high voltage and high voltage customers and at 85.7% 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 Act for Establishing Energy Supply Resilience in June 2020, 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

- The number of registered electricity retailers has continued to rise since the full liberalization of the retail electricity market in April 2016, reaching 730 retailers as of August 2021. As of March 2021, PPPs accounted for a 19.5% share of the total volume of electricity sold. PPSs also held 20.2% of sales to households and other low voltage customers.

- The volume of trades on the JEPX spot market has been on the rise, reaching 312.8 TWh (equivalent to more than 30% of all electric power sold nationwide) in fiscal 2020. The average system price has hovered around 7-9 yen/kWh since fiscal 2015. Prices fell in April 2020 as demand dropped from the impact of measures against COVID-19. Later in the year, prices skyrocketed from the effects of a summer heat wave and from a supply crunch in the winter that was driven by fuel procurement. As a result, the average system price of supply for fiscal 2020 as a whole was 11.21 yen/kWh.

- A baseload trading market was created in fiscal 2019. A total volume of 332.1 MW was sold for delivery in fiscal 2021, with clearing prices ranging from 6.06 to 9.19% 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.

- A balancing market began operating in April 2021 for Replacement Reserve for FIT (balancing capacity with a long response time that balances errors in renewable energy predictions). There are plans to successively add other products traded in this market.

- The non-fossil value trading market was launched in 2018. It will be divided into two markets in 2021 or later: one trading in non-fossil value from FIT electricity, and another trading in non-fossil value from non-FIT electricity.

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.

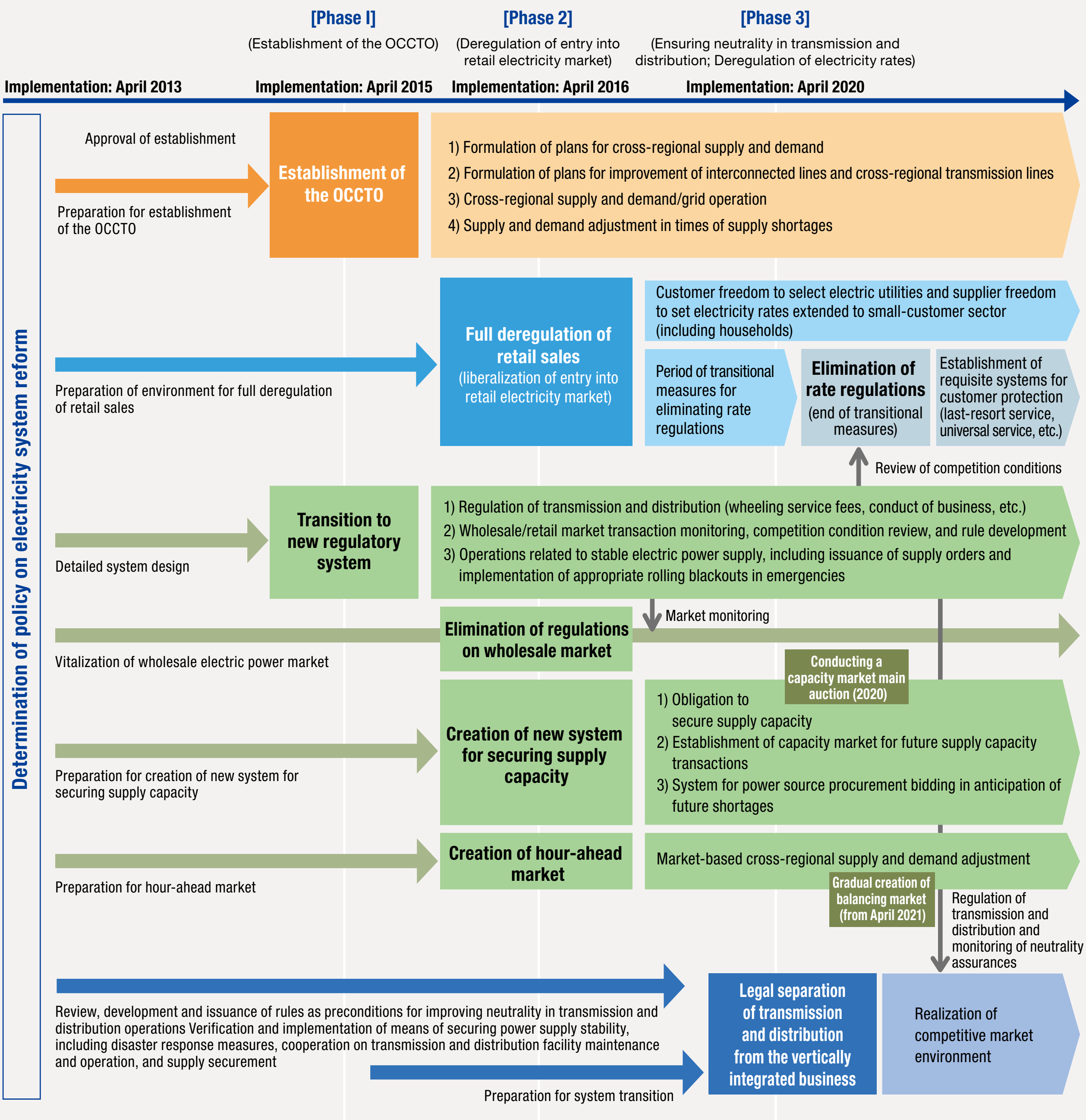
(3) Electricity System Reform

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.

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

Roadmap to Electricity System Reform

Figure 1.1



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

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 "1. Electricity Rates" in 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 is underway in markets (1), (2), and (4). Market (4) is scheduled to be split into two markets in fiscal 2021, a market for achieving the target mandated by the Act on Sophisticated Methods of Energy Supply Structures, and a renewable energy value trading market (see "3. Trading Markets" in Chapter V). Trading in certain products commenced in (3) in April 2021, and will be gradually expanded to other products.

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" (Figures 1.2 and 1.3).

Data show that 986 entities had obtained power generation licenses in the electricity generation sector as of June 30, 2021, and generating capacity was 270 GW[1] as of March 2021. 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.

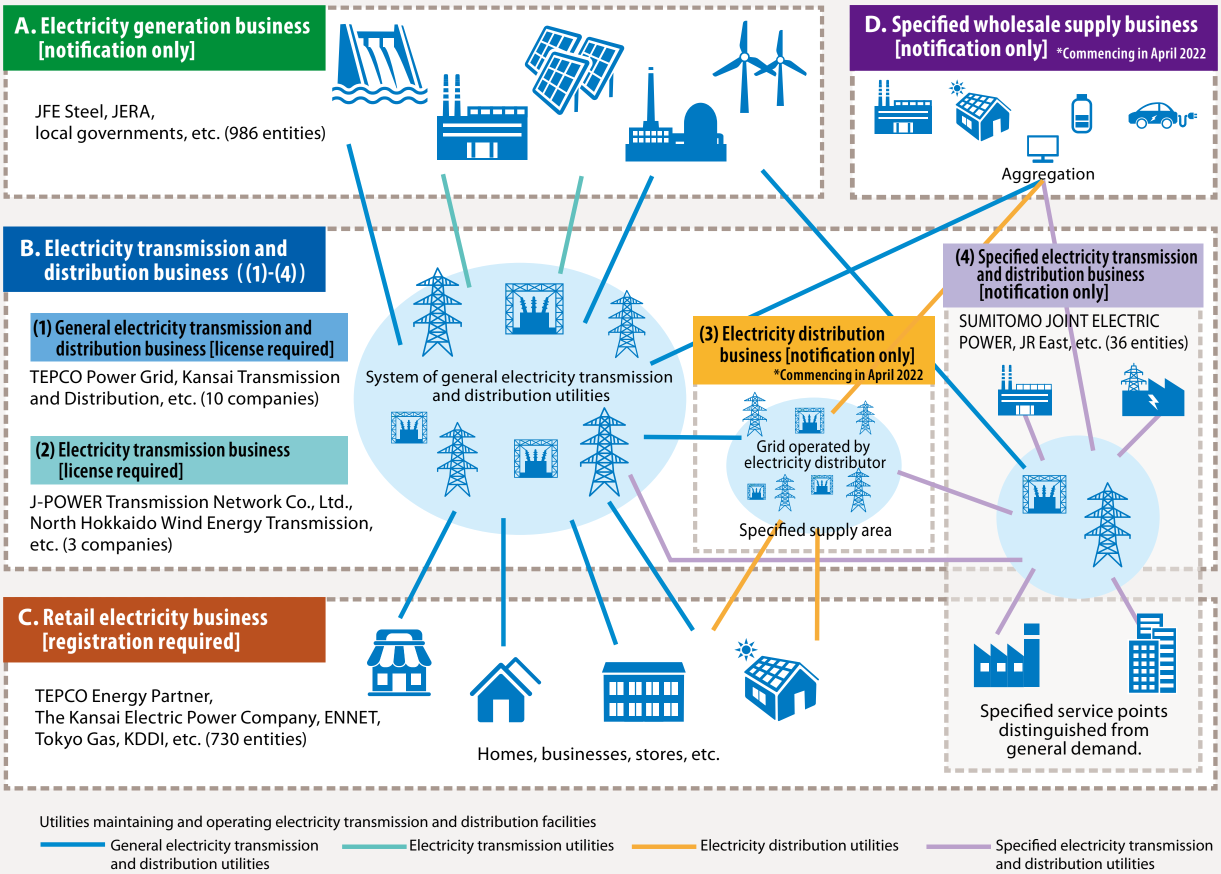
In the transmission and distribution sector, a total of 10 utilities (the 9 utilities spun out from the former general electricity utilities other than Okinawa Electric Co., and Okinawa Electric Co.) have been conducting business as general electricity transmission and distribution utilities. Three other companies, including J-POWER Transmission Network Co., Ltd., are conducting business as electricity transmission utilities. In addition, 36 corporations (as of August 26, 2021), including Sumitomo Joint Electric Power Co., Ltd., are operating as specified electricity transmission and distribution utilities.

In the electricity retail sector, data released by METI's Agency for Natural Resources and Energy show that a total of 730 entities had obtained retail licenses (as of August 25, 2021). 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

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)"

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.

utilities. Net system energy demand in fiscal 2020 came to 821 TWh, of which former general electricity utilities accounted for about 81%.

Amidst the spread of distributed energy resources (DER), the Electricity Business Act was partially revised by the Act for Establishing Energy Supply Resilience enacted in June 2020. The revisions included licensing provisions regarding the (1) specified wholesale supply business and the (2) electricity distribution business. Also known as aggregators, (1) licensees aggregate and adjust the electricity of many DER, including through demand response, and supply the electricity to electricity retailers and other buyers. (2) Licensees balance electricity supply and demand and engage in other distribution operations in a specified area, using the distribution grid of a general transmission and distribution utility. These businesses will begin operating in April 2022. (For more information on (b), see "2. (5) Efforts to Improve Resilience and Increase Use of Renewables in Power Transmission and Distribution Sector" in Chapter IV.)

(2) Regulatory Organizations

a. Agency for Natural Resources and Energy

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

b. Electricity and Gas Market Surveillance Commission

The Electricity and Gas Market Surveillance Commission was established in September 2015—as a separate entity from the Agency for Natural Resources and Energy directly reporting to the Minister of Economy, Trade and Industry—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, design in detail, and run both a capacity market and a balancing market.
- To study the efficient use of electricity transmission and distribution facilities ("connect and manage").
- To check the content of disaster response coordination plans and operate a mutual assistance system for disaster recovery costs.*
- To formulate cross-regional network development plans and submit them to the government.*
- To grant subsidies related to the feed-in tariff (FIT) scheme for renewable energy and grant premiums related to the feed-in premium (FIP) scheme.*
- To manage the reserve fund for the disposition of solar panels and other hardware components.*

*New functions added in conjunction with the June 2020 enactment of the Act for Establishing Energy Supply Resilience..

II. ENERGY AND ENVIRONMENTAL POLICY

1. Strategic Energy Plan

In October 2020, the Japanese government announced its goal of making Japan carbon neutral by 2050. This was followed in December by the government's unveiling of the "Green Growth Strategy Through Achieving Carbon Neutrality in 2050," which lays out a vision for achieving carbon neutrality by setting high targets for 14 growth industries and by implementing a comprehensive set of policies. In April 2021, the government declared that it would seek to reduce greenhouse gas emissions in fiscal 2030 by 46% from the level in fiscal 2013, and thereafter further strive toward 50%. To lay out the path to realizing these goals, the Cabinet approved the Sixth Strategic Energy Plan.

The Plan looks back at the actions taken over the ten years that followed the Fukushima Daiichi Nuclear Power Plant accident (hereafter, "Fukushima Daiichi accident") and underscores the government's duty to carry the disaster area's reconstruction process to completion. The Plan also lays out two other key focuses: responding to climate change, and tackling the challenges associated with Japan's energy supply and demand structure. The basic concept of the Plan is to achieve what are referred to as the "S+3E"—namely, striving for energy security in way that gives top priority to safety and balances both economic efficiency and environmental protection.

The Plan maps out the challenges and actions for achieving carbon neutrality in 2050, as well as government policy measures to be implemented towards 2030 based on those challenges and actions.

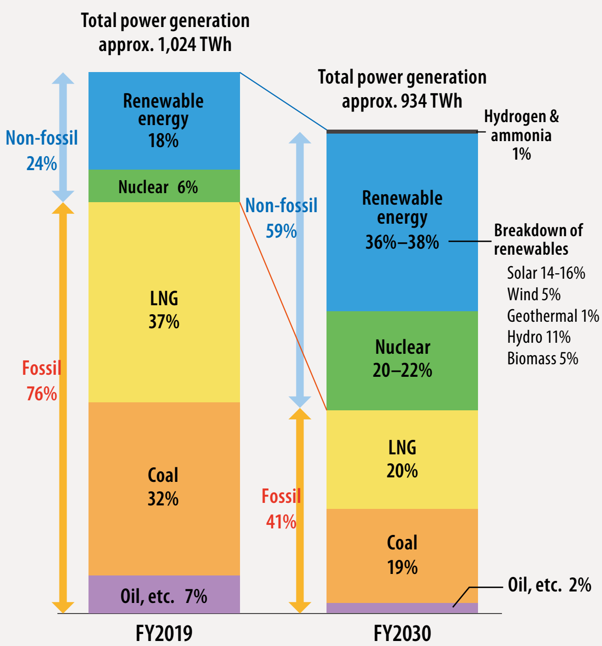
(1) Challenges and Actions for Achieving Carbon Neutrality in 2050

The Plan emphasizes the importance of securing a stable and affordable supply of energy while giving top priority to ensuring safety. Working from this premise, it calls for steady implementation of decarbonization efforts for achieving the goal of carbon neutrality in 2050, using currently practical decarbonized electric power sources. It also advocates maximizing the adoption of renewable energy, under the principle of giving top priority to shifting to renewables as the main energy source. At the same time, it looks beyond currently practical decarbonization technologies to pursue new options that need to be innovated, such as hydrogen/ammonia power generation, or thermal power generation founded on carbon storage and reuse through CCUS (see "1. (2) Future Plans" in Chapter IV).

(2) Policy Measures towards 2030

The following goals are set for the S+3E concept: (1) regarding energy security, an improvement in energy self-sufficiency to approximately 30%); (2) regarding economic efficiency, a reduction of costs in the face of an anticipated increase in surcharges arising from widening adoption of renewables; (3) regarding the environment, the pursuit of, among other greenhouse gas reduction targets, a reduction of energy-related CO_2 emissions by approximately 45%; and (4) regarding safety, action to increase the safety of nuclear power.

Power Generation Mix in Fiscal 2030 — Figure 2.1



Source: METI, "Energy Supply and Demand Outlook for FY2030" (2021)

According to the Plan's outlook for energy supply and demand in fiscal 2030, electricity demand will be contained at 864 TWh despite anticipated economic growth by pursuing thoroughgoing energy (electric power) conservation efforts. Regarding the power generation mix, the Plan aims to realize a well-balanced mix that enables simultaneous achievement of the S+3E by making renewables the main power source, restarting nuclear power plants with top priority placed on safety, and reducing dependence on thermal power generation as much as possible. Specifically, the energy mix (in terms of electric power generated) in fiscal 2030 will be raised the share of renewables from the previous Plan's target of 22%–24% to 36%–38% (the actual level in fiscal 2019 was 18%), while nuclear power's contribution will be kept at 20%–22%. The share of thermal power will be minimized as much as possible by steadily phasing out inefficient coal-fired generation, while retaining the installed capacity needed to provide a supply capacity capable of countering momentary or sustained drops in electricity generation from renewables. Specifically, the Plan aims to reduce dependence on LNG and coal from 37% and 32% in 2019 to 20% and 19% (Figure 2.1).

2. Nuclear Power Generation

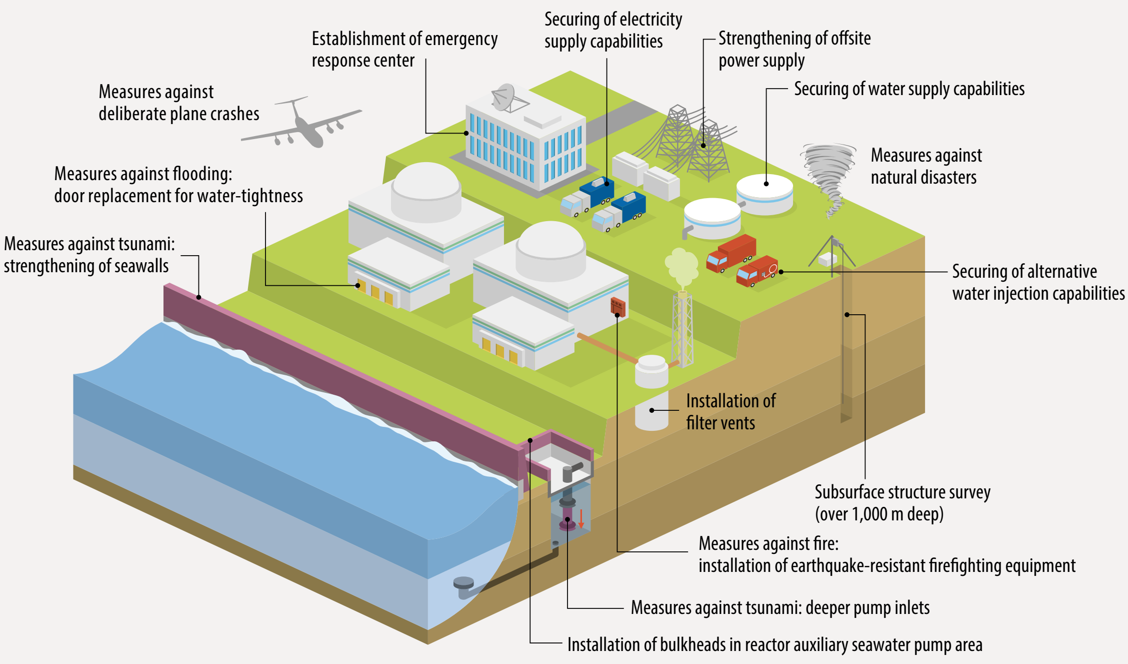
(1) Action on Nuclear Safety

a. Establishment of the Nuclear Regulation Authority

The March 2011 accident at Tokyo Electric Power Company's Fukushima Daiichi Nuclear Power Plant (Fukushima Daiichi accident) led to an overhaul of the system of administration of nuclear power in order to separate safety regulation from its use and to unify nuclear safety regulation work. The Nuclear Regulation Authority (NRA), comprising a chairman and four commissioners, was established in September 2012 as an affiliated agency of the Ministry of the Environment. As a result of this change, the resumption of a nuclear power plant's operation is predicated on the acquisition of licensing through a safety review performed in accordance with the NRA's New Regulatory Requirements (described below), and on the local governments' consents (not a legal requirement).

Safety Measures Required by New Regulatory Requirements

Figure 2.2



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

b. New Regulatory Requirements

The Act on the Regulation of Nuclear Source Material, Nuclear Fuel Material and Reactors (Nuclear Reactors Regulation Act) was revised following the Fukushima Daiichi accident. The main revisions are as follows.

- Thorough reinforcement of regulatory standards for nuclear facilities to include measures against severe accidents (Figure 2.2).
- Requirement for bringing existing nuclear power facilities into conformance with new standards informed by the latest insights (introduction of a backfitting program).
- Setting the period of operation of electricity-generating nuclear reactors at 40 years. Also, limiting the extension of this term to one time only and a length not to exceed 20 years.
- Integration of nuclear power safety regulations with the Nuclear Reactors Regulation Act (separation from the Electricity Business Act).

The NRA verifies whether the installation, operation, etc. of electricity-generating nuclear reactors conform to the New Regulatory Requirements through the following 3-tier regulatory review process. Tier 1 grants permission for changes in reactor installation; Tier 2 approves the construction plan and requires preservice inspections; and Tier 3 approves the operational safety program and requires the passing of pre-service inspections.

c. Initiatives by the Private Sector

Alongside the measures being taken by the regulatory agencies, in November 2012 the nuclear power industry, seeking to prevent the occurrence of accidents like the Fukushima Daiichi accident, launched the Japan Nuclear Safety Institute (JANSI) as an organization for encouraging nuclear power plant operators to voluntarily strive for safety excellence. JANSI advances efforts to ensure a higher level of safety at each power plant through approaches that go beyond the regulatory framework. In order to firmly implant this initiative, the nuclear power industry also established the Atomic Energy Association (ATENA) in July 2018 as an organization whose role is to draft effective safety measures by leveraging insights and resources across the industry and by engaging in dialogue with regulatory authorities. JANSI and ATENA are working together to encourage nuclear power plant operators to introduce more effective safety measures, with the goal of raising the safety standards of nuclear power plants.

(2) State of Nuclear Power Generation

Prior to the March 2011 Fukushima Daiichi accident, Japan had 57 nuclear reactors in operation, and nuclear power accounted for roughly 25% of the total electric power generated in fiscal 2010. In 2014, all nuclear reactors were provisionally shut down. After it became possible

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

Current State of Nuclear Plant Reviews and Restarts

Table 2.1

Tier 1 review completed (change in installation license granted) (17 units)	Restarted	10 units
	Pending completion of Tier 2 and 3 reviews (construction approval, safety regulations, pre-service inspections), and consents of local communities	7 units
Under Tier 1 review (including 2 units under construction)		10 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**

Electric Power Company	Plant	Restart date
Kansai	Takahama Unit 3	Feb. 26, 2016
Kansai	Takahama Unit 4	Jun. 16, 2017
Kansai	Ohi Unit 3	Apr. 10, 2018
Kansai	Ohi Unit 4	Jun. 5, 2018
Kansai	Mihama Unit 3	Jul. 27, 2021
Shikoku	Ikata Unit 3	Sep.7, 2016
Kyushu	Genkai Unit 3	May 16, 2018
Kyushu	Genkai Unit 4	Jul. 19, 2018
Kyushu	Sendai Unit 1	Sep. 10, 2015
Kyushu	Sendai Unit 2	Nov. 17, 2015

Note: Excludes the three reactors of JPDR, Fugen, and Monju.

Source: Compiled from Japan Atomic Industrial Forum, Inc., "Current Status of Nuclear Power Plants" (August 10, 2021) and other materials

Nuclear Power Plant Capacity Factor (calendar year basis)

Table 2.2

	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" (August 10, 2021)

to determine the economic viability of each plant in light of the New Regulatory Requirements, 24 of the reactors, representing aging small and medium-sized models, were selected for decommissioning. As a result, the number of reactors fell to 36 (including three under construction) as of August 2021. Starting in 2015, some of those reactors were brought back into service, with a total of 10 operating as of August 2021 (nuclear power provided around 5% of total electricity generated in 2020).

One of the restarted reactors, the No. 3 reactor at Kansai Electric Power Company's Mihama plant, had exceeded its mandated service life of 40 years but was able to resume operation in July 2021 through an extension approved by the NRA, which was the first such approval to be granted. However, the reactor was stopped again in October 2021 for failure to complete its specialized safety facility[1] on schedule.

Of the 36 available reactors, 27 (including two under construction) applied for permission for change in reactor installation under the Tier 1 review. Permission was granted to 17 reactors, and 10 of them were able to resume operation after passing the Tier 2 and 3 reviews and gaining their local governments' consents (Table 2.1). However, all 27 need to return to full operation in order for Japan to achieve the goal of raising nuclear energy's contribution in the fiscal 2030 power generation mix to 20%–22%, as envisioned by the Sixth Strategic Energy Plan approved by the government in October 2021.

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.

For reference, the capacity factor of nuclear power plants from 2010 to 2020 is listed in Table 2.2.

(3) Nuclear Fuel Cycle

a. Basic Policy

Japan, a country lacking in energy resources, has adopted a basic policy that seeks to make effective use of resources and reduce the volume and harmfulness of high-level radioactive waste by pursuing a nuclear fuel cycle that reprocesses spent fuel and effectively utilizes the plutonium and other fuels recovered (as outlined in the 6th Strategic Energy Plan, approved by the Cabinet in October 2021). To this end, the Federation of Electric Power Companies of Japan (FEPC) unveiled in December 2020 its "Pluthermal Program" ("pluthermal" is a portmanteau of "plutonium" and "thermal [reactor]"), the main focus of which is to expeditiously maximize the use of MOX made from plutonium as a fuel for light water reactors. This program responds to several needs, such as maintaining energy security and fulfilling Japan's principle of not possessing plutonium stocks that have no purpose. FEPC studied all operating reactors for inclusion in the program, and announced in December 2020 that it would implement it for at least 12 reactors[2] by fiscal 2030.

b. JNFL's Nuclear Fuel Cycle Operations

Japan Nuclear Fuel Ltd. (JNFL), which is owned by a number of electric power companies and other private-sector enterprises, engages in five nuclear fuel cycle operations at its sites in Rokkasho Village, Aomori Prefecture: uranium enrichment, reprocessing, MOX fuel fabrication, management of high-level radioactive waste, and disposal of low-level radioactive waste.

Its enrichment plant began operating in 1992. In May 2017, JNFL received the NRA's approval of its application for permission to switch to using a new, cost-efficient type of centrifuge offering improved performance and to introduce other changes in compliance with the New Regulatory Requirements enacted after the Fukushima Daiichi accident. JNFL voluntarily suspended its operation of enrichment in the following September in order to carry out construction for the upgrades being made to its enrichment plant.

JNFL's reprocessing plant (maximum capacity: 800 tU/year), the construction of which began in 1993, started accepting spent fuel in 2000 and launched active testing in 2006. An application was filed with the NRA for approval of operational changes needed to conform with the New Regulatory Requirements. Following a review, the application was approved by the NRA in July 2020. Construction of the new facilities is expected to be completed in fiscal 2022.

Construction of the MOX fuel fabrication plant (maximum capacity: 130 tHM/year) started in 2010 and is scheduled for completion in fiscal 2024.

The Vitrified Waste Storage Center receives vitrified high-level waste (HLW) of ten Japanese utilities from their reprocessing contractors in the UK and France, and holds it in interim storage for 30 to 50 years. The return of HLW generated through reprocessing in France (1,310 casks in total) started in 1995 and completed in 2007. JNFL has been receiving the HLW processed in the UK since 2010.

The Low-Level Radioactive Waste Disposal Center has been disposing of low-level waste from nuclear power plants in Japan since 1992 in underground pits.

c. Recyclable-Fuel Storage Center (interim storage of spent fuel)

Tokyo Electric Power Company Holdings (TEPCO) and the Japan Atomic Power Company are currently building a facility in Mutsu City, Aomori Prefecture, for dry-cask interim storage of spent fuel until it is transported to a reprocessing plant, which will start with 50-year storage of up to 3,000 t, and its capacity will be ultimately expanded to 5,000 t. Approval of the application for operational changes to comply with the New Regulatory Requirements was granted in November 2020, and operation is expected to begin in fiscal 2023, following the completion of additional safety features and other construction.

d. Disposal of High-level Radioactive Waste

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. In October 2020, Suttsu Town and Kamoenai Village in Hokkaido each voted to accept a literature review,[3] which is the first step in the process of host selection. NUMO initiated literature reviews in both municipalities in the following month.

2 In December 2009, the No. 3 reactor at Kyushu Electric Power Company's Genkai Nuclear Power Plant became the first in Japan to commence commercial operation using MOX fuel made from recovered plutonium. Since then, four other reactors have followed suit.

e. Development of Fast Reactors and High-temperature Gas-cooled Reactors

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 (thermal output: 140,000 kW), and later the Monju prototype fast breeder reactor (electrical output: 280,000 kW), which reached its first criticality in April 1994. However, in December 2016, the government finally 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 at Oarai Research & Development Institute in Ibaraki Prefecture 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.

In July 2021, the JAEA restarted the HTTR (High Temperature Engineering Test Reactor; thermal output: 30,000 kW) at Oarai Research & Development Institute after a hiatus of ten and a half years. The HTTR is a high-temperature gas-cooled reactor that was built to perform demonstration tests such as extracting high-temperature helium gas (950°C) and using it to produce hydrogen. The resumption of its operation is expected to lead to implementation of research contracts from the OECD Nuclear Energy Agency and to bilateral collaborations with countries such as the UK and the USA. Full-scale hydrogen production testing is scheduled to start around 2028.

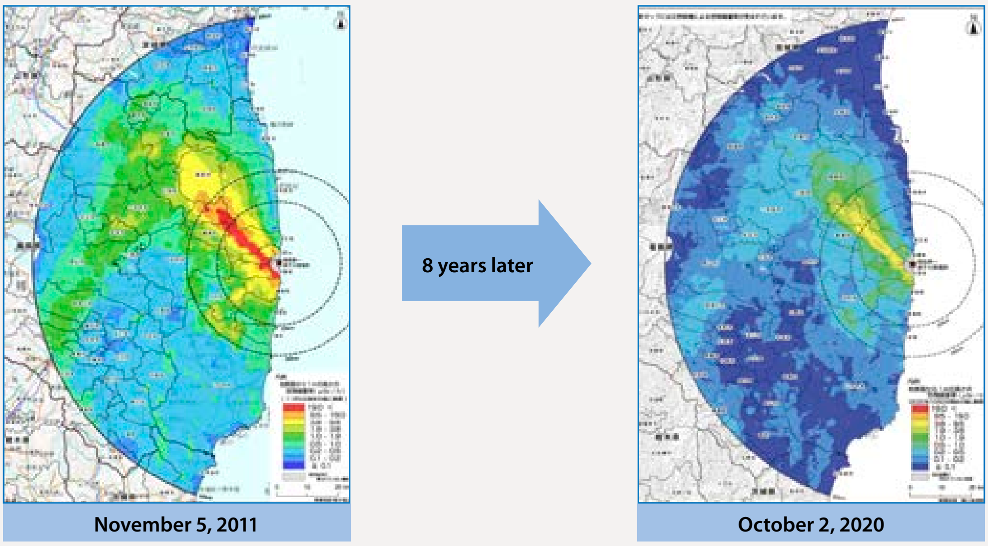
(4) Decommissioning Work at Fukushima Daiichi Nuclear Power Plant

Efforts to decommission the Fukushima Daiichi Nuclear Power Plant's reactors are being carried out through an inter-ministerial council that reports to the Nuclear Emergency Response Headquarters, which is led by the Prime Minister, so that the full support of the government can be marshalled for the decommissioning process.

a. Decommissioning Roadmap

In December 2011, nine months after the Fukushima Daiichi accident, 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. The roadmap was most recently revised in December 2019. By October 2020, radiation levels in the surrounding area had decreased by 80% (Figure 2.3) and

Changes in Air Dose Rate Figure 2.3

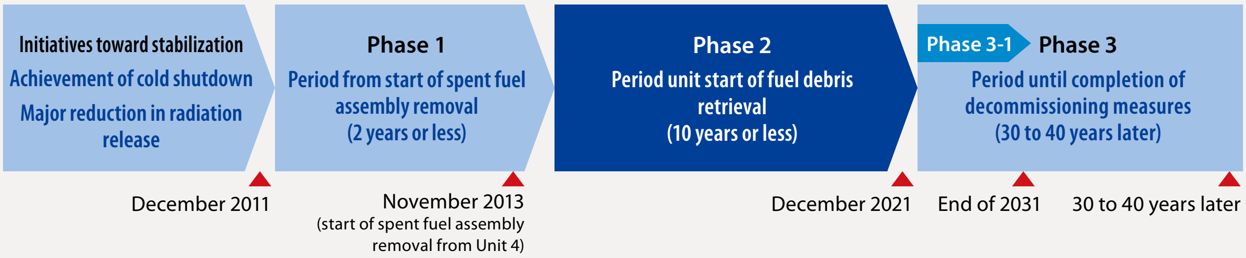


Source: Reconstruction Agency, "Acceleration of Reconstruction Efforts"

3 The literature review is followed by two more steps: an "overview survey" that includes drilling and other assays, and then a "detailed survey" that involves studies in an underground facility. This three-stage process takes around 20 years to complete. At the conclusion of each stage, NUMO takes comments from the heads of local governments, and does not proceed to the next step if doing so goes against the opinions expressed.

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)

gradual progress was being made in reconstruction and the return of displaced residents. The latest revised edition gives top priority to safety and early reduction of risk and calls for simultaneously advancement of both 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 control of radioactive contaminated water. 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. Removing Fuel from Spent Fuel Pools

After the accident, it was decided in the interests of risk mitigation to remove the spent fuel then being stored in the spent fuel storage 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 ended in February 2021. Currently, a platform for aiding fuel removal at Unit 2 is being constructed, and rubble impeding fuel removal at Unit 1 is being taken away. The entire removal process is slated for completion in 2031.

c. Retrieval 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 the debris emits extremely high levels of radiation that preclude entry by personnel, a plan was made to retrieve the debris in the Unit 2 reactor with a robotic arm, starting in 2021. However, the plan was set back by around one year due to, among other issues, the spread of COVID-19 in the UK, where fabrication and testing of the robotic arm was underway.

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, three strategies have been implemented: 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. Since the amount of this water has continued to grow, the government decided in April 2021 to release the water into the ocean after diluting the concentration to below the legal limit. In July, an agreement was reached with the International Atomic Energy Agency (IAEA) concerning the scope of its technical assistance for the discharge of the treated water. Prior to the scheduled discharge in 2023, the IAEA will conduct a safety review of the plan, monitor the

Installed Capacity of Renewable Energy (as of end December 2020)

Table 2.3

[Unit: MW]

Type	Combined total by end June 2012	Combined capacity installed under FIT	Total
Solar power (residential)	4,700	7,461	12,161
Solar power (non-residential)	900	47,390	48,290
Wind power	2,600	1,955	4,555
Small / medium hydropower	9,600	670	10,270
Biomass	2,300	2,606	4,906
Geothermal power	500	91	591
Total	20,600	60,174	80,774

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

area of release, and carry out other preparations. In August 2021, the TEPCO announced its intention to dilute the tritium concentration of the water to one seventh of the WHO's drinking water standard by adding large volumes of seawater, and to discharge the diluted water at a point approximately one kilometer off the coast of the power plant, via a tunnel that will be bored in the bedrock.

3. Renewable Energy

(1) Current Status and Targets

The Sixth Strategic Energy Plan that was announced by the government in October 2021 sets as its top priority the transformation of renewable energy into the main electric power source. It thus calls for maximizing the adoption of renewables. To this end, it lays out the goal of raising the current target for renewable energy's contribution to power generation in 2030 from 22%–24% to 36%–38% (see "1. Strategic Energy Plan" in this chapter).

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 60 GW between the launch of the FIT scheme and the end of December 2020. Including pre-FIT capacity, total installed renewables capacity reached approximately 81 GW.

(2) FIT Scheme and Issues

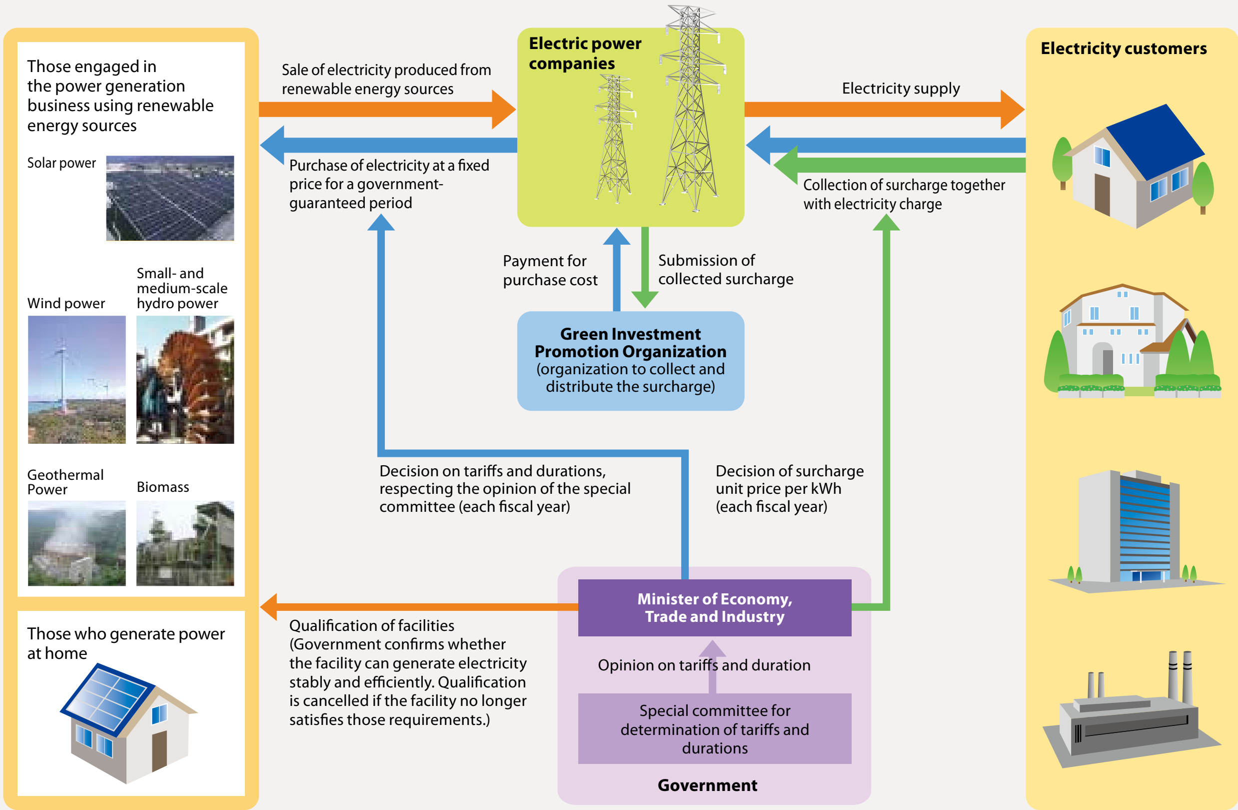
The government passed the Act on Special Measures Concerning Procurement of Electricity from Renewable Energy Sources by Electricity Utilities in August 2011, which requires the electricity utilities to purchase all the electricity generated from renewable energy sources (including hydropower plants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

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 2021 is 3.36 yen per kWh (2.6986 trillion yen for Japan as a whole), or 10,483 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 (from April 2022 onward, the Organization for Cross-regional Coordination of Transmission Operators), 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.

Outline of the FIT Scheme

Figure 2.5



Source: Green Investment Promotion Organization website

Sakai Solar Power Station (Kansai Electric Power Co.)

Purchase Prices and Durations under the FIT Scheme

Table 2.4

Purchase category			Purchase price [yen/kWh]					Duration
			FY2017	FY2018	FY2019	FY2020	FY2021	
Solar	Less than 10 kW	Output controller not required	28	26	24	21	19	10
		Output controller required[*1]	30	28	26			
		Output controller not required, dual generation	25		24			
		Output controller required, dual generation[*1]	27		26			
	10 kW–50 kW		21	18	14	13	12	20
	50 kW–250 kW					12	11	
	250 kW–500 kW					Bidding system		
	500 kW–2,000 kW				Bidding system			
	2,000 kW or above		Bidding system					
Onshore wind power	Less than 20 kW	Newly installed	55	20	19	18	17	20
	20 kW or above		21					
	250 kW or above						Bidding system	
	All capacities	Replacement capacity	18	17	16	16	15	
Offshore wind power	Bottom-fixed offshore wind power		36	36	36	Bidding system	32	
	Floating offshore wind power		36	36	36	36	36	
Geothermal	Less than 15,000 kW		40	40	40	40	40	15
	15,000 kW or above		26	26	26	26	26	
Geothermal (replacement of all equipment)	Less than 15,000 kW		30	30	30	30	30	
	15,000 kW or above		20	20	20	20	20	
Geothermal (replacement of equipment excepting underground equipment)	Less than 15,000 kW		19	19	19	19	19	
	15,000 kW or above		12	12	12	12	12	
Hydro	Less than 200 kW		34	34	34	34	34	20
	200 kW–1,000 kW		29	29	29	29	29	
	1,000 kW–5,000 kW		27	27	27	27	27	
	5,000 kW–30,000 kW		20	20	20	20	20	
Hydro using existing conduits[*2]	Less than 200 kW		25	25	25	25	25	
	200 kW–1,000 kW		21	21	21	21	21	
	1,000 kW–5,000 kW		15	15	15	15	15	
	5,000 kW–30,000 kW		12	12	12	12	12	
Biomass	Methane fermentation gasification (biomass-derived)		39	39	39	39	39	20
	Woody biomass (thinnings, etc.)	Less than 2,000 kW	40	40	40	40	40	
		2,000 kW or above	32	32	32	32	32	
	Construction material waste	All capacities	13	13	13	13	13	
	General waste and other biomass	All capacities	17	17	17	17	17	

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

*2 Upgrades to electrical facilities and penstocks utilizing existing conduits.

Source: Compiled from Agency for Natural Resources and Energy website

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 and biomass generation above a certain level has also been introduced to bring down purchase prices. Results of tenders are shown in Table 2.5 and 2.6.

(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 (part of the Act for Establishing Energy Supply Resilience). 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 photovoltaic power generation system operators 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, and Start of Bidding

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 lease agreement 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 developers by tender to carry out projects in those areas. In June 2021, a developer was selected for an area off Goto City, Nagasaki Prefecture. Also, tenders have been taken for two areas off Akita Prefecture and one off Chiba Prefecture. Many Japanese utilities are seeking to enter this market through collaboration with various partners, particularly European utilities experienced in developing offshore wind farms. Because of the potential for installing large generation capacity and reducing costs, the government sees offshore wind power as a trump card for making renewable energy the main source of electricity, and is studying options such as developing a system for DC power transmission from the generating areas to consumption areas. .

Yonago Biomass Power Station
The Yonago Biomass Power Station is a woody biomass electric power plant with a power output of 54,500kW. The estimated annual generated energy is approximately 390 million kWh. The commercial operation is scheduled in March 2022. The investment ratio of Chubu Electric Power Co. is 30 %.

Results of Tenders for Solar Power Generation

Table 2.5

Timing	Eligible facilities	Successful bids
First tender (November 2017)	2,000 kW or above	Total output: 141,366 kW (9 bids) Successful bid price: 17.20–21.00 yen/kWh
Second tender (September 2018)	2,000 kW or above	No bids came in below the ceiling price
Third tender (December 2018)	2,000 kW or above	Total output: 196,960 kW (7 bids) Successful bid price: 14.25–15.45 yen/kWh
Fourth tender (September 2019)	500 kW or above	Total output: 195,883 kW (63 bids) Successful bid prices: 10.50–13.99 yen/kWh
Fifth tender (January 2020)	500 kW or above	Total output: 39,818 kW (27 bids) Successful bid prices: 10.99–13.00 yen/kWh
Sixth tender (November 2020)	250 kW or above	Total output: 368,373.5 kW (254 bids) Successful bid prices: 10.00–12.00 yen/kWh
Seventh tender (December 2020)	250 kW or above	Total output: 69,400.5 kW (254 bids) Successful bid prices: 10.48–11.50 yen/kWh
Eighth tender (June 2021)	250 kW or above	Total output: 208,000.0 kW (254 bids) Successful bid prices: 10.00–10.98 yen/kWh

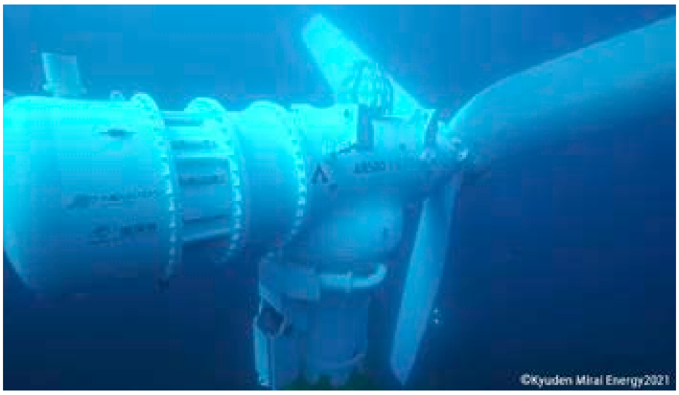
Source: Compiled from Green Investment Promotion Organization website.

Results of Tenders for Biomass Power Generation

Table 2.6

Timing	Eligible facilities	Successful bids
December 2018	Facilities that generate power output of 10,000 kW or more using general wood material and other biomass	Total output: 2,000,000.0 kW (1 bid) Successful bid price: 19.60 yen/kWh
December 2018	Facilities that generate power using liquid biomass fuel	No bids came in below the ceiling price
January 2020	Facilities that generate power output of 10,000 kW or more using general wood material and other biomass	No bids came in below the ceiling price
December 2020	Facilities that generate power output of 10,000 kW or more using general wood material and other biomass	Total output: 1,920.0 kW (1 bid) Successful bid price: 18.50 yen/kWh

Source: Compiled from Green Investment Promotion Organization website.



Ministry of the Environment: Project for the Promotion of Practical Applications of Tidal Power Generation Technology
- Project launch: June 2019
- Operator: Kyuden Mirai Energy Company, Incorporated
- System: Output, 500kW; Manufacturer, SIMEC Atlantis Energy

Choshi Offshore Wind Power Station (TEPCO Renewable Power)

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 containing the average global temperature increase at 2°C above pre-industrial revolution levels and striving to keep it no higher than 1.5°C, as well as balancing anthropogenic GHG emission and absorption in the second half of this century. The 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 Japanese government set in 2015 the goal of reducing emissions in fiscal 2030 by 26.0% from fiscal 2013, and established in June 2019 a reduction target of 80% for fiscal 2050. Both goals were reported to the UN Secretariat.

Subsequently, amidst the rise in the international community's interest in addressing global warming, Prime Minister Yoshihide Suga declared in a policy speech October 2020 that "by 2050 Japan will aim to reduce greenhouse gas emissions to net-zero, that is, to realize a carbon-neutral, decarbonized society." In the following December, the government announced the Green Growth Strategy as a specific set of policies for achieving that goal. This action plan identifies challenges in 14 priority sectors and lays out processes for tackling them. The goal of achieving carbon neutrality in 2050 was codified as a core policy through a revision of the Act on Promotion of Global Warming Countermeasures that was passed in May 2021.

Speaking at the Leaders Summit on Climate hosted online by the USA in April 2021, Prime Minister Suga stated that Japan "aims to reduce its greenhouse gas emissions by 46 percent in fiscal year 2030 from its fiscal year 2013 levels, setting an ambitious target which is aligned with the long-term goal of achieving net-zero by 2050" and "will continue strenuous efforts in its challenge to meet the lofty goal of cutting its emission by 50 percent."

b. Green Growth Strategy

In December 2020, the government released the Green Growth Strategy (GGS) as an industrial policy for creating a virtuous cycle of economic growth and environmental protection that would pave the way for achieving carbon neutrality in 2050. It establishes 14 priority sectors and

Government Action on GHG Reduction Targets Table 2.7

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.
July 2015	The Japanese government submits to the UNFCCC Secretariat its INDC target of reducing emissions by 26% below fiscal 2013 levels by fiscal 2030.
December 2015	Paris Agreement adopted.
June 2019	The Long-term Strategy under the Paris Agreement approved by the Cabinet (decision to reduce emissions in 2050 by 80%).
October 2020	Prime Minister Suga declares goal to make Japan carbon neutral by 2050.
December 2020	Green Growth Strategy announced as plan for achieving carbon neutrality by 2050.
April 2021	Japan announces that its GHG emission reduction target for 2030 will be raised to 46% at US-hosted Leaders Summit on Climate.

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

outlines the challenges of each and how they will be resolved, providing a roadmap for attaining carbon neutrality through the use of key policy tools such as grant funding, tax incentives, financial guidance, and international collaboration.

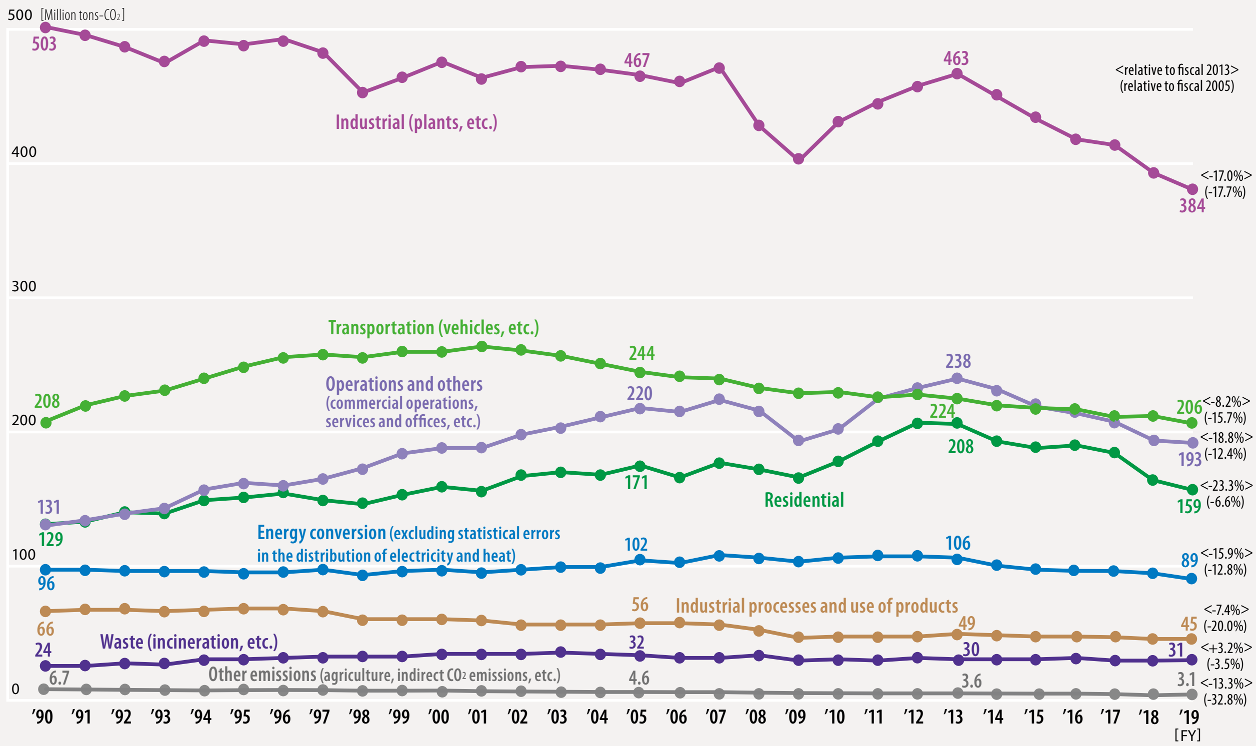
The GGS's 14 focus areas include several energy-related sectors, one of which is offshore wind power. Here, the government is considering increasing generation capacity to 10 GW by 2030, and to 30–40 GW by 2040, constructing grids to connect wind farms to areas with power demand (DC power transmission), and carrying out harbor and port improvements needed to install, maintain, and manage large wind turbines. The GGS also calls for the leveraging of ammonia, which does not emit CO_2 when combusted, as an effective fuel for thermal power generation, particularly co-firing with coal. The goal is to establish practical technology for 20% ammonia co-firing and introduce and spread its use domestically by 2030, followed by transfer of the technology to Southeast Asian countries. Moreover, the GGS positions hydrogen as a key realm of technology that can be applied to decarbonization across many different sectors, such as power generation, industry, and transport. Plans include developing hydrogen-fueled gas turbines, establishing the market for this technology, and exporting the technology to other parts of Asia. One more example of the energy-related strategies is to implement comprehensive measures for making all new vehicles sold electrified by no later than the mid-2030s. The government will study detailed policies for working toward this goal.

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

a. GHG Emissions in Japan

In fiscal 2019, Japan's GHG emissions measured 1,212 million tons (CO_2 equivalent), and emissions of CO_2 accounted for 91.4% (1,108 million tons) of this total. CO_2 emissions showed 15.9% decrease from fiscal 2013 and a 14.4% decrease from fiscal 2005 (Figure 2.6).

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)

CO_2 emissions in individual sectors have been decreasing since 2013, and declining by 17.0%, 18.8%, and 23.3% respectively in the industrial sector, the commercial sector, and the residential sector between fiscal 2013 and fiscal 2019. 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. 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 Commitment to a Low Carbon Society that was announced by Japan Business Federation in 2013, and has been promoting measures on both the supply and demand sides of the electricity. In July 2015, the 10 FEPC members, 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 fiscal2020 (preliminary figures) came to 328 million tons-CO_2 and the CO_2 emission factor was 0.439 kg-CO_2/kWh.

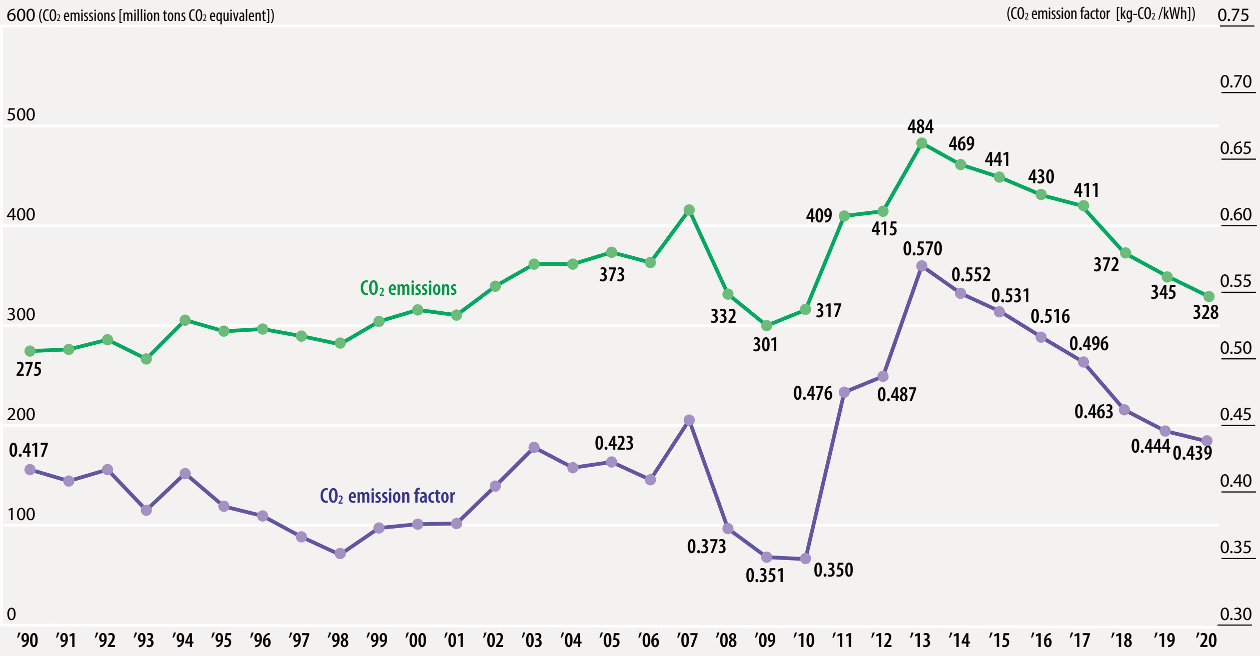
For some time, FEPC has worked to reduce carbon emissions from both electric power supply and demand, including by establishing interconnections with renewable energy grids and improving the efficiency of thermal power plants. With the Japanese government's announcement of the goal to achieve carbon neutrality in fiscal 2050 and decision to raise the fiscal 2030 emissions reduction target to 46% (compared with fiscal 2013), FEPC is looking to step up their efforts in this endeavor. In May 2021, FEPC released "Achieving Carbon Neutrality in 2050," a policy statement outlining the members' commitment to maximize their transition to renewable energy and make every effort to solve challenges to the adoption of renewables through collaboration with partners such as the government and research institutes. The members also see the continued use of nuclear power generation at a certain scale to be essential to the achievement of carbon neutrality, and thus will further utilize this form of energy while voluntarily making safety improvements. Moreover, they will strive to decarbonize thermal power generation by seeking to overcome challenges that stand in the way of innovation and deployment of CCUS/carbon recycling and power generation using the next-generation fuels hydrogen and ammonia. In addition to decarbonizing the supply side, the path to carbon neutrality also requires actions on the demand side. Specifically, the members will strive to maximize the electrification of the industrial, transport, commercial, and residential sectors, including by conducting R&D on high-efficiency heat pumps to pave the way for their wide use.

The Transmission and Distribution Grid Council, comprising the ten general electricity transmission and distribution utilities, announced in May 2021 "Toward Carbon Neutrality in 2050: A Roadmap to the Next-generation Electric Power Network." Among other policies, the roadmap states that the council members will further increase the share of renewables in their power generation mix and establish supply/demand control technologies that utilize VPP and other forms of distributed power generation, as part of their contributions to the achievement of carbon neutrality in 2050.

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

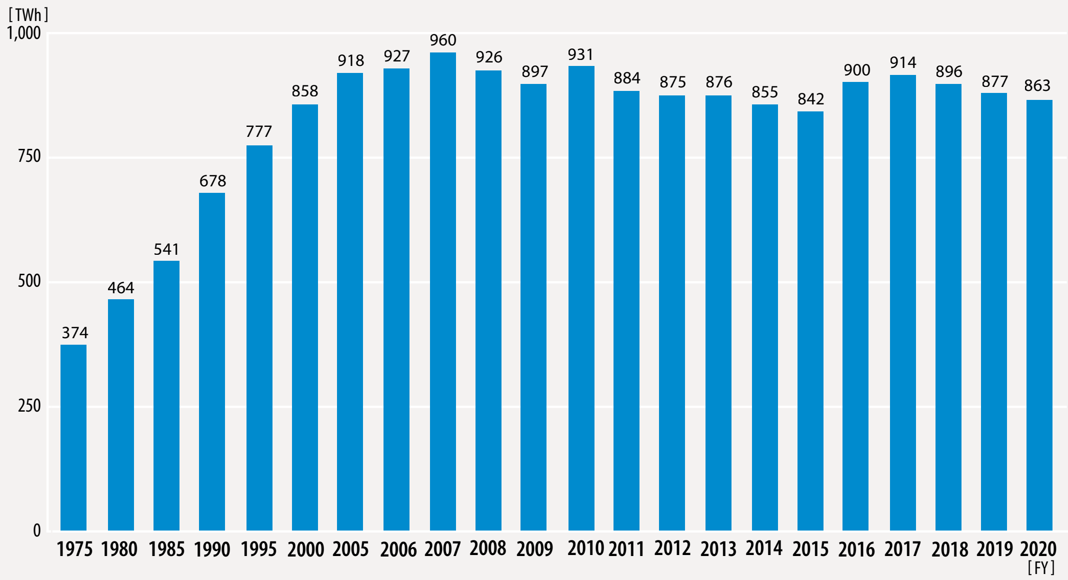
1. Electricity Demand and Peak Load

Japan's electricity demand increased for the most part until the early 2000s. The real GDP growth rate in fiscal 2020, a year in which economic activity was constrained by the COVID-19 pandemic, was -4.6% compared to fiscal 2019, when it stood at 0.0% versus the preceding year. Annual electricity demand[1] has either declined or remained unchanged since reaching 959.7 TWh in fiscal 2007, and in fiscal 2020 came to 863.2 TWh (1.6% 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 is not included in these statistics, 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 2020 came to 159.2 GW (0.3% increase from previous fiscal year).

Demand had been trending downward since April 2020 due to the impact of the COVID-19 pandemic, but has shifted upward since December 2020.

Power consumption in fiscal 2020 breaks down by use as follows: 27% 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 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

Changes in Electricity Demand, 1975–2020 Figure 3.1

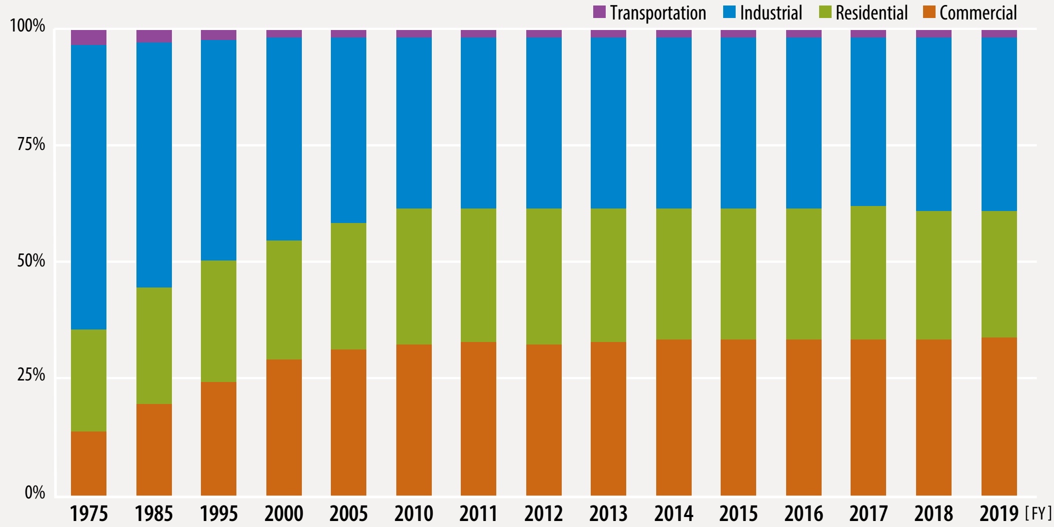


Source: Compiled from Agency for Natural Resources and Energy, "Handbook of Electric Power Industry" (2020) and "Surveys and Statistics of Electricity" (2021)

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

Breakdown of Power Consumption by Sector, 1975–2019

Figure 3.2



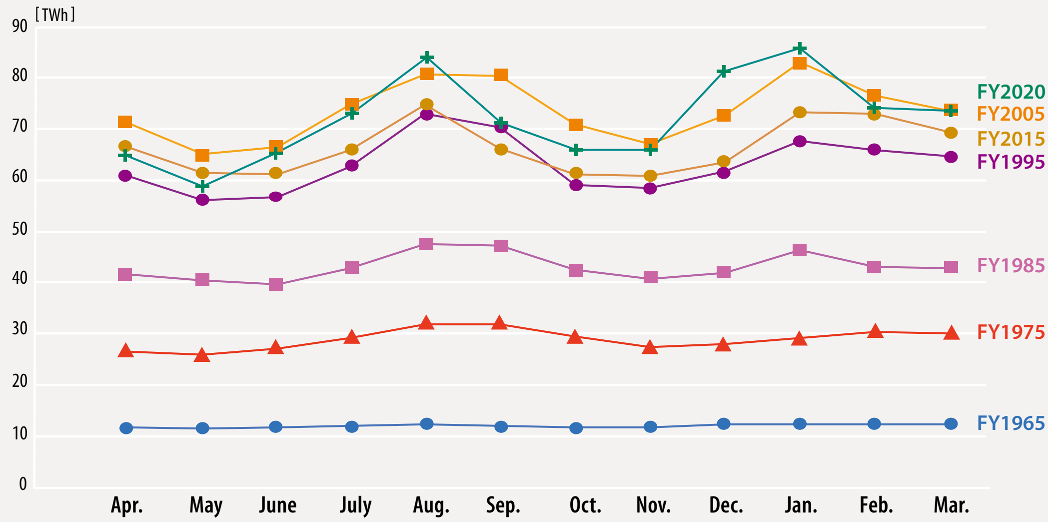
Note: The method of calculation was changed from fiscal 1990.

Source: Agency for Natural Resources and Energy, "Energy Balance in Japan" (2021)

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 2019, non-industrial consumption accounted for 61% of final power consumption.

Electric Power Consumption over the Course of a Year

Figure 3.3

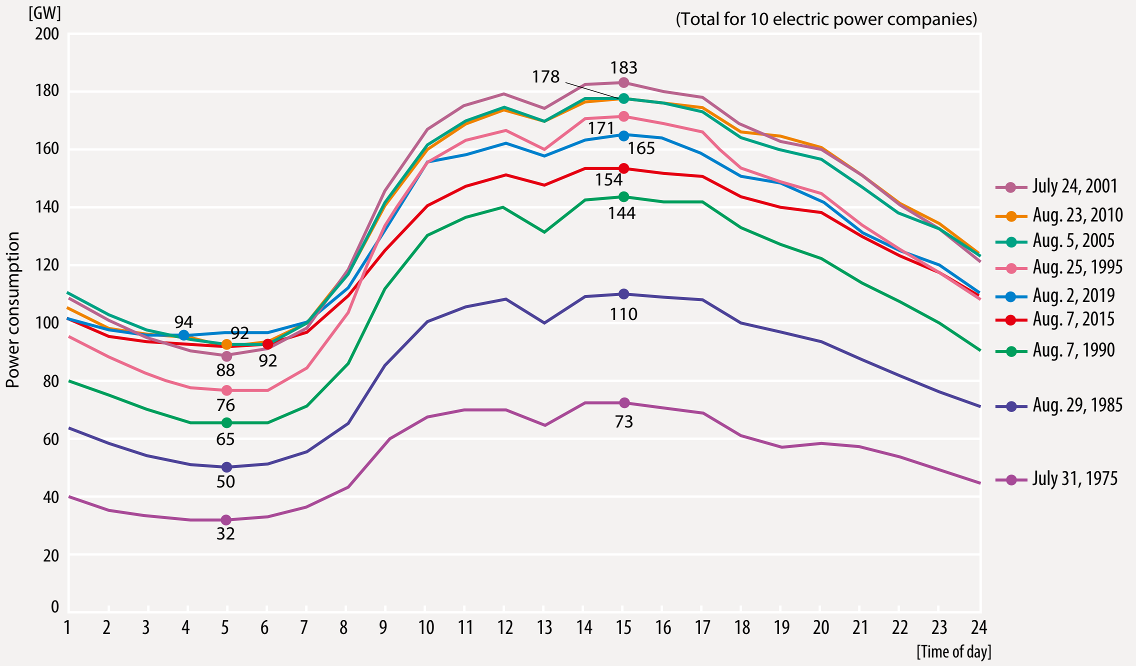


Note 1: Figures for fiscal 1975 and 1985 exclude Okinawa Electric Power Co.
Note 2: Figures are totals for 10 electric power companies through fiscal 2015, and for 10 areas in fiscal 2016.

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

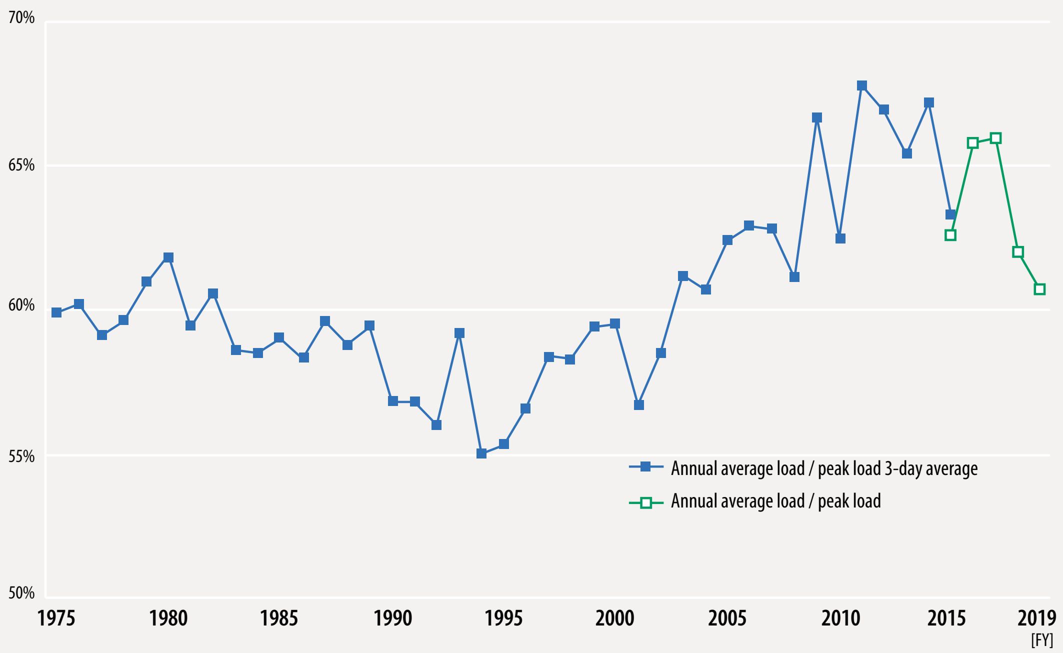


Note: Figures for fiscal 1975 exclude Okinawa Electric Power Co.

Source: Japan Atomic Energy Relations Organization, "Graphical Flip-chart of Nuclear & Energy Related Topics" (2021)

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)

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.

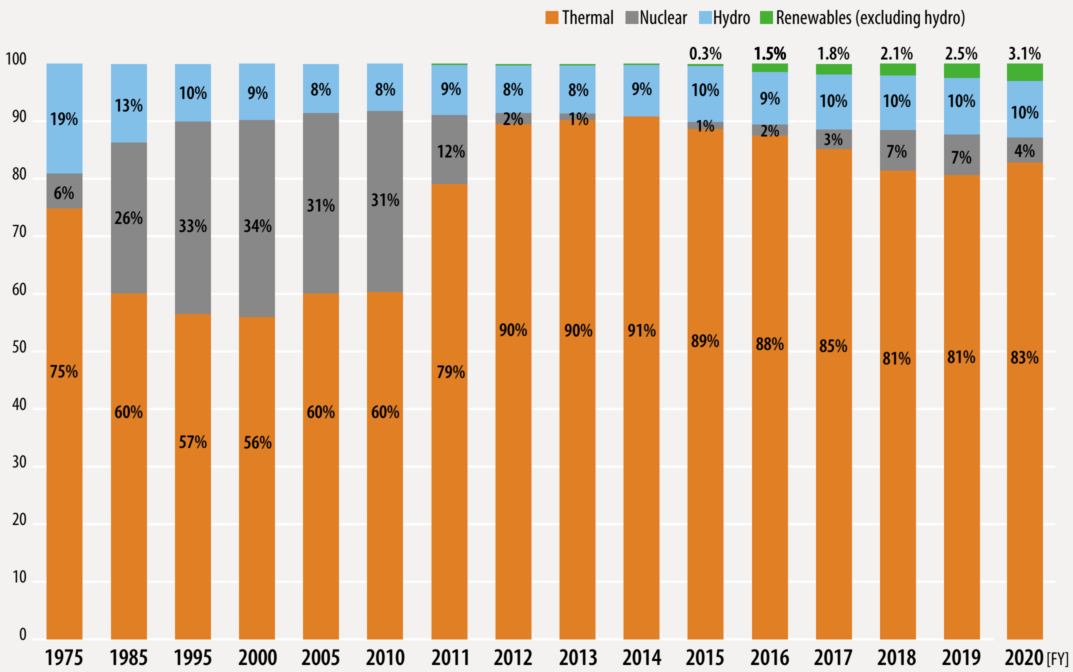
Efficiency in the use of generation facilities declines with growing variation in demand, pushing up power supply costs. Nevertheless, while the annual load factor (i.e., the ratio of annual average load to annual peak load, an indicator of the efficiency of use of generation facilities) followed a downward trend up to the mid-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).

2. Electric Power Generated

Electric power generated[2] came to 845.4 TWh in fiscal 2020 (2.1% decrease from previous fiscal year). The progressive shutdown of nuclear power plants following the Fukushima Daiichi Nuclear Power Plant accident precipitated by the March 2011 earthquake and tsunami increased dependence on thermal power plants and caused thermal's share of power generated to rise from 79.1% in fiscal 2010 to 82.6% in fiscal 2020 (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 Unit 1 of Kyushu Electric Power Co.'s Sendai Nuclear Power Plant in September 2015, several other plants have gradually come back online. However, nuclear's share of power generated in fiscal 2020 was still only 4.4%.

Power Generation Mix, 1975–2020

Figure 3.6



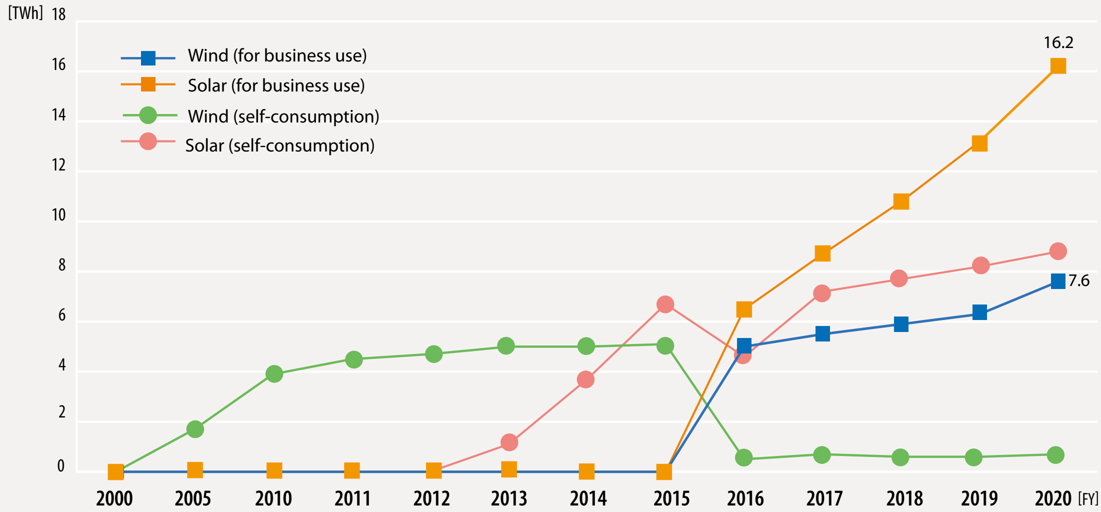
Note: Figures on electric power generated for electric utilities are generation-end figures through fiscal 2015, and transmission-end figures from fiscal 2016.

Source: Compiled from Agency for Natural Resources and Energy, "Handbook of Electric Power Industry" (2020) and "Surveys and Statistics of Electricity" (2021)

2 Electric power generated by electricity utilities.

Trends in Electric Power Generated by Wind and Solar Energy

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" 2020) and "Surveys and Statistics of Electricity" (2021)

On the other hand, the construction of renewable energy installations such as wind and solar power plants has increased. In fiscal 2020, 7.6 TWh of electric power was generated by wind power, and 16.2 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

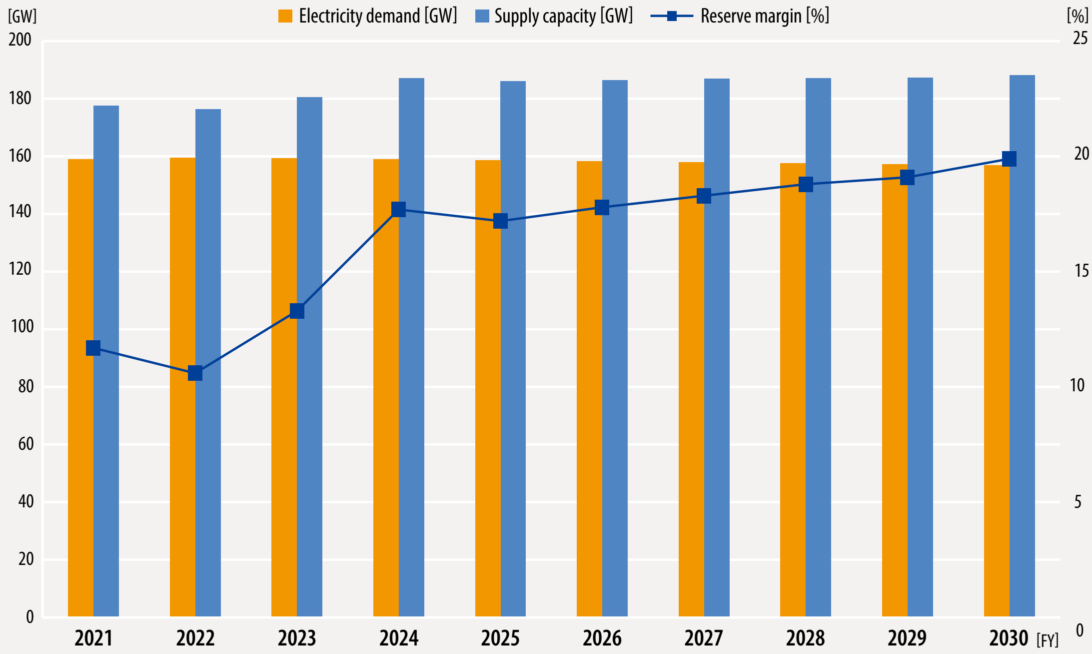
(1) Present and Projected State of Supply and Demand Balance

a. Recent Developments

Ten 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. Moreover, a grim outlook has been forecast for supply and demand going forward. This is mainly because the lackluster trading prices in the electric power market in recent years have weakened the power generation business, leading to a spate of thermal power plant closures and idlings. Some strategies for addressing this challenge have been proposed, such as timing planned outages of generation facilities to take place outside periods of peak demand, and ensuring supply capacity by leveraging markets, demand response, and interregional electric power sharing.

Projected Electricity Demand and Supply Capacity

Figure 3.8



Source: OCCTO, "Aggregation of Electricity Supply Plans for FY2021"

b. Supply and Demand Projections

As for the electricity supply and demand situation, it has remained possible in recent years to maintain the minimum 3% reserve margin needed to ensure supply continuity in all areas of Japan. The average rate of change in both electricity demand and supply capacity over the 10-year period from fiscal 2021 to fiscal 2030 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 electricity retailers. Power source I' provides balancing capacity when weather conditions are severe, and is procured utilizing generated output and demand response programs.

In fiscal 2021, 11,110 MW of power source I and 133,810 MW of power source II were procured. In addition, 4,270 MW of power source I' was procured, of which 1,760 MW of demand was met by demand response.

IV. ELECTRIC POWER FACILITIES

1. Power Generation Facilities[1]

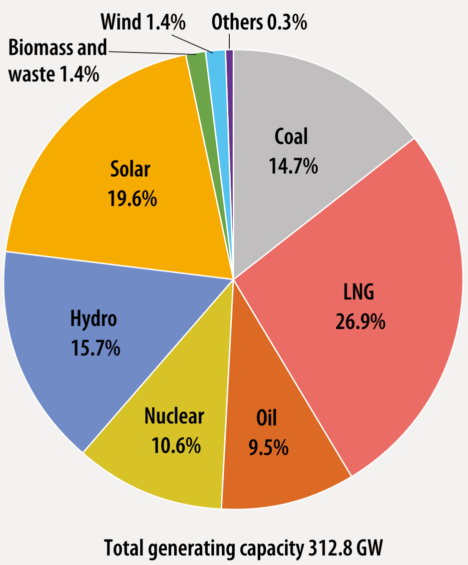
Total generating capacity in Japan was 312.8 GW at the end of fiscal 2020. This consisted of 51.1% thermal power (14.7% coal, 26.9% LNG, and 9.5% oil), 10.6% nuclear power, 15.7% hydro, and 22.5% renewables (excluding hydro). Figure 4.1 shows the breakdown of total generating capacity by power source at the end of fiscal 2020.

(1) Power Generation Facilities for Electric Utilities

a. Thermal Power

The total installed capacity of thermal power plants was 159.9 GW as of the end of fiscal 2020. This accounts for 51.1% 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).

Breakdown of Commercial Power Generation Facilities by Power Source (FY2020) Figure 4.1



Source: OCCTO, "Aggregation of Electricity Supply Plans for FY2021"

Coal-fired generating capacity came to 45.9 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. The government's approach for phasing out inefficient coal power is to start offering incentives for curtailing power generation through the capacity market from fiscal 2021 onward, and to launch in fiscal 2023 a power generation efficiency benchmark system based on the Act on the Rational Use of Energy.

LNG-fired generating capacity totaled 84.3 GW. LNG-fired power plants produce lower SOx, NOx, and CO_2 emissions than oil- and coal-fired plants. Construction of large LNG-fired power plants employing high-efficiency combined-cycle technologies is underway to further reduce emissions of these substances. A new plant[2] added to the grid in 2018 exhibits significant improvements in performance, with gas turbine inlet temperatures of 1,600°C and power generation efficiency of approximately 63.08%.

Oil-fired generating capacity was 29.7 GW. Oil plays a measurable role in peak power supply and balancing but accounted for just 1.7% of all power generated in fiscal 2020, representing a considerably smaller contribution versus other thermal power generation methods (coal, 32.5%; LNG, 41.9%).

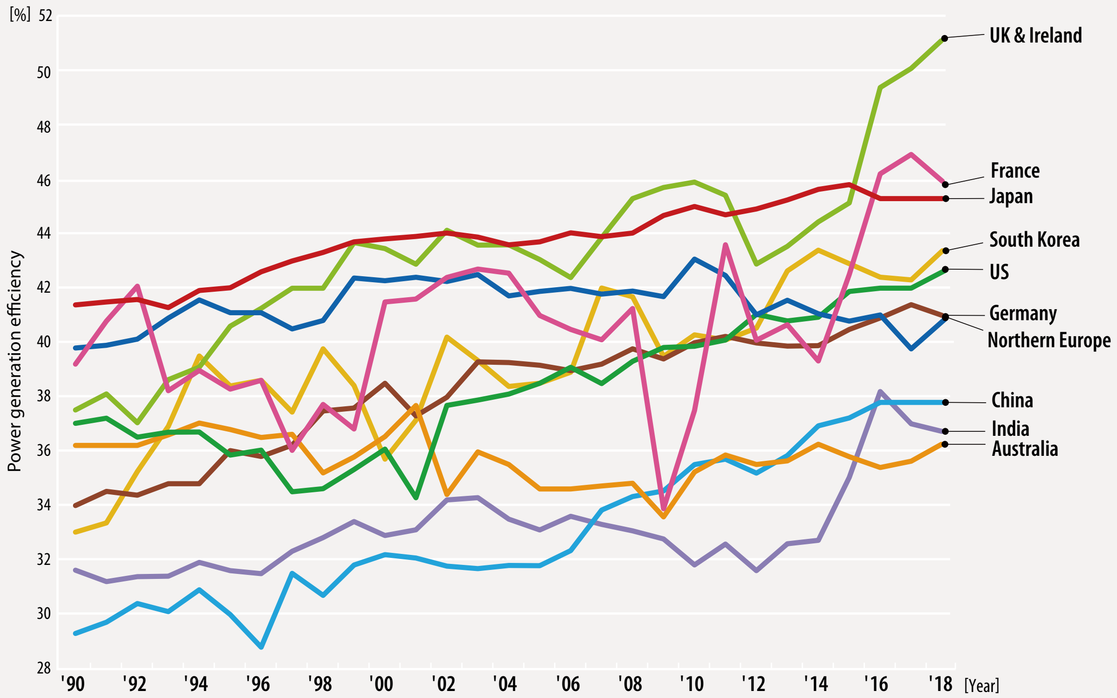
b. Hydro Power

Hydro power generating capacity stood at 49.1 GW at the end of fiscal 2020. 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.

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

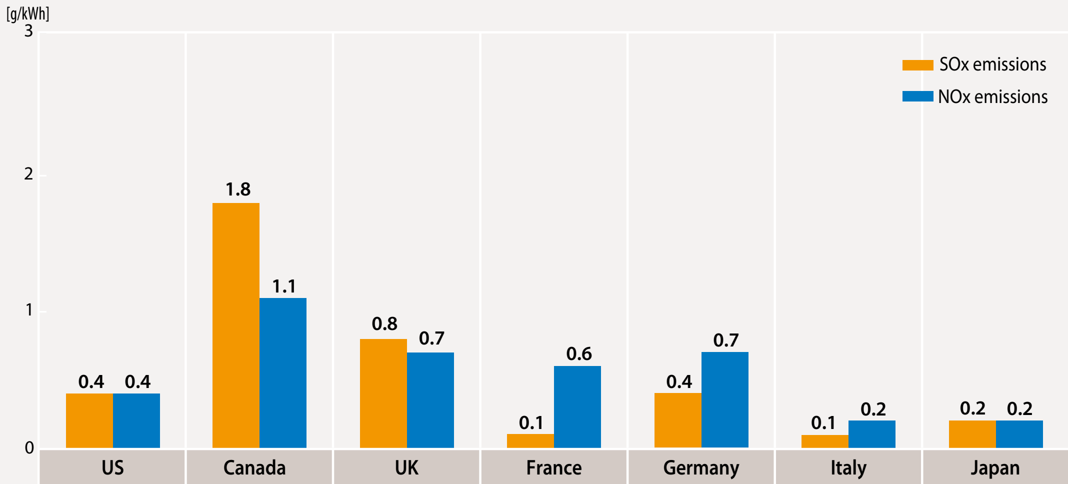


Note: 1. Power generation efficiency is generation-end weighted average of power generation efficiencies of coal, oil, and gas (low heating value basis).
2. Covers facilities of electricity generation utilities whose main business is selling electricity to third parties.
3. Figures for Japan are for the Japanese fiscal year (April–March).

Source: FEPC, "INFOBASE 2020" (2020)

Comparison of SOx and NOx Emissions per Unit of Power Generated at Thermal Power Plants of Major Countries (2018)

Figure 4.3

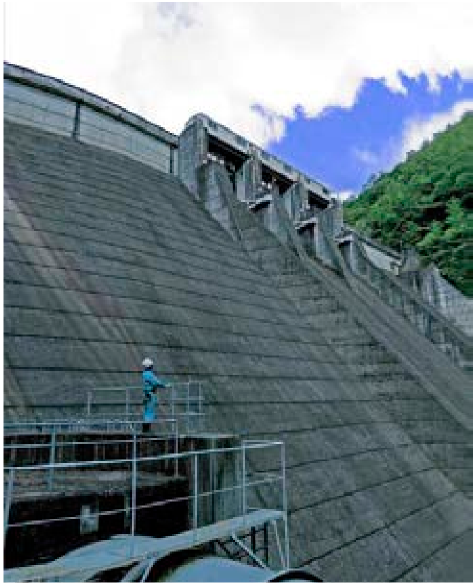


Source: FEPC, "INFOBASE 2020" (2020)

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

Osaki CoolGen Project
Ownership: J-POWER 50%, Chugoku Electric Power Co. 50%
Type: Oxygen-blown IGCC
Output: 166MW

Hekinan Thermal Power Station (JERA)



Odomari Dam (Chugoku Electric Power Co.)

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

Yanaizunishiyama geothermal power station (Yanaizu-city, Fukushima) (Tohoku Electric Power Co.)

c. Renewable Energy

• Solar

Installed solar power generating capacity at the end of fiscal 2020 was 61.2 GW. The deployment of renewable energies, mainly solar power, has been progressing in Japan. Solar power makes up approximately 86.3% 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 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

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

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 4.4 GW as of the end of fiscal 2020. 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 2020.

• Biomass and waste

Biomass and waste generating capacity at the end of fiscal 2020 came to 4.2 GW. In Japan, this form of power generation has centered upon municipal waste incineration and the direct combustion of black liquor from papermaking 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 2020 was 33.1 GW (33 units, excluding 3 under construction and 24 scheduled for decommissioning). Ten nuclear reactors (all PWRs) were in commercial operation as of September 2021 (see "2. Nuclear Power Generation" in Chapter II).

(2) Future Plans

a. Transition of Power Generating Capacity and Power Development Plans

In March 2021, OCCTO published the "Aggregation of Electricity Supply Plans for FY2021."[4] Figure 4.4 shows generating capacity by power source, and Table 4.1 shows the breakdown of power development plans up to fiscal 2030 (new installation, uprating/derating, and retirement plans).[5]

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. 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. Actions toward Achieving Carbon Neutrality in 2050

The Sixth Strategic Energy Plan (see "1. Strategic Energy Plan" in Chapter II) announced by the government in October 2021 calls for efforts to steadily advance decarbonization through the use of currently practical decarbonized electricity (such as power generated from renewable or nuclear energy), and for the pursuit of innovation in areas such as hydrogen/ammonia power generation, and thermal power generation founded on carbon storage and reuse through CCUS and carbon recycling.

• Hydrogen and Ammonia

Hydrogen and ammonia will be used as fuels for thermal power generation. These fuels do not release CO_2 when combusted, and thermal power generation with them offers balancing and inertial functionalities, thereby contributing to stable grid operation. Moreover, many types of existing power generation equipment, such as gas turbines, can continue to be used without modification or replacement. Because of these advantages, hydrogen/ammonia firing is seen as an effective choice among the set of power generation options for achieving carbon neutrality. Accordingly, Japan will seek to overcome various technological obstacles so that hydrogen and ammonia power generation can play a key role in the supply and balancing capacities of the electric power system in 2050.

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.[6]

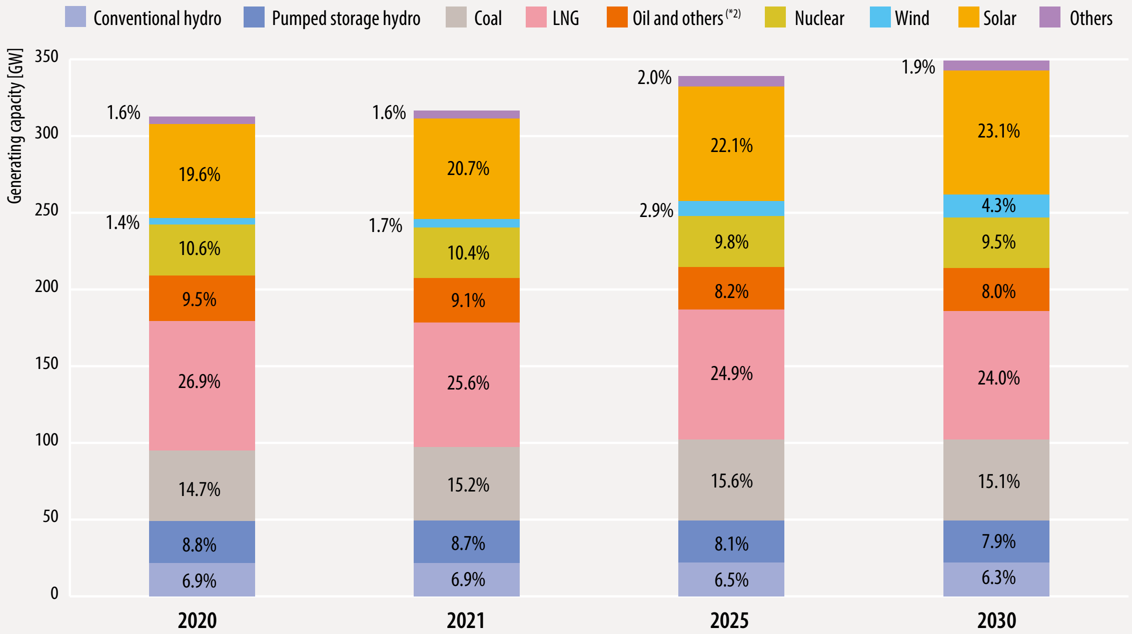
4 All electricity utilities are annually required to submit to the national government (via OCCTO) a supply plan that maps out their supply of electricity and development of power sources and transmission lines over the ensuing 10 years.

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

6 The plan aims to reduce the cost of hydrogen delivered from plants to 30 yen/Nm^3 in around 2030 and to 20 yen/Nm^3 thereafter.

Trends in Generating Capacity by Power Source, 2020–2030 (*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 FY2021"

Power Development Plans up to FY 2030 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		**391**	**61**	**60**	**36**	**-183**	**33**	**268**
	Conventional	391	61	60	36	-183	33	268
	Pumped storage	–	–	–	–	–	–	–
Thermal		**11,638**	**30**	**0**	**0**	**-6,603**	**35**	**5,035**
	Coal	4,413	6	–	–	-518	3	3,895
	LNG	7,174	15	–	–	-4,326	12	2,848
	Oil	51	9	–	–	-1,759	20	-1,708
Nuclear		**10,180**	**7**	**152**	**1**	**0**	**0**	**10,332**
Renewables		**5,953**	**250**	**2**	**1**	**-647**	**66**	**5,308**
	Wind	1,566	54	–	–	-474	52	1,092
	Solar	3,323	168	–	–	-2	1	3,321
	Geothermal	44	3	–	–	-24	1	20
	Biomass	968	20	–	–	-75	5	893
	Waste	52	5	2	1	-75	7	-21
Total		**28,162**	**348**	**214**	**38**	**-7,432**	**134**	**20,944**

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, FY2021"

• CCUS and Carbon Recycling

Looking at carbon capture and storage (CCS) technologies, a government-led project has been carrying out large-scale demonstration testing toward commercialization of CCS. Testing began in 2016 with a CO_2 injection rate of 100,000 t/year, reaching a total of 300,000 t in 2019.

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.

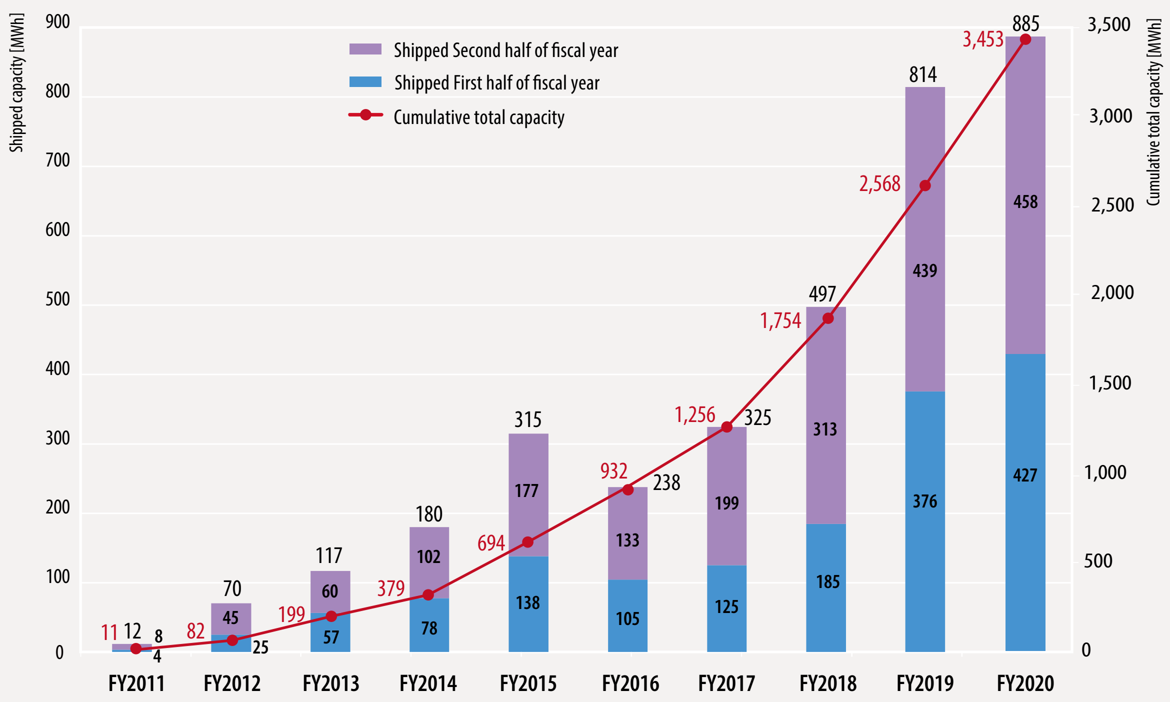
• Storage Batteries

METI is also seeking to further expand the adoption of renewable energy[7] by using storage batteries and other technologies to address the power output fluctuations associated with intermittent renewables.

The use of battery storage systems is rising. A cumulative total of over 490,000 stationary lithium-ion battery storage systems with a capacity in excess of 3.5 GWh were in use in fiscal 2020 (Figure 4.5). Meanwhile, METI is conducting experimental projects using battery storage systems. 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.

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 Storage Battery Systems" (2021).

7 The Sixth Strategic Energy Plan sets a target of 36%–38% for renewables' contribution to the power generation mix in 2030.

(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.

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 2021, these transmission lines had a circuit length of approximately 180,000 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 2021, Japan's ten general electricity transmission and distribution utilities had 7,137 substations with a total installed capacity of approximately 869,000 MVA (Table 4.2). Almost all substations are now unmanned, with remote monitoring and control.

It is difficult to find additional sites for substations in urban areas because of the heavy concentration of commercial establishments and residences. To address this challenge, general electricity transmission and distribution utilities are reducing their footprints with the use of gas insulated switchgear (GIS) and are installing substations beneath office buildings, schools, and other existing structures.

(3) Distribution Facilities

Distribution lines are classified into extra-high voltage lines (33/22 kV), high voltage lines (6kV), and low voltage lines

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)

Transmission and Distribution Facilities

Table 4.2

	1975	1985	1995	2005	2015	2016	2017	2018	2019	2020
Circuit length of transmission lines [km]										
220kV or above	14,167	23,486	29,107	35,209	36,949	36,845	36,865	36,986	37,021	37,216
110kV Under 220kV	28,913	35,106	36,952	35,962	35,588	35,709	35,459	35,390	35,441	35,457
Under 110kV	69,361	78,660	88,648	95,176	106,167	106,238	106,341	106,494	106,784	107,058
Total	112,441	137,252	154,707	166,347	178,704	178,792	178,665	178,870	179,246	179,731
Transformation facility capacities										
Substation output capacity (MVA)	234,748	447,866	657,536	778,740	833,112	842,084	843,886	846,638	850,313	868,556
Total Number of substations	3,466	5,152	5,814	6,570	6,718	6,766	6,774	6,783	6,786	7,137
Circuit length of distribution lines [km]										
Overhead	2,623,787	3,179,970	3,661,963	3,918,743	4,005,974	4,015,703	4,023,882	4,031,278	4,038,426	4,046,028
Underground	14,358	25,348	50,371	65,287	70,733	71,360	72,096	72,735	73,420	73,995
Total	2,638,145	3,205,318	3,712,334	3,984,030	4,076,707	4,087,063	4,095,978	4,104,013	4,111,846	4,120,023

Source: FEPC, "Electricity Statistics Information"

(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 2021, the total length of distribution lines in Japan was approximately 4,120,000 km. Of this, approximately 74,000 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.

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

Smart meters for 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 85.7% of low voltage customers (including households) had been provided with smart meters as of the end of March 2021. All customers should have smart meters by the end of March 2025.

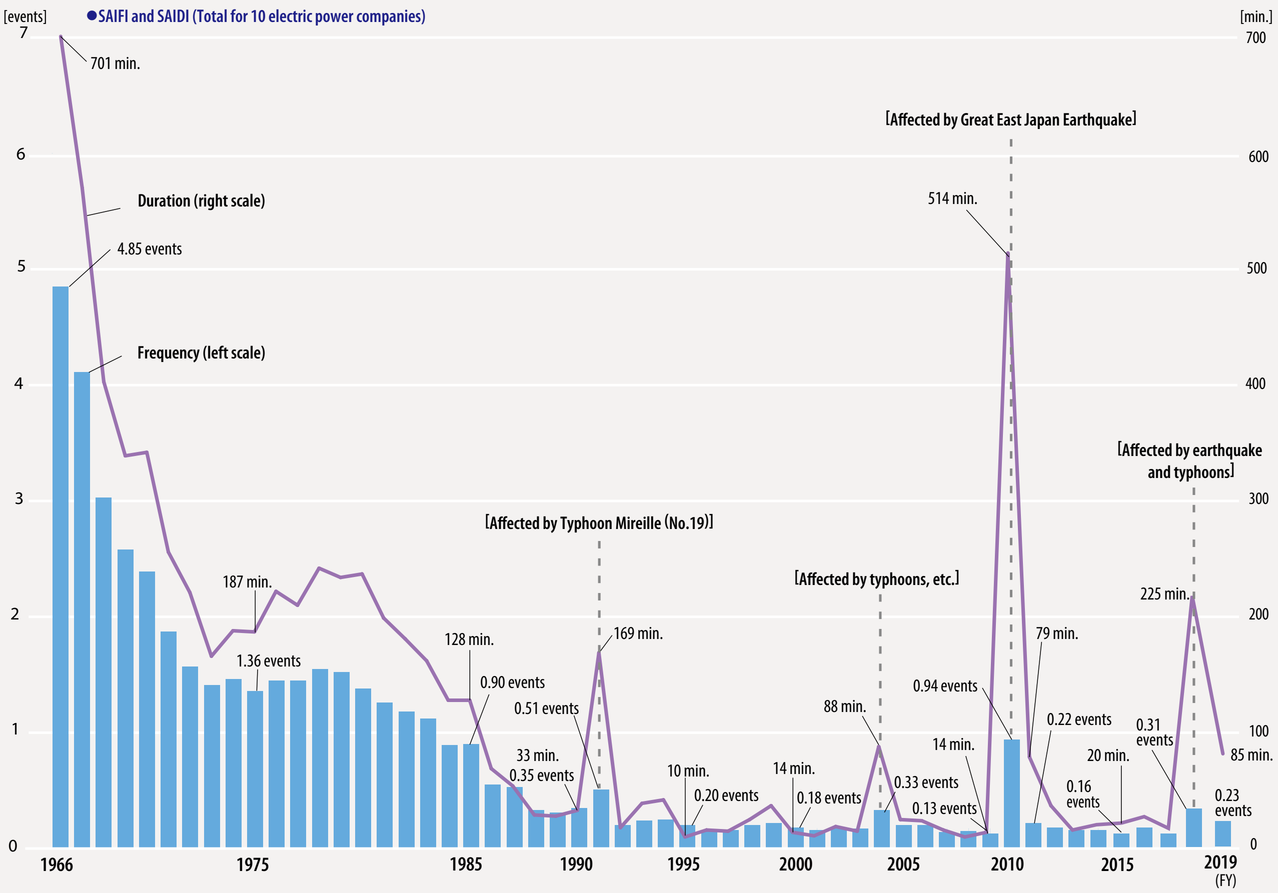
(4) Supply Reliability (SAIDI, SAIFI)

Supply reliability is being kept high compared to international standards by conducting patrols to prevent outages in advance as well as by developing high voltage distribution network facilities as outlined above. Since the 1990s, a high level of supply reliability has been maintained except for major disasters such as the Great East Japan Earthquake (Figure 4.6).

In fiscal 2019, the System Average Interruption Frequency Index (SAIFI) was 0.23 interruptions and the System Average Interruption Duration Index (SAIDI) was 85 minutes. The national averages were lower than in fiscal 2018 despite major interruptions such as the lengthy, large-scale power outage that occurred in the Tokyo Electric Power Company's service area due to Typhoon Faxai (No. 15) in September 2019 (930,000 households were without power at the peak, and it generally took 12 days to restore service).

SAIFI and SAIDI Trends

Figure 4.6



Note: 9 electric power companies up to FY1988

Source: FEPC, "INFOBASE 2020" (2020)

(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 Act for Establishing Energy Supply Resilience was enacted in June 2020 to secure a resilient and sustainable power supply system through measures supporting rapid disaster recovery, facilitated investment in transmission/distribution grids, increased implementation of renewables, and other enhancements.

The provisions of the act that pertain to the electricity business can be largely divided into the following three areas of action. (a) 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.
(b) 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.
(c) Establishment of disaster-resilient distributed power supply systems: Introduce an electricity distribution licensing system to provide legal standing to electricity distribution utilities, which, unlike general electricity transmission and distribution utilities, operate local distribution grids including distributed power sources and operate as independent networks in emergencies.

Certain provisions came into effect in October 2020, while other ones, such as the establishment of an electricity distribution licensing system, will go into effect from April 2022 onward.

(6) Digitalization in the Transmission and Distribution Sector

To address challenges such as aging equipment and reduced maintenance staffing, digital technologies are being used in the power transmission and distribution sector to streamline maintenance and inspections. For example, general transmission/distribution utilities are seeking to shrink manpower needs and improve maintenance techniques through the development of an "Autonomous Flight System for Transmission Line Inspection Drones" that enables drones to autonomously follow and photograph transmission lines, and through demonstration projects that use imaging analysis and AI tools to automatically detect failures from photographs of facilities.

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[8]. 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 former general electricity utilities 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 nationally monitors conditions such as the supply/demand situation and grid operational status, and instructs the utilities to interregionally exchange electricity when the supply/demand situation deteriorates. It is also reviewing the ways that the interconnections are used.

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.

8 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.

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 had 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. Subsequently, the general electricity transmission and distribution utilities (excluding Okinawa Electric Power Company) established a balancing market in April 2021 to improve the efficiency of supply and demand management. As a result, the utilities can use this market to procure balancing capacity from sources across the country, rather than just from their own supply areas.

(2) Interregional Interconnections

As of 2021, the interregional interconnections in operation are mainly AC transmission lines. In the eastern region (50 Hz), 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 western region (60 Hz), 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 four interconnections (totaling 2,100 MW) between the Tokyo area and Chubu area networks: Sakuma Frequency Converter (300 MW), Shin-Shinano Frequency Converter (600 MW), Higashi-Shimizu Frequency Converter (300 MW), and a new addition, Hida-Shinano Frequency Converter (900 MW), which began operating in March 2021 (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 Sakuma and Higashi-Shimizu frequency converters' capacity will be expanded by a total of 900 MW by the end of fiscal 2027 (from 2.1 GW to 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.

(3) Medium- and Long-range Grid Improvements

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.

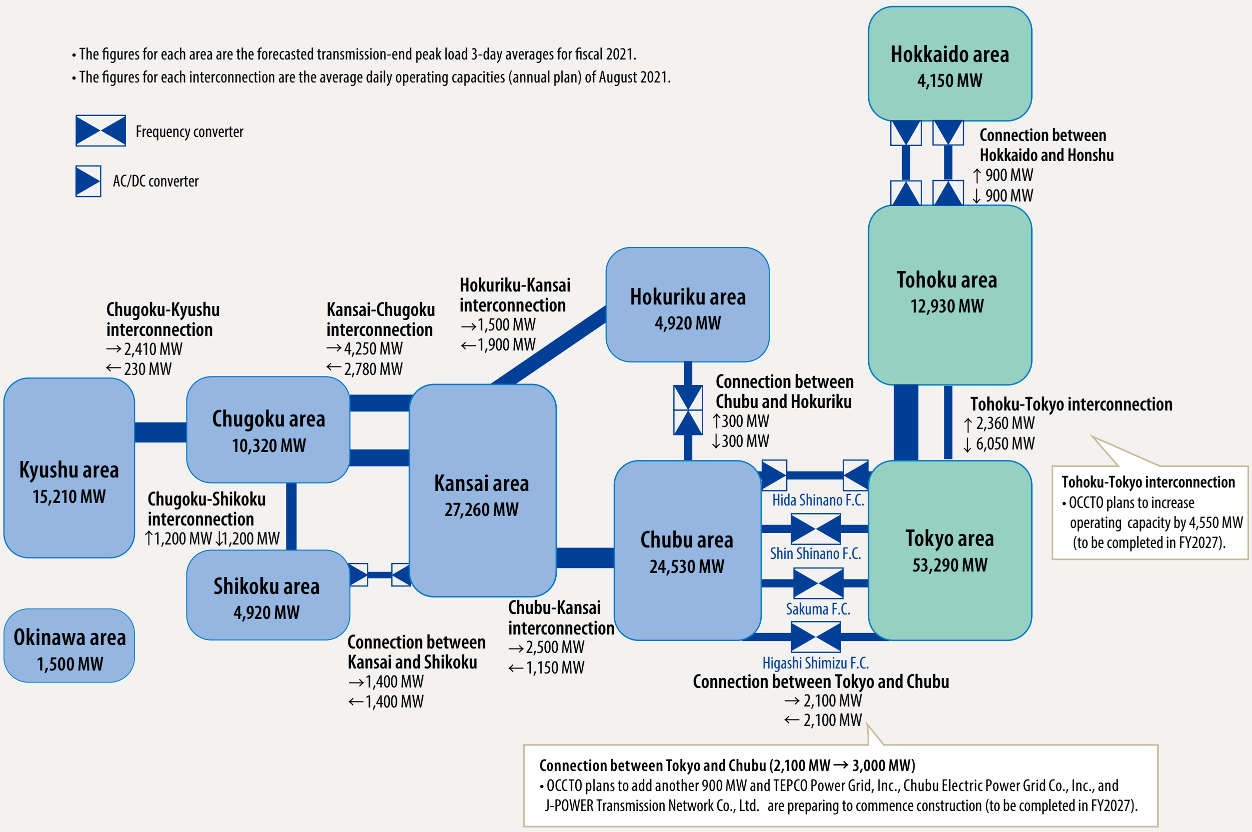
Also, to support the achievement of Japan's goal of becoming carbon neutral in 2050, which was announced by the government in 2020, the general electricity transmission and distribution utilities are advancing efforts to develop a more resilient electric power network.

In the area of grid strengthening, OCCTO is working out a master plan to be issued in 2022 as a cross-regional network development framework for systematic implementation of facility expansions to interregional interconnections and main grids. Under the master plan, the transition to systematic development of the power transmission network will involve a shift from a "pull" approach, where planning is done in response to requests from the power sources as they are made, to a "push" approach in which systematic development is carried out based on the master plan, with consideration given to the potential of each power source.

Premised on this, OCCTO 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

National Grid Connections

Figure 4.7



Source: Compiled by the authors from Agency for Natural Resources and Energy, "Detailed Design for Constructing a Sustainable Electric Power System" (2020), and OCCTO, "Grid Operating Capacity in FY2021–2030 (Annual & Long-term)" (2021)

transmission capacity in the event of N-1 failure.[9] 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 since January 2021 for main grids without available capacity. It is also being implemented for local grids on a pilot basis in certain areas, with an eye on nationwide deployment in the future.

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

V. RETAIL BUSINESS AND TRADING MARKETS

1. Electricity Rates

(1) Regulated Electricity Rates

Up until full liberalization of the retail electricity market in April 2016, general electricity utilities supplied electricity 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 2021, 50.54 million low voltage customers (61% of the total) paid regulated rates.

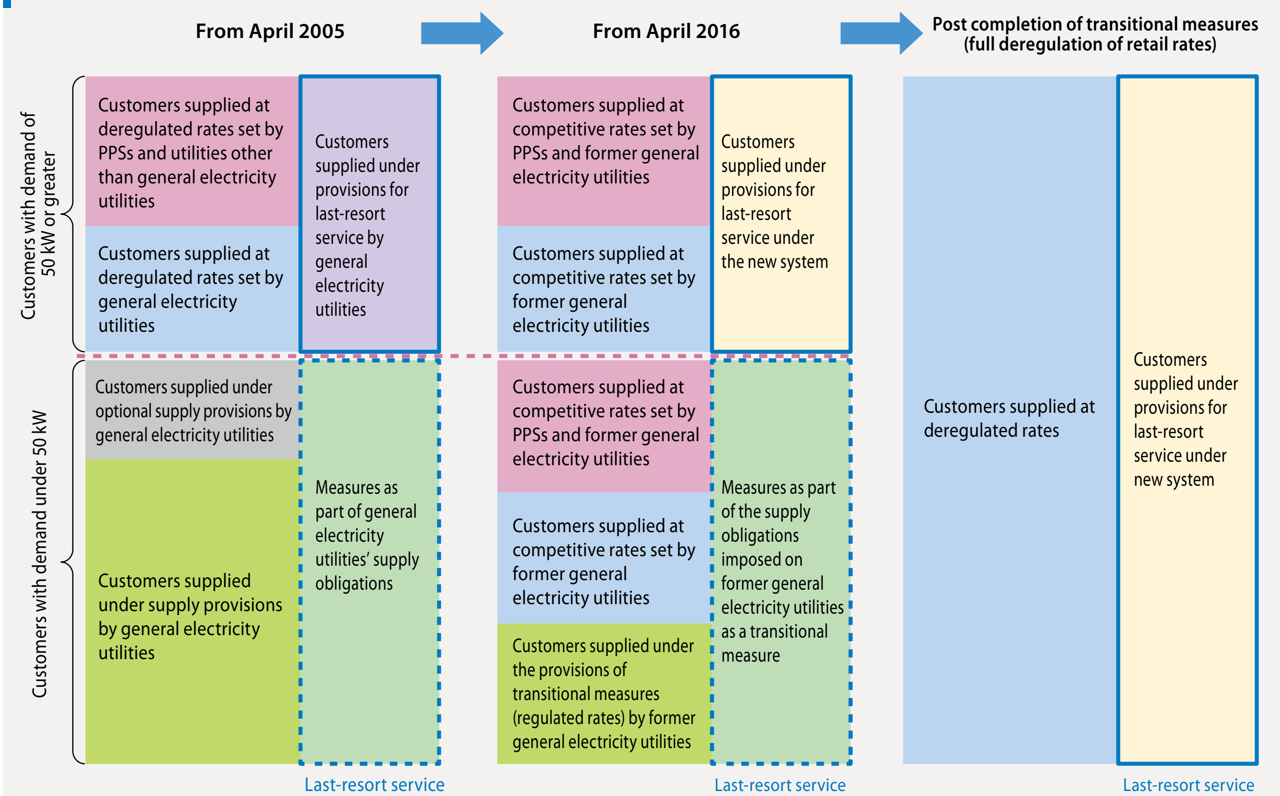
Regulated rates were originally to be discontinued at the end of March 2020. However, as competition had not developed sufficiently, METI decided in July 2019 to maintain regulated rates from April 2020 onwards. Discontinuation of regulated rates will continue to be considered, while paying close attention 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 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

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

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.

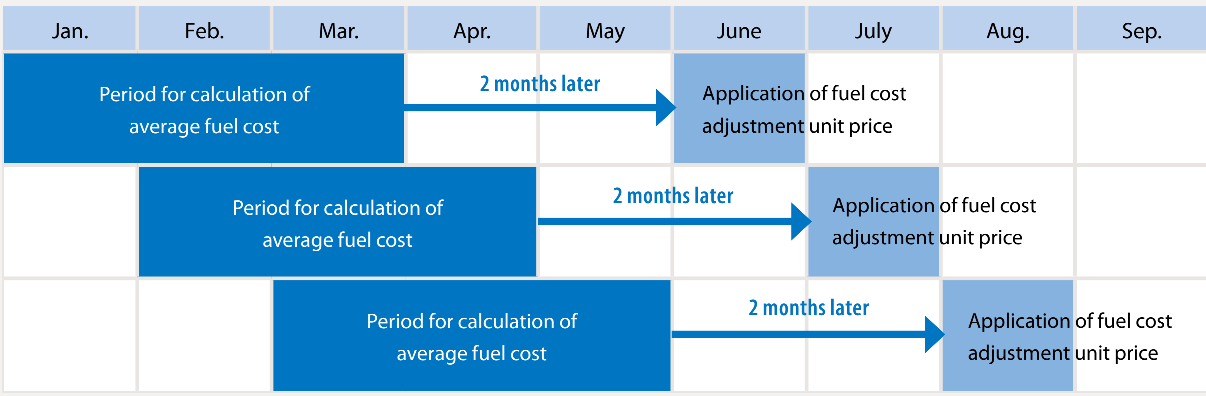
At present, the period (time gap) before fuel price fluctuations are reflected in electricity prices is set to two months in order to level rate fluctuations, and fuel price three-month averages are reflected in the electricity rates charged each month (Figure 5.2).

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 certain period (under the current system, general electricity transmission and distribution utilities do the purchasing). In April 2022, a "feed-in premium" system that pays a premium (the difference of the market power price and a standard price) will be launched for large-scale commercial solar or wind power sources, which are expected to evolve into competitive power sources in the future. The cost of purchase is recovered via a surcharge calculated in proportion to the volume of use by customers that constitutes one component of electricity rates (see "3. Renewable Energy" in Chapter II).

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

Figure 5.2



Source: Compiled from FEPC materials

(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 "2. Efforts to Acquire Customers" in this Chapter).

(3) Trends in Unit Electricity Rates

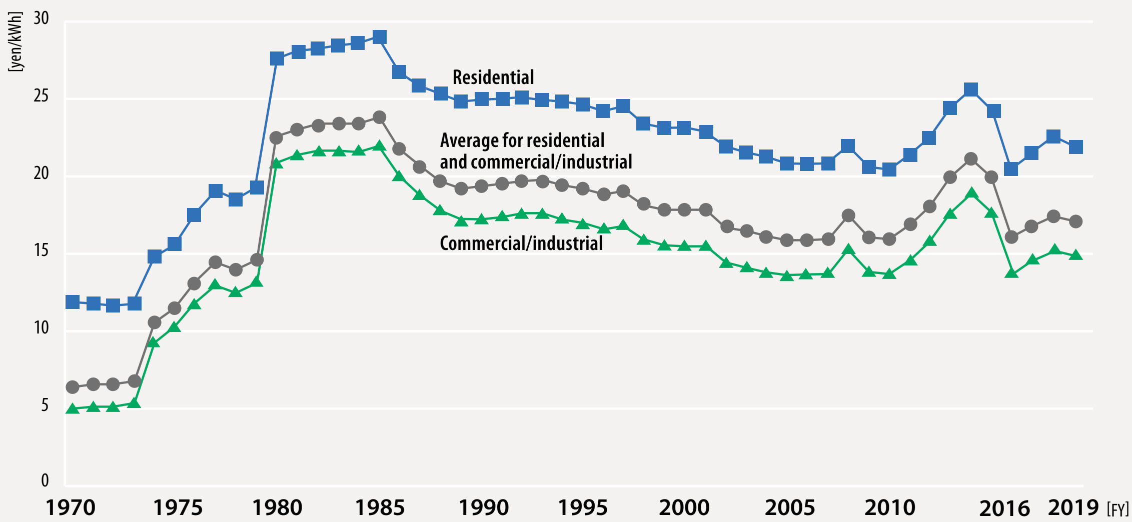
Electricity rates in Japan climbed sharply in the 1970s and early 1980s due to the oil crises, but subsequently entered a long-term decline, owing in part to operational streamlining efforts by the former general electricity utilities. Since the Great East Japan Earthquake in 2011, however, rates have 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, and then started declining again in fiscal 2019 (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 former general electricity utilities and PPSs retail electricity, 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

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, "FY2020 Annual Report on Energy" (2021)

Average Unit Wheeling Charges of General Electricity Transmission and Distribution Utilities (As of October 2021) 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	9.77	4.56	2.04
Tokyo	8.60	3.80	2.01
Chubu	8.98	3.51	1.83
Hokuriku	7.80	3.76	1.81
Kansai	7.86	4.06	2.07
Chugoku	8.28	3.98	1.61
Shikoku	8.79	4.21	1.96
Kyushu	8.35	3.89	2.14
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

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, revisions to the wheeling charge system are being developed for implementation around fiscal 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) Fee 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 in July 2018) included a plan to introduce a fee 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 2024.

2. Efforts to Acquire Customers

(1) Number of Registered Electricity Retailers, and PPS Share

The number of registered electricity retailers has continued to rise since the full liberalization of the retail electricity market in April 2016, reaching 730 retailers as of August 2021. For reference, in the cumulative total for April 2016 to June 2021, there were 95 transfers of business and 38 cases of business discontinuance or corporate dissolution.

As of March 2021, PPSs accounted for a roughly 19.5% share of the total volume of electricity sold, and approximately 20.2% of sales to low voltage customers (Figure 5.4). Here, PPSs include electricity retailers that newly entered the market (other than the former general electricity utilities), and subsidiaries of the former general electricity utilities. The former general electricity utilities' retail sales outside their established service areas contributed 2.3% to the total.

(2) Activities of Electricity Retailers

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

On the other hand, electricity retailers provide low voltage customers with customer services and so on through rate plans tailored to customers' needs and lifestyles, point-based loyalty programs, and membership websites. Services that utilize information on electricity usage obtained from smart meters are also emerging.

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.

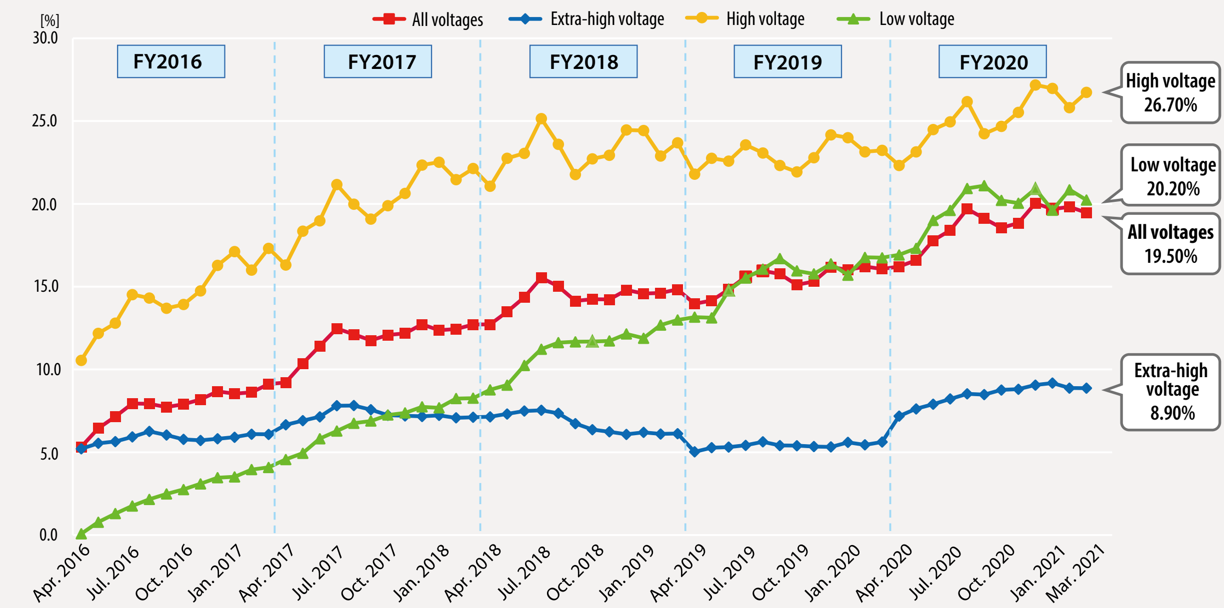
Meanwhile, PPSs are seeking to acquire new customers through diverse approaches, including offering lower rates to families with heavy electricity usage.

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

PPS Share of All Electricity Sold

Figure 5.4



Note: Shares are based on volume of electricity sold. Source: Agency for Natural Resources and Energy, "Progress on Full Liberalization of the Electricity and Gas Retail Markets" 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 amidst the trend toward stronger measures for reducing greenhouse gas emissions, 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 2021. 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 revised as needed to reflect changes in the electricity retail environment.

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 July 28, 2021, there were 266 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 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, reaching approximately 312.8 TWh in fiscal 2020. This means that more than 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. Prices fell in April 2020 as demand dropped from the impact of measures against COVID-19. In that month, trading occurred at the lowest possible system price of 0.01 yen/kWh. Later in the year, prices skyrocketed from the effects of a summer heat wave and from a supply crunch in the winter that was driven by fuel procurement. As a result, the average system price of supply for fiscal 2020 as a whole was 11.21 yen/kWh (Figure 5.5).

(2) New Markets

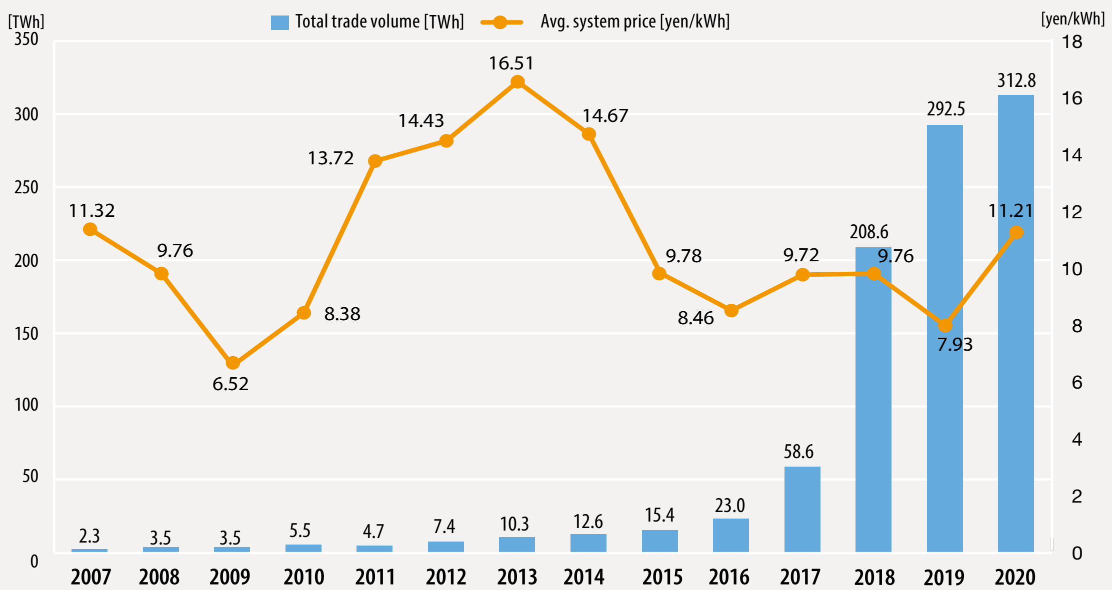
New markets have been developed to encourage further competition in the electricity sector, secure stable power supply, and actualize environmental value. The intention is that the creation of these unconventional new markets will serve to actualize and render tradable new forms of value to accompany 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

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" (2020), and JEPX data sources such as coal, large hydropower, and nuclear power plants. To surmount this challenge, 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 (this market was launched in July 2019). It is expected that the resulting increase in transactions in the wholesale market will lead to increased competition in the retail market. Three auctions for delivery in fiscal 2021 were conducted, for a total volume of 332.1 MW, with clearing prices ranging from 6.06 to 9.19 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 have been concerned 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, a capacity market was established in 2020 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.

Auctions are conducted in the capacity market for securing capacity four years in advance. Capacity traded in 2020 for delivery in fiscal 2024 amounted to 167.69 GW in volume, and had a clearing price of 14,137 yen/kW. The awarding of contracts for delivery in fiscal 2025 through auction is scheduled to be announced in December 2021.

c. Balancing Market

The tasks of controlling frequency and balancing supply and demand are performed by general electricity transmission and distribution utilities in each area. With regard to balancing, it is important that 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 "3. (2) Securing Balancing Capacity" in Chapter III).

Subsequently, a balancing market for procuring and operating balancing supply and demand more efficiently on a cross-regional basis was studied, and began operating in April 2021 for Replacement Reserve for FIT (balancing capacity with a long response time that balances errors in renewable energy predictions). There are plans to successively add other types of balancing capacity as products traded in this market.

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 in May 2018 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.

In addition, the existing non-fossil value trading market will be divided into two markets in 2021 or later to improve the environment for consumer access to renewable energy value: a renewable energy value trading market in which consumers can directly participate in trading (market dealing in FIT renewable energy certificates), and a market for achieving the target[1] mandated by the Act on Sophisticated Methods of Energy Supply Structures regarding the non-fossil share of the power generation mix (dealing in non-FIT renewable energy certificates).

In addition, an electricity futures market run by Tokyo Commodity Exchange, Inc. was established on September 17, 2019 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.

1 The Act on Sophisticated Methods of Energy Supply Structures was established in 2009 as a regulatory framework for encouraging energy suppliers to increase their adoption of non-fossil energy sources and to make sophisticated and effective use of non-fossil fuels. It requires electricity retailers that annually sell 500 GWh or more to raise the non-fossil share of the electricity they sell to at least 44% in 2030.

TOPICS: Actions toward Carbon Neutrality in 2050

The global movement toward decarbonization has gained momentum in recent years, with many major countries setting targets for reducing their greenhouse gas emissions. The Japanese government announced in October 2020 the goal of attaining carbon neutrality by 2050, and pledged in the following April to achieve a 46% cut in greenhouse gas emissions by 2030 compared to fiscal 2013. Measures for reaching these goals are outlined in the Sixth Strategic Energy Plan released in October 2021.

Following this course set by the government, businesses have also been stepping up their efforts to advance toward carbon neutrality. Given that the electrical power industry accounts for roughly 40% of all energy-related emissions and that other sectors such as manufacturing and transportation will likely shift to greater use of electricity, it is hoped that voluntary initiatives by electric utilities will contribute significantly to carbon neutrality.

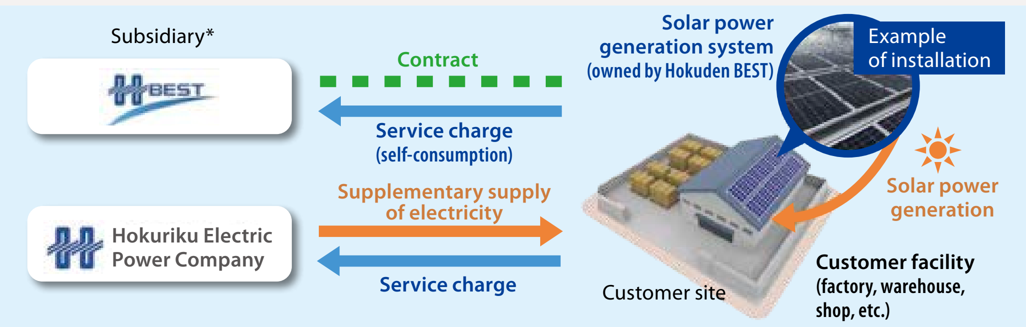
The Federation of Electric Power Companies of Japan has drawn up a roadmap for achieving carbon neutrality by 2050, declaring its intention to decarbonize power sources on the supply side and promote electrification on the demand side, through approaches designed to realize the "S + 3E" (safety, energy security, economic efficiency, and environment). Under the current level of technology, however, it is not realistically possible to satisfy all electrical power demand with electricity from only one type of energy source. Accordingly, this situation calls for the pursuit of a full spectrum of options, including the development of breakthrough innovations. This section presents examples of the electric power industry's efforts to contribute the reduction of greenhouse gas emissions with promising technologies.

(1) Maximizing the adoption of renewable energy

Actions need to be taken now to maximize the adoption of renewable energy in order to lay the foundation for its use as the primary energy source for electric power generation in the future. These actions include decreasing renewable energy costs, seeking the local community support and regulatory reforms needed to secure land for new installations, and utilizing storage batteries to get the most out of variable renewable energy. Major electricity generation utilities, comprising mainly the former general electricity utilities, have set targets for their adoption of renewable energy (Table 1).

One of the more distinctive initiatives is Hokuriku Electric Power Company's use of the third-party ownership model for solar power generation. This enables customers to use renewable energy without having to make initial investments in the solar power generation systems installed at their site. The company has already secured high voltage customer contracts (including informal agreements) totaling 4,000 kW, and started expanding this service for low voltage customers in fiscal 2021 (Figure 1).

Overview of Third-party Ownership Model Figure 1



Source: Hokuriku Electric Power Company *Note added by JEPIC

Renewable Energy (RE) Adoption Targets of Former General Electricity Utilities and J-POWER

Table 1

UTILITY	TARGET	KEY ACTIONS
Hokkaido EPCo	Increase RE power capacity by at least 300,000 kW by FY2030	•Participation in an offshore wind farm project (Ishikari Bay) •Participation in one of Mexico's largest solar power generation projects •Repowering of a hydroelectric power plant (Shintoku)
Tohoku EPCo	Develop RE power capacity of 2 million kW in mainly the Tohoku and Niigata areas as early as possible from 2030 onward	•Development of new hydroelectric power plants (Tamagawa No. 2 & Shinkamimatsuzawa) •Participation in offshore wind farm projects (Tsugaru offshore & Northern Akita offshore) •Refurbishing and new development of geothermal power plants (Matsukawa & Kijiyama)
TEPCO	Development of new RE capacity of 6 to 7 million kW domestically and internationally by early 2030s	•Repowering of domestic hydroelectric power plants •Development of overseas hydroelectric power plants (Dariali & Coc San) •Participation in offshore wind farm projects (Choshi Offshore & Northern Akita Offshore)
Chubu EPCo	Develop RE capacity of at least 2 million kW by around 2030	•Development of new hydroelectric power plants (Abekawa & Seinaiji) •Wind farm development & project participation (Akita Port/Noshiro Port offshore & Atsumi onshore) •Development of biomass power plants (Yatsushiro, Omaezaki Port & Yonago)
Hokuriku EPCo	Increase RE capacity to 2 billion kWh/yr by FY2030	•Development of new hydroelectric power plants and improvement of existing ones (+0.14 bln kWh/yr) •Increasing of biomass co-firing ratio (+1.5 bln kWh/yr) •Development of RE capacity of 300,000 kW (mainly wind power)
Kansai EPCo	Raise RE capacity to 6 million kW by 2030s (new development of at least 2 million kW domestically / internationally)	•Development of hydroelectric power plants (Shin-Utsubo & Shin-Sakagami) •Development of biomass power plants (Aioi Unit No. 2 & Iwaki, Fukushima) •Wind farm development & project participation (Northern Akita offshore & Akita Port/Noshiro Port offshore)
Chugoku EPCo	Introduction of new RE capacity of 300,000 to 700,000 kW by FY2030	•Repowering of a hydroelectric power plant (Takiyamagawa) •Coal & biomass co-firing (Misumi Unit No. 2) •Participation in wind farm project (Yunlin offshore, Taiwan)
Shikoku EPCo	Seek to develop RE capacity of 500,000 kW domestically / internationally by FY2030	•Development of new hydroelectric power plant (Kurofujigawa) •Solar power plant development & project participation (Huatacondo, Chile) •Participation in wind farm project (Yunlin offshore, Taiwan)
Kyushu EPCo	Seek to develop RE capacity of 5 million kW domestically / internationally by FY2030	•Repowering of hydroelectric power plants (Tsukahara, Sugiyasu & Shin-Taketa) •Refurbishing and development of geothermal power plants (5 sites in Kyushu; Sarukuradake in Fukushima) •Wind farm development & project participation (Hibikinada offshore & Yurihonjo offshore
Okinawa EPCo	Develop new RE capacity of 100,000 kW by FY2030	•Photovoltaic Third-Party Ownership project implementation & expansion •Development of wind power •Demonstration of community microgrid (Kurimajima, Miyakojima)
J-POWER	Develop new RE capacity of at least 1.5 million kW by FY2025	•Repowering of hydroelectric power plants (Nagayama & Ogamigo) •Wind farm development & project participation (Hibikinada & Kaminokuni No. 2) •Refurbishing& development of geothermal power plants (Onikobe & Appi)

Source: Federation of Electric Power Companies of Japan, "Achieving Carbon Neutrality in 2050"

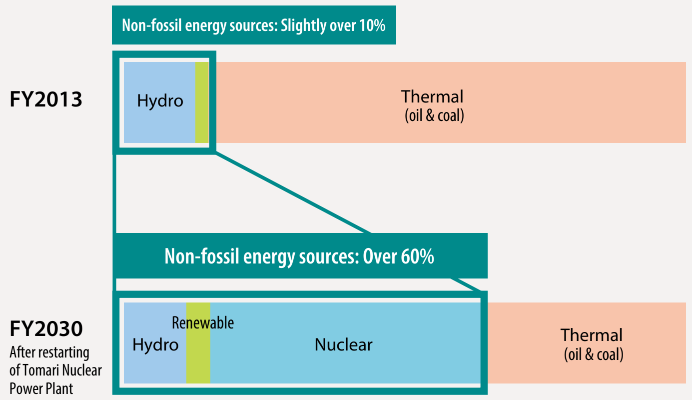
Another notable initiative is Chugoku Electric Power Company's participation in an energy aggregation demonstration project that seeks to construct a stable and efficient electrical power system and spread the use of renewable energy. The project, which combines the company's renewable energy power generation and storage battery systems, is attempting to acquire the technical and operational expertise needed to run an energy aggregation business, and to demonstrate the economic viability of the business model.

(2) Utilizing nuclear power

Nuclear power has a significant role to play as a technologically established zero-emission energy source. Efforts are now underway to leverage this energy source, founded on a commitment to improving nuclear safety. These include laying the groundwork for the early restarting and stable operation of existing reactors, and research on next-generation reactors.

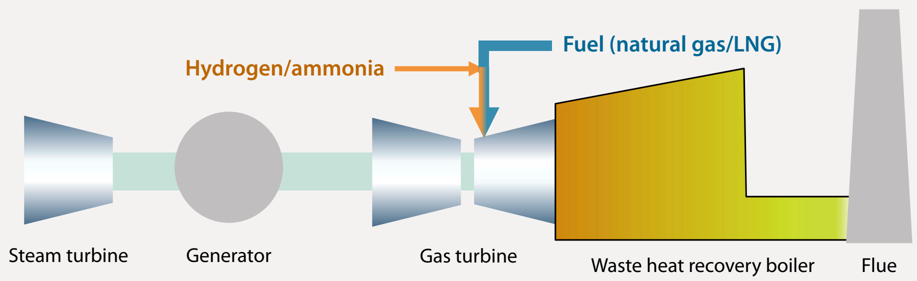
Hokkaido Electric Power Company is among the electric utilities that are vigorously striving to utilize nuclear power. The company has set a goal of achieving a 60% reduction in carbon emissions by 2030 compared to fiscal 2013, and, assuming that its Tomari Nuclear Power Plant will be restarted at an early stage, plans to make nuclear power the dominant source of its supply of non-fossil fuel electricity by fiscal 2030 (Figure 2).

Energy Composition of the HEPCO Group's Electricity Generation Business Figure 2



Source: Hokkaido Electric Power Co., Inc.

Schema for hydrogen/ammonia co-firing Figure 3



Source: Tohoku Electric Power Co., Inc

(3) Utilizing Hydrogen and Ammonia

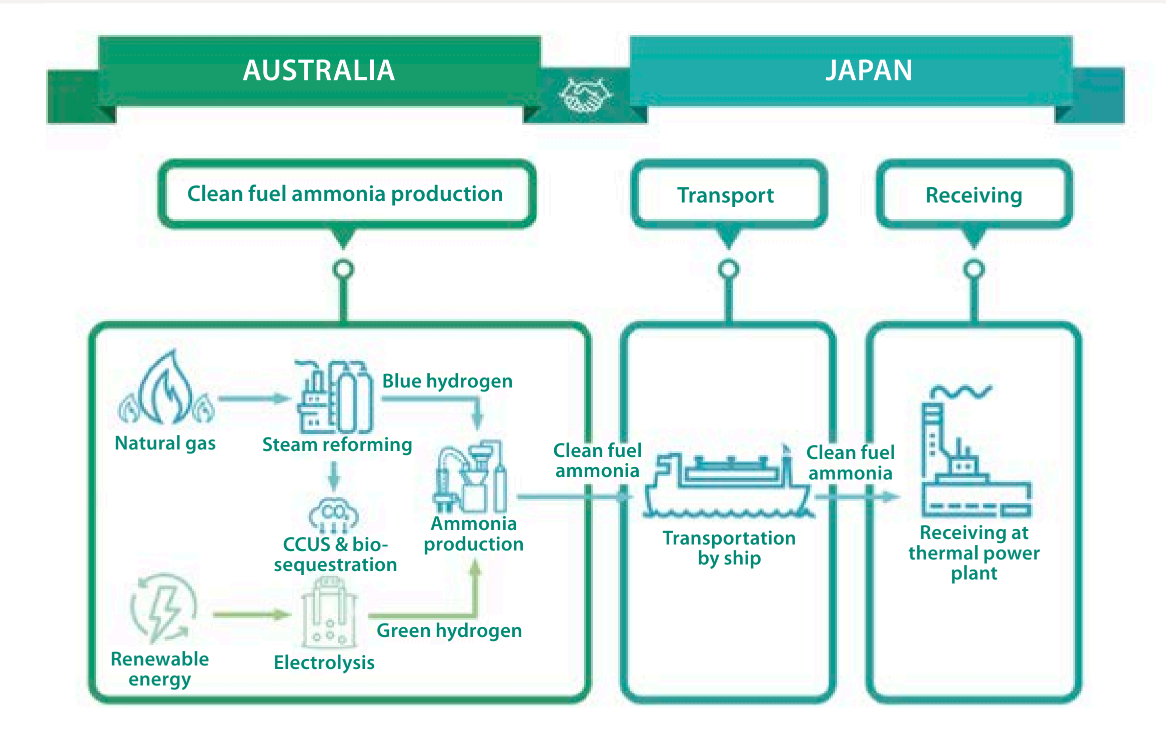
Power generation using fuels that do not release CO_2 when combusted, such as hydrogen and ammonia, is seen as one promising area of technology for attaining zero emissions on the supply side. However, several challenges stand in the way of large-scale hydrogen power generation, including not only the establishment of viable methods for hydrogen manufacturing and storage, but also development of transportation infrastructure and reduction of costs. In contrast, technologies are already in use for ammonia production, transport, and storage, and thus ammonia is seen as having greater potential for early deployment as a zero-emission fuel.

Tohoku Electric Power Company is using the Niigata Thermal Power Station's Unit No. 5 (109,000 kW) to carry out a project for demonstrating the stable combustion of hydrogen and ammonia, among other testing. The insights gained from the project will be used to inform plans for deployment in 2026 or later of power plant units that combust a mix of the two fuels, or just one of them (Figure 3).

Tokyo Electric Power Company and Chubu Electric Power Company, working through an electricity generation utility they jointly formed, are carrying out a demonstration project subsidized by the New Energy and Industrial Technology Development Organization (NEDO) to establish a technology for ammonia combustion. The project is seeking to realize 20% ammonia co-firing with coal by fiscal 2024, using a 1 million kW-class commercial coal-fired power plant.

Hokuriku Electric Power Company and Kansai Electric Power Company are conducting a feasibility study on development of a clean fuel ammonia supply chain. This project aims to establish a supply chain whereby clean fuel ammonia is manufactured in Australia—with CCUS technology and bio-sequestration are used to abate the CO_2 released from the process of producing ammonia from natural gas—and is transported by sea to Japan for use as a fuel in power generation and ship operation (Figure 4).

Overview of Australia-Japan Clean Fuel Ammonia Supply Chain Figure 4



Source: Kansai Electric Power Co., Inc.

(4) CCUS: Carbon Dioxide Capture, Utilization, and Storage

Due to constraints inherent in the structure of society and industry, the release of carbon emissions is unavoidable to a certain extent in some sectors where electrification is difficult to implement, such as those with demand for heat that depends on ultra-high temperatures. CCUS technologies need to be established to address such emissions.

J-POWER has been involved in various carbon storage demonstration and technological development projects. Since May 2020, it has been formulating, under a Joint Crediting Mechanism[1] (JCM) feasibility study, a detailed plan for a CCS project demonstrating the underground injection and storage of CO_2 emitted by natural gas production in Indonesia (Figure 5).

(5) Promoting demand-side electrification

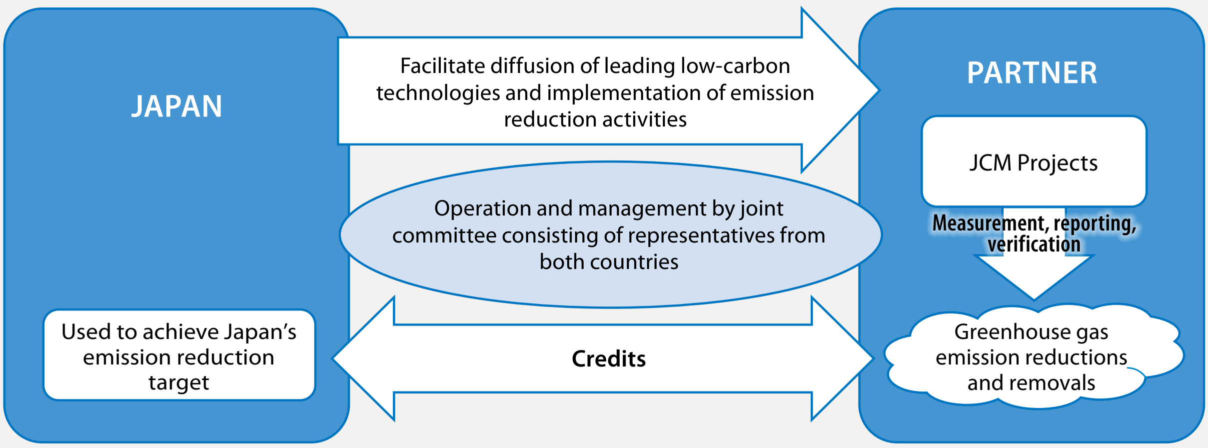
In order to successfully realize carbon neutrality across society as a whole, actions must be taken not only to decarbonize the supply side, but also to advance electrification on the demand side. The Tokyo Electric Power Company, working together with the Japan Post Group in a strategic partnership announced in April 2021, is making efforts to promote demand-side electrification. These efforts include utilizing renewable energy for the electrical power consumed at post offices, expanding the deployment of electric vehicles for postal delivery, and installing EV charging stations at post offices that can be used by customers and local businesses, among other actions.

(6) Ushering in the next-generation electric power network

In May 2021, the ten general electricity transmission and distribution utilities comprising the Transmission and Distribution Grid Council laid out a roadmap for developing the next-generation electric power network that will provide the foundation for achieving carbon neutrality. The plan encompasses key initiatives such as: systematic grid development for making renewable energy the main source of power; addressing the technological challenges brought by the increase in the ratio of non-synchronous power sources; and utilization of existing and new resources to ensure balancing capacity and increase the sophistication of grid stabilization technologies.

Schema of the Joint Crediting Mechanism

Figure 5

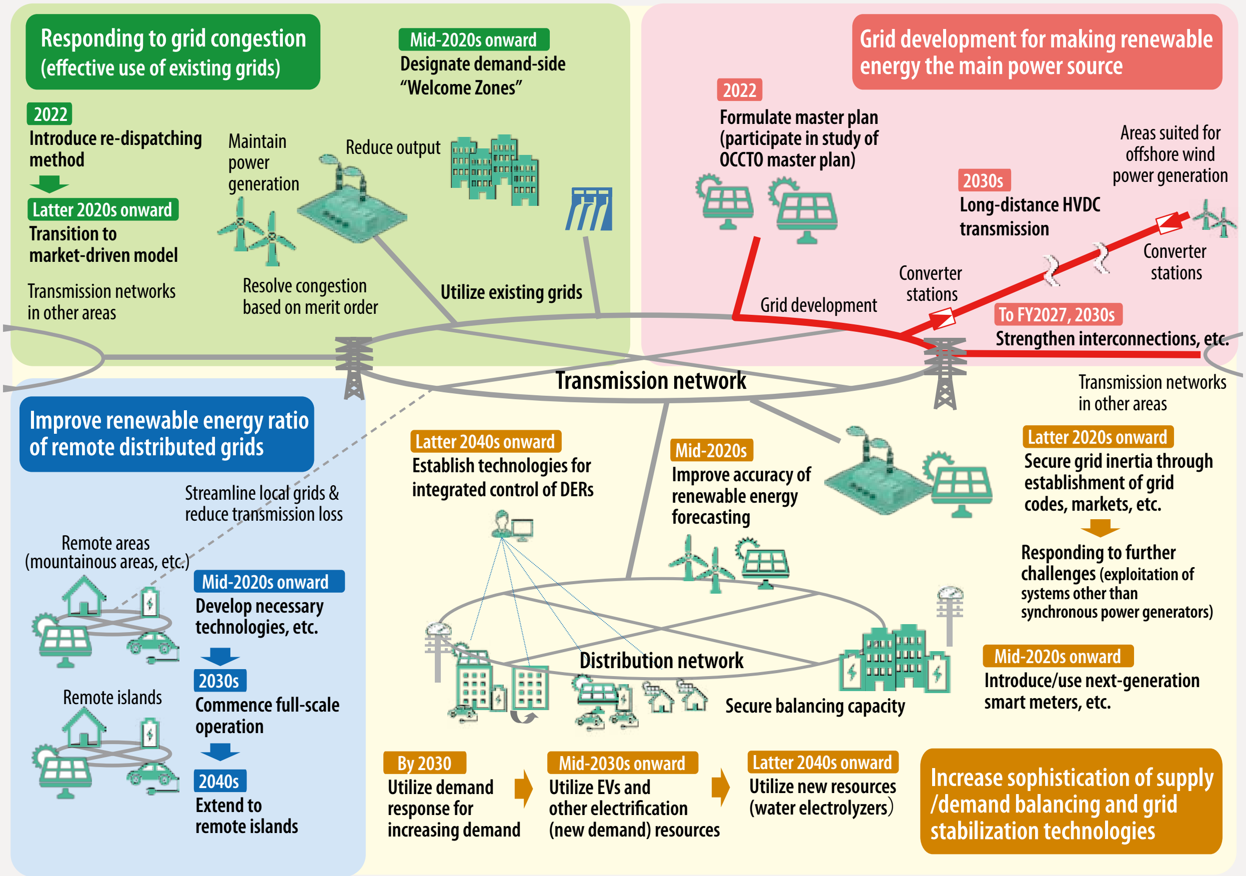


Source: Ministry of Foreign Affairs of Japan website

1 This is a program for bilateral sharing of carbon reduction effects gained through the diffusion of decarbonization technologies to developing countries. Japan has been entering into JCM consultations with developing countries since 2011. To date, JCMs have been established with Mongolia, Bangladesh, Ethiopia, Kenya, Maldives, Vietnam, Laos, Indonesia, Costa Rica, Palau, Cambodia, Mexico, Saudi Arabia, Chile, Myanmar, Thailand, and the Philippines.

Overview of next-generation electric power network for achieving carbon neutrality in 2050

Figure 6



Source: Transmission and Distribution Grid Council, "Toward Carbon Neutrality in 2050"

STATISTICAL DATA

Electric Power Generation*

[TWh]

FY	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Hydroelectric	**91.7**	**83.6**	**84.9**	**86.9**	**91.4**	**84.6**	**90.1**	**87.4**	**86.3**	**86.3**
Electric Utilities	74.4	67.4	68.6	70.3	74.9	81.9	87.9	85.0	84.3	84.5
Industry-owned	17.3	16.3	16.3	16.7	16.5	2.7	2.3	2.4	2.0	1.8
Thermal**	**906.9**	**986.8**	**987.3**	**955.4**	**908.8**	**877.0**	**861.4**	**823.6**	**792.9**	**790.0**
Electric Utilities	678.5	735.9	743.1	717.8	675.7	794.4	777.5	726.2	696.2	697.9
Industry-owned	228.4	250.8	244.2	237.6	233.1	82.6	83.9	97.4	96.7	92.1
Nuclear	**101.8**	**15.9**	**9.3**	**–**	**9.4**	**17.3**	**31.3**	**62.1**	**61.0**	**37.0**
Electric Utilities	101.8	15.9	9.3	–	9.4	17.3	31.3	62.1	61.0	37.0
Industry-owned	–	–	–	–	–	–	–	–	–	–
Wind Power	**4.7**	**4.8**	**5.2**	**5.0**	**5.2**	**5.5**	**6.1**	**6.5**	**6.9**	**8.3**
Electric Utilities	0.2	0.2	0.2	0.0	0.1	5.0	5.5	5.9	6.3	7.6
Industry-owned	4.5	4.7	5.0	5.0	5.1	0.5	0.7	0.6	0.6	0.7
Solar	**0.1**	**0.2**	**1.2**	**3.8**	**6.8**	**11.1**	**15.9**	**18.5**	**21.4**	**25.0**
Electric Utilities	0.0	0.1	0.1	0.1	0.1	6.5	8.7	10.8	13.2	16.2
Industry-owned	0.0	0.1	1.1	3.7	6.7	4.6	7.2	7.7	8.2	8.8
Geothermal	**2.7**	**2.6**	**2.6**	**2.6**	**2.6**	**2.2**	**2.1**	**2.1**	**2.1**	**2.1**
Electric Utilities	2.5	2.5	2.4	2.4	2.4	2.2	2.1	2.1	2.0	2.0
Industry-owned	0.2	0.1	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1
Others	**–**	**–**	**–**	**–**	**–**	**0.3**	**0.3**	**0.2**	**0.2**	**0.2**
Electric Utilities	–	–	–	–	–	0.3	0.3	0.2	0.2	0.2
Industry-owned	–	–	–	–	–	–	–	–	–	–
Total	**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**	**949.0**
Electric Utilities	857.4	822.0	823.7	790.6	762.6	907.6	913.2	892.2	863.2	845.4
Industry-owned	250.4	272.0	266.8	263.2	261.6	90.4	94.1	108.2	107.6	103.6

*Figures for industry-owned generation represent the total amount generated by power plants with a generating capacity of 1,000kW or above.
*In conjunction with the launch of the licensing system in fiscal 2016, certain utilities' electricity generated that had been counted under "Industry-owned" up through fiscal 2015 has been counted under "Electric Utilities" since fiscal 2016. **Including biomass and waste-to-energy.

Source : METI (2011-2020)

Electric Power Consumption

[TWh]

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

	FY	2016	2017	2018	2019
Low Voltage	Residential	272.9	280.4	271.4	267.7
	Commercial and Industrial	37.9	38.4	37.1	35.7
Specified-Scale Demand*	High Voltage	308.3	310.6	307.8	302.8
	Extra-High Voltage	231.4	233.8	236.3	229.9
Specified Supply**		6.0	6.1	6.3	6.2
Self-Consumption		43.2	45.1	37.4	34.9
Supplied by Electric Utilities		**899.8**	**914.4**	**896.2**	**877.1**
Power Generated and Consumed by Privately-owend Power Facilities		70.8	70.0	77.2	75.6
Total Consumption		**970.6**	**984.3**	**973.4**	**952.7**
Others (Last Resort Supply and Isolated Area Supply)		2.3	2.3	2.3	2.2

*Contracted demand of 50 kW or above (in principle) received from general electricity utilities or specified-scale electricity suppliers.
**System that permits an electricity supplier to directly supply electricity to a consumer with which it shares a close relationship in manufacturing processes, capital, etc., without having to register as an electricity retailer.

Source: METI

Installed Generating Capacity*

[MW]

FY	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Hydroelectric	**48,419**	**48,934**	**48,932**	**49,597**	**50,035**	**50,058**	**50,014**	**50,037**	**50,033**	**50,033**
Electric Utilities	44,168	44,651	44,676	45,403	45,786	49,521	49,562	49,582	49,635	49,635
Industry-owned	4,250	4,282	4,256	4,194	4,248	536	452	455	398	398
Thermal**	**185,309**	**188,903**	**191,258**	**193,356**	**190,805**	**193,910**	**193,462**	**193,026**	**189,784**	**191,758**
Electric Utilities	136,132	139,794	141,901	143,777	143,040	174,392	173,261	171,469	168,760	170,260
Industry-owned	49,177	49,109	49,357	49,579	47,765	19,517	20,201	21,557	21,024	21,498
Nuclear	**48,960**	**46,148**	**44,264**	**44,264**	**42,048**	**41,482**	**39,132**	**38,042**	**33,083**	**33,083**
Electric Utilities	48,960	46,148	44,264	44,264	42,048	41,482	39,132	38,042	33,083	33,083
Industry-owned	–	–	–	–	–	–	–	–	–	–
Wind Power	**2,419**	**2,562**	**2,646**	**2,750**	**2,808**	**3,203**	**3,483**	**3,498**	**3,951**	**4,119**
Electric Utilities	85	83	82	30	50	2,893	3,091	3,165	3,580	3,750
Industry-owned	2,334	2,479	2,563	2,720	2,758	310	391	332	371	369
Solar	**85**	**267**	**1,559**	**4,085**	**5,624**	**9,110**	**12,592**	**14,974**	**16,522**	**19,028**
Electric Utilities	61	65	67	81	87	5,655	7,318	8,922	10,549	12,408
Industry-owned	24	202	1,492	4,005	5,536	3,455	5,274	6,052	5,973	6,620
Geothermal	**537**	**512**	**512**	**508**	**517**	**526**	**471**	**473**	**481**	**487**
Electric Utilities	502	477	477	473	473	511	466	463	463	469
Industry-owned	35	35	35	35	43	15	5	11	18	18
Others	–	–	–	–	–	**64**	**54**	**43**	**43**	**43**
Electric Utilities	–	–	–	–	–	64	54	43	43	43
Industry-owned	–	–	–	–	–	0	0	0	0	0
Total	**285,729**	**287,327**	**289,171**	**294,560**	**291,836**	**298,352**	**299,209**	**300,093**	**293,897**	**298,550**
Electric Utilities	229,908	231,219	231,468	234,028	231,484	274,519	272,885	271,685	266,112	269,648
Industry-owned	55,821	56,107	57,703	60,532	60,352	23,834	26,324	28,407	27,785	28,903

*Figures represent the total amount generated by power plants with a generating capacity of 1,000kW or above.
*In conjunction with the launch of the licensing system in fiscal 2016, certain utilities' power generation facilities that had been counted under "Industry-owned" up through fiscal 2015 have been counted under "Electric Utilities" since fiscal 2016.
**Including biomass and waste-to-energy.

Source : FEPC (2011-2015), METI (2016-2020)

Transmission, Substations and Distribution Facilities of General Electricity Transmission and Distribution Utilities (As of March 31, 2021)

Voltage [kV]	Transmission Lines [km]				Substations	
	Route length		Circuit length		Number	Output Capacity [MVA]
	Overhead	Underground	Overhead	Underground		
500	8,044	113	15,602	201	85	228,650
275	7,449	611	14,727	1,524	162	176,165
220	2,617	61	5,028	134	71	43,860
187	2,686	15	5,227	35	48	19,005
110–154	15,495	1,045	28,221	1,974	758	161,939
66–77	38,303	7,438	68,537	13,421	4,665	229,019
≦55	13,719	6,153	14,955	10,145	1,348	9,919
Total	**88,312**	**15,436**	**152,295**	**27,435**	**7,137**	**868,556**

Distribution Lines [km]				Transformers	
Route length		Circuit length		Output Capacity [MVA]	
Overhead	Underground	Overhead	Underground	Overhead	Underground
954,994	44,071	4,046,028	73,995	348,689	35,967

Source : FEPC

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

FY	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Peak Load [GW]	156.4	157.2	161.6	154.3	161.2	156.2	157.1	159.7	158.7	159.2
Supply Capability [GW]	175.9	176.9	179.5	179.8	184.2	180.4	185.2	178.9	178.4	167.3
Annual Electricity Demand [TWh]	926.8	914.7	917.5	898.9	888.2	887.1	892.6	886.9	879.9	850.8
Reserve [GW]*	19.5	19.7	17.9	25.6	23.0	24.2	28.1	19.2	19.7	8.1
Reserve Margin [%]*	12.5	12.6	11.1	16.6	14.3	15.5	17.9	12.0	12.4	5.1
Load Factor [%]**	67.4	66.4	64.8	66.5	62.9	64.8	64.9	63.4	63.3	61.0

* 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 (2015-2020)

Summarized Comparative Table Classified by Country for the Year 2019

	USA	UK	France	Germany	Russia	China	India*	Japan
Total Installed Capacity [MW]	**1,212,584**	**77,898**	**135,328**	**226,396**	**275,800**	**2,010,060**	**411,773**	**293,897**
Hydroelectric	100,816	4,365	25,557	14,662	51,800	358,040	45,447	50,033
Thermal	829,875	43,910	18,589	78,529	191,900	1,189,570	282,350	189,784
Nuclear	106,351	9,261	63,130	9,516	30,300	48,740	6,780	33,083
Renewables and others	175,542	20,362	28,051	123,688	1,700	413,710	77,916	20,997
Total Energy Production [GWh]	**4,131,152**	**323,801**	**537,700**	**609,406**	**1,121,000**	**7,326,900**	**1,521,785**	**970,771**
Hydroelectric	287,949	7,602	60,000	19,730	196,000	1,302,100	134,991	86,314
Thermal	2,569,164	146,319	42,600	266,223	714,000	5,046,500	1,244,959	792,810
Nuclear	809,057	56,184	379,500	75,071	209,000	348,700	37,813	61,035
Renewables and others	464,981	113,694	55,600	248,382	2,100	629,600	104,022	30,612
Capacity Factor [%]	–	42.4	45.4	30.7	–	43.7	56.0	35.0
Total Energy Production per Capita [kWh]	12,586	4,847	8,295	7,340	7,638	5,233	1,172	7,688
Domestic Energy Supplies [GWh]	4,150,188	328,198	473,410	–	1,110,100	6,283,500	–	–
Energy Sales [GWh]	3,811,151	273,493	–	439,830	–	5,911,100	1,209,972	836,038
Number of Customers [At year-end; thousand]	154,898	31,275	–	–	–	603,454	298,877	88,329
Maximum Demand [MW]	786,214	48,230	88,500	–	151,700	–	183,804	164,610
Annual Load Factor [%]	59.9	70.5	61.1	–	79.7	–	–	60.7
Thermal Efficiency [%]	–	32.2	–	43.7	40.5	40.1	–	–
Loss Factor (Transmission and Distribution) [%]	5.1	8.0	7.7	–	–	5.9	20.7	–
Total Consumption per capita [kWh]	–	4,431	6,739	6,107	6,888	5,186	932	7,545

*Figures other than Capacity Factor and Maximum Demand represent the actual figures for 2018.

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
Tohoku	Falcon Gas Thermal IPP	Mexico	CCGT	2,233	10	2001
JERA	Falcon Gas Thermal IPP	Mexico	CCGT	2,233	20	2001
JERA	Linden Gas Thermal IPP	USA	Gas	972	50	1992 (Unit1-5), 2002 (Unit 6)
Kansai	Aviator	USA	Onshore Wind	525	48.5	2020
Chugoku	South Field Energy	USA	CCGT	1,182	10.0	2021
Shikoku	Huatacondo	Chile	PV	98	30	2019
Shikoku	South Field Energy	USA	CCGT	1,182	9	2021
Kyushu	South Field Energy	USA	CCGT	1,182	18.1	2021
Kyushu	Thermochem, Inc	USA	Geothermal Services	–	(Private)	–
Kyushu	Project on Master Plan Study for Development of Renewable Energy with Stabilization Measures for the National Electric System	Cuba	Consulting	–	–	2020
J-POWER	Jackson	USA	CCGT	1,200	100	2022
J-POWER	Refugio	USA	Solar	400	25	2023

Europe

Company	Project	Location	Type	Capacity [MW]	Equity [%]	COD
Tokyo	TetraSpar floating offshore wind demonstration project	Norway	Floating Offshore Wind	4	30	2021
Chubu	Offshore Transmission Business (Hornsea One)	UK	Transmission	–	49	2021
Chubu	Acquisition of 20% shares of Eneco Group	Netherlands	Integrated Energy Business	–	20	2020
JERA	Gunfleet Sands Offshore Wind IPP	UK	Offshore Wind	173	25	2010
Kansai	Moray East	UK	Offshore Wind	952	10	2022
Kansai	Electricity North West	UK	Distribution	–	22	–
J-POWER	Triton Knoll	UK	Offshore Wind	857	25	2022

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	Dhaka underground substation	Bangladesh	Consulting	–	–	2024
Chubu	New Clark City	Philippines	Distribution and Retail	–	9	2019
JERA	TeaM Energy IPP	Philippines	Coal/Gas	3,592	10~50	–
JERA	EGCO Corporation	Thailand	Gas/Coal/Renewable	6,016	12.3	–
JERA	ReNew Company	India	Solar/Wind	8,271	8	–
Kansai	Nam Ngiep 1	Laos	Hydro	290	45	2019
Kansai	New Clark City	Philippines	Distribution and Retail	–	9	2019
Chugoku	Yunlin	Taiwan	Offshore Wind	640	3.375	2022
Chugoku	Feng Ping Xi	Taiwan	Hydro	37.1	25.0	2024
Shikoku	Ahlone	Myanmar	CCGT	121	28.5	2013
Shikoku	Yunlin	Taiwan	Offshore Wind	640	4.4	2022
Kyushu	Sarulla/Geothermal IPP	Indonesia	Geothermal	330	25	2017
Kyushu	EGCO	Thailand	Electric Business	5,691	6.1	–
J-POWER	Central Java	Indonesia	Coal (USC)	2,000	34	2022

Others

Company	Project	Location	Type	Capacity [MW]	Equity [%]	COD
Hokuriku	Fujairah F3 IPP	United Arab Emirates	CCGT	2,400	19.6	2023
Chugoku	Energy Fiji Limited	Fiji	Electric Company	329	44	–
Kyushu	Taweelah B IWPP	United Arab Emirates	Hydro	2,000	6	2020
Kyushu	Execution of Agreement on "The Project for Capacity Development of Power Transmission Systems in Kenya“ With JICA	Kenya	Consulting	–	–	2021
Okinawa	Project for Introduction of Hybrid Power Generation System in Pacific Island Countries	Fiji, Tuvalu, Kiribati, Federated States of Micronesia (FSM), Republic of the Marshall Islands (RMI), Samoa, Tonga, Cook Islands, Nauru, Papua New Guinea, Solomon Islands and Palau	ODA	–	–	2017-2022
J-POWER	K2-Hydro	Australia	Hydro (Pumped-Storage)	250	10	2024

Participation in the Solar Power Generation Project in Mexico (2020-)

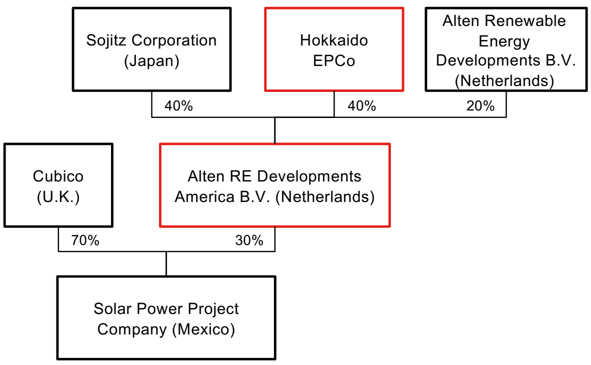
Hokkaido Electric Power Co., Inc. (HEPCO) is participating in the operation of a solar power plant in Mexico through an equity stake in Alten RE Developments America B.V., which invests in solar power generation businesses.

- Project Summary

  Power generated by a 290 MW 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

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

- HEPCO's equity

  HEPCO, through its equity stake in Alten RE Developments America B.V., owns a 12% stake in the solar power generation 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 Sumatra, 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

Participation in TetraSpar floating offshore wind demonstration Project in Norway

TEPCO RP has participated in the TetraSpar floating foundation demonstration project, alongside Shell, RWE, and Stiesdal Offshore Technologies.

Assembled in the port

Installed in the Metcenter Test site in Norway

- Purpose
  - Promote the transition to renewable energies as primary energy sources.
  - Expand the possibilities of offshore wind power and contribute to the realization of a clean and sustainable carbon-neutral society.
- Facilities
  - Location: Metcenter Test site (Stavanger, Norway)
  - Type: TetraSpar floating offshore wind foundation
  - Capacity: 3.6MW
  - Partnership: Shell 46.2%. TEPCO RP 30.0%. RWE 23.1%. Stiesdal Offshore Technologies 0.7%
  - COD: 2021
- Features
  - TetraSpar floating offshore wind foundation is suitable for Japan's ocean and weather climate, and is expected to make it easier to build regional supply chains and keep costs low.

Underground substation project in Bangladesh (Dhaka)

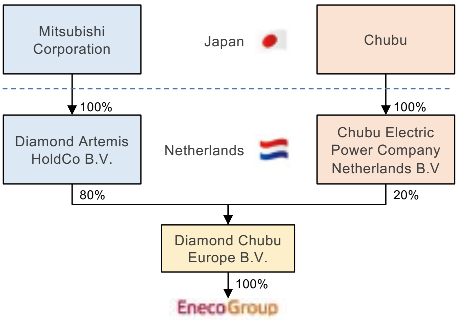
Consulting services for underground substation (March 2019 - June 2025)

- Purpose
  - Use limited land space effectively in Dhaka, which has an extremely high population density
  - Enable the stable supply of electricity and create improvements in power demand conditions
- Features
  - First underground substation (UGSS) in Dhaka
  - Structure of the facility: 132/33/11 kV
  - Above-ground: Commercial building
  - Client: Dhaka Electric Supply Company Limited (DESCO), Bangladesh
- TEPCO's consulting services
  - Network requirements study
  - Location selection for UGSS
  - Specifications study for substation, equipment and underground cabling
  - Joint studies with local partners on civil and architectural issues
  - Connection study between UGSS and underground tunnel
  - Coordination study for superstructure design
  - Transportation study from ground level into UGSS

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 2020

Total revenues	€ 4,148 million
Net Result	€ 118 million
Number of customer contracts	5.9 million
Number of employees	About 3,000 FTE※
Franchise Area	Netherlands, Belgium, Germany, UK

※full time equivalent

➢ 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.

JERA

Linden Gas Thermal IPP

➢ Purpose

Linden is a co-generation facility, supplying electricity to the wholesale market of New York and steam to the local industry of New Jersey.

➢ Features

- Capacity : 972MW
- Type: Combined Cycle Power Generation (Unit 1 ~ 5)
  Gas Turbine Power Generation (Unit 6)
- Fuel: Natural gas
- Location: Linden, New Jersey, U.S.A.
- COD: 1992 (Unit 1 ~ 5)
  2002 (Unit 6)

➢ Notes

Retrofitting the combustion system to enable co-firing of refinery produced fuel including hydrogen at Unit 6 with the target completion around 2022.

Hokuriku Electric Power Co.

Fujairah F3 IPP Project in UAE

Hokuriku Electric Power Company acquired 19.6% interest in the project and 34% shares of the company, that will undertake operation and maintenance, in March 2021.

- Purpose
  - Overseas business expansion by utilizing the knowledge and experience of power plant operation.
- Features
  - Type : CCGT
  - Capacity : 2,400MW
  - COD : April 2023
  - Offtake : PPA with EWEC
- Shareholders of the Project (As of July 2021)
  - Project Company
    - TAQA and Mubadala Investment Company, Local Shareholders representing the Emirate of Abu Dhabi, UAE 60.0%
    - Marubeni Corporation 20.4%
    - Hokuriku Electric Power Company 19.6%
  - O&M Company
    - Marubeni Corporation 66.0%
    - Hokuriku Electric Power Company 34.0%

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%
  - The other partners : 51%

Nam Ngiep 1 Hydropower Project

- Location
  - On the Nam Ngiep River (A Tributary of the Mekong River) in Laos
- Features
  - Hydropower Plant
  - Name : Nam Ngiep 1
  - Large-Scale Dam (167m high and 530m long in its dam crest)
  - Capacity :
    - Main Power Station 272MW
    - Re-regulation Power Station 18MW
- Partners
  - The Kansai Electric Power CO., Inc. (KPIC Netherlands B.V.) : 45%
  - EGAT International : 30%
  - Lao Holdings State Enterprise : 25%

Chugoku Electric Power Co.

Participation in Energy Fiji Limited in Fiji (2021)

The Government of Fiji aims to promote renewable energy usage up to 100% in the country by 2036.
We intend to accelerate renewable energy development such as hydro power and solar power in the country with Energy Fiji Limited.

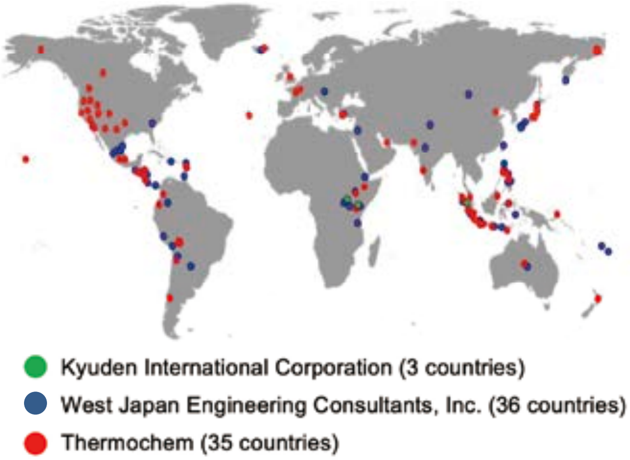
- Features
  - Project: Energy Fiji Limited
  - Location: Fiji
  - Capacity: 329MW
    Diesel:181MW, Hydro:138MW, Wind:10MW
  - Equity Share: 44.0%

Kyushu Electric Power Co.

Integrated Geothermal Technical Company "Thermochem“ in USA & Indonesia

Kyuden International Corporation and West Japan Engineering Consultants, Inc., both companies of the Kyuden Group, executed a share purchase agreement for the acquisition of Thermochem

Countries / regions with a track record of geothermal work



➢ Company profile of Thermochem

Company name	Thermochem, Inc., and PT. Thermochem Indonesia
Headquarters	Santa Rosa, California, USA, and Bandung, Indonesia
Established	1983 (USA), 1998 (Indonesia)
Main services	(1) Technical Services (2) Design, development and manufacture of specialized equipment and instrumentation (3) Consulting services

➢ Purpose

- Increase their individual impact and contribute to the geothermal industry
- Expand the presence in the international geothermal power generation business
- Achieve equity ownership of 5,000MW by 2030

JICA Technical Consulting Project in Republic of Cuba

JICA Project for Formulating Power Sector Renewable Energy Master Plan

Conference for renewable energy master plan survey

➢ Counterparts
- Unión Nacional Eléctrica
- Ministerio de Energía y Minas

➢ Purpose
- Expand the usage of renewable energy in Republic of Cuba

➢ Activities on this project
- Evaluate renewable energy potential
- Propose the way of national power system stability
- Formulate the master plan of the electric utility sector
- Improve engineer’s skills

➢ Period
- From March 2021 (2 years)

Okinawa Electric Power Co.

Technical Cooperation in Pacific Island Countries

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), Republic of the Marshall Islands (RMI), Samoa, Tonga, Cook Islands, Nauru, Papua New Guinea, Solomon Islands and Palau
- 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

Construction site of the Jackson power plant, as of June, 2021

- Features
  - Announced in June 2019
  - 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 as merchant plant
- Overview
  - Capacity: 1,200 MW (600 MW x 2 units)
  - Fuel: Natural Gas
  - Technology: CCGT
  - Equity Ownership: 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 of North Sea, east of England

Location of the Triton Knoll Offshore Wind Farm

Construction site of the Triton Knoll Offshore Wind Farm, as of March, 2021

- Features
  - First overseas offshore wind project among Japanese Power Utilities
  - Participated in August 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) scheme 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: 2022

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.

Tokai Training Center

Preparation of master plan for introduction of nuclear power

Nuclear power plant simulator

- Purpose
  - Education and Training
  - Supporting to introduce NPP
  - Enhancing the relationship
- Facilities
  - Tokai and Tsuruga training center
  - NPP simulator
- Results
  - We have provided education for approximately 23 countries, 560 people. In addition, we can support FS for NPP introducing based on our experiences.

Member Companies Data (As of March 31, 2021) *

	FY 2020			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	740,790	22,683	1,651	4,469	2,070	–	8,190
Tohoku EPCo	251,441	2,286,803	65,952	2,556	12,073	2,750	243	17,622
TEPCO HD	1,400,975	5,866,824	204,484	9,874	–	8,212	51	18,137
Chubu EPCo	430,777	2,935,409	110,729	5,463	–	3,617	88	9,167
Hokuriku EPCo	117,641	639,445	25,940	1,963	4,565	1,746	–	8,274
Kansai EPCo	489,320	3,092,398	102,331	8,235	14,566	6,578	11	29,391
Chugoku EPCo	197,024	1,307,498	46,390	2,905	6,951	820	6	10,682
Shikoku EPCo	145,551	719,231	21,986	1,153	3,395	890	2	5,440
Kyushu EPCo	237,304	2,131,799	75,171	3,584	10,010	4,140	213	17,948
Okinawa EPCo	7,586	190,520	7,137	–	2,145	–	2	2,147
J-POWER	180,502	909,144	–	8,560	8,773	–	580	17,913
JAPC	120,000	96,336	–	–	–	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 (Japan Atomic Power Company data are from summary statement of business)

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	2,730,146	–	–	65,476	–	–	65,476

Source: Financial statement

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COVER PHOTO:

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Member Companies (As of February 2022)

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http://www.tohoku-epco.co.jp/english/

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

Chubu Electric Power Co., Inc.
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http://www.chuden.co.jp/english/

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

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

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

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

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

The Okinawa Electric Power Co., Inc.
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http://www.okiden.co.jp/en/

Electric Power Development Co., Ltd. (J-POWER)
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http://www.jpower.co.jp/english/

The Japan Atomic Power Co.
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