The Electric Power Industry in Japan
2024

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.

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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 8, 2023, unless otherwise specified.

Extreme weather conditions and increasingly devastating natural disasters around the world have made climate change a critical issue that requires action by the entire international community. Japan has internationally expressed its strong commitment to tackling this challenge as a nation, pledging to reduce its greenhouse gas emissions by 46% by fiscal 2030 and to become carbon neutral by 2050. Meanwhile, in the wake of the Russian invasion of Ukraine, the need to secure a stable supply of the energy that provides the foundation for everyday life and economic activities has become all the more a crucial challenge.

The Japanese government is seeking to simultaneously realize decarbonization, stable supply of energy, and economic growth by advancing "Green Transformation" (GX). This initiative aims to shift industry and society from a structure that has heavily depended on fossil fuels since the Industrial Revolution to one that uses an energy mix centered on clean energy. In February 2023, the Cabinet approved the Basic Policy for the Realization of GX, which rests on two pillars: (1) maximizing the use of renewable energy, nuclear power, and other decarbonized energy sources that help increase Japan's energy self-sufficiency, while also thoroughly implementing energy efficiency improvements, and (2) putting into action the Pro-Growth Carbon Pricing Concept, including by supporting bold initial investment that leverages GX Economy Transition Bonds.

In May 2023, the Diet passed the Act on Power Sources for Green Transformation and Decarbonization and the GX Promotion Act, resulting in the amendment of various related laws. The first one includes concrete measures for promoting maximum utilization of renewable energy in harmony with local communities, and for utilizing nuclear power based on the overriding premise of ensuring safety. The nuclear energy measures include building innovative next-generation reactors at nuclear power plants whose existing reactors are scheduled for decommissioning, and effectively making it possible for reactors to operate for more than 60 years after their commissioning by excluding periods of shutdown due to difficult-to-foresee circumstances from the calculation of the one-time 20-year extensions that may be added to the 40-year limit on operation. These and the other nuclear energy measures represent a profound shift from the policy of reducing nuclear dependence that the government adopted following the Great East Japan Earthquake.

The GX Promotion Act mandates the government's issuance of GX Economy Transition Bonds worth 20 trillion yen over a ten-year period starting in fiscal 2023. The funds will be used to support innovative technological development and capital investment that promise to help decarbonize energy and raw materials, improve earnings, and achieve other benefits.

Acceleration of the GX initiative is expected to provide impetus for realizing stable supply of energy and for putting Japan's economy back on a growth trajectory.

This year's Topics section presents some of the initiatives that electric power companies are implementing to strengthen disaster prevention and resilience.

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. As of August 1, 2023, the number of operators in these sectors was 1,084, 39, and 730, respectively.

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 issued a draft of the Sixth Strategic Energy Plan in July 2021, and then approved the plan in October.

- International developments surrounding the crisis in Ukraine have brought into relief the risks posed by dependence on a single country for the supply of fossil fuels and resources. Resource-poor Japan has come to recognize the importance of putting together a well-balanced electric power portfolio.

- The government held the first meeting of the GX Implementation Council in July 2022 as part of its efforts to achieve energy security and decarbonization. The Basic Policy for the Realization of GX was approved by the Cabinet in February 2023, followed in May by the Diet's passage of the Act on Power Sources for Green Transformation and Decarbonization and the GX Promotion Act.

- 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. Of them, 24 were selected for decommissioning. As of October 2023, 12 of the remaining 36 (including three under construction) were back in operation.

- The operational life of nuclear reactors is capped at 40 years in principle, and may not be extended without the permission of the Minister of Economy, Trade and Industry. The maximum extension of 20 years now excludes periods of reactor shutdown due to circumstances that the nuclear power plant operator could not readily foresee (such as changes in safety regulations, or the issuance of administrative guidance or injunctions), and thus reactors could effectively operate for more than 60 years after their commissioning.

- Installed capacity of renewables (especially solar) began increasing in 2012 as the result of a feed-in tariff (FIT) scheme. In April 2022, the government launched a feed-in premium scheme that adds premiums to the market prices of power sources such as large-scale commercial solar and wind power, with the aim of firmly establishing renewables as the main source of electricity.

- The government's current energy policy positions offshore wind power, which can be introduced on a large scale at comparatively lower cost, as the trump card for making renewables the main source of electric power. The goal is to achieve a total installed capacity of 10 GW by 2030, and of 30 to 45 GW by 2040. In 2021, the government selected developers by tender to carry out projects in promotion zones it designated.

- In fiscal 2021, Japan's GHG emissions measured 1,170 million tons (CO_2 equivalent), and emissions of CO_2 accounted for 90.9% of this total, down 19.2% from the fiscal 2013 level.

III. SUPPLY AND DEMAND

- In fiscal 2022, electricity demand[1] in Japan was 866.5 TWh (down 1.7% YoY) and the peak load 3-day average came to 160.5 GW (down 1.1% YoY).

- In fiscal 2022, electric power generated[2] in Japan came to 832.7 TWh (down 3.6% YoY), of which 21.8 TWh was generated by solar power and 7.4 TWh by wind power.

- Deterioration of the electric power generation industry's operating environment has led to a spate of thermal power plant shutdowns and closures in recent years, prompting concern over the stability of electricity supply. There is concern that a one-in-ten-year weather event could reduce power reserves below the 3% margin in some service areas.

- Electricity supply was strained in the early half of 2022 by abnormal weather events that occurred outside the summer and winter peak demand periods. Unseasonal cold and heat waves prompted the government to issue an electricity supply warning in March and an advisory in June.

- Measures being taken to ease strain on electricity supply include changing the timing of inspection and maintenance, securing supply capacity through markets, demand response, and interregional electric power sharing, and implementing energy efficiency programs for customers.

- The Russian invasion of Ukraine prompted ongoing concern over the uncertain future of fuel procurement. As a step toward ensuring stable supply of liquified natural gas (LNG), the government is considering establishing a new scheme whereby businesses would maintain extra inventory.

IV. ELECTRIC POWER FACILITIES

- Total generating capacity in Japan came to 318.6 GW at the end of fiscal 2022. This consisted of 47.5% thermal power (15.9% coal, 24.8% LNG, and 6.8% oil), 10.4% nuclear power, 15.4% hydro, and 26.0% renewables (excluding hydro). Development of 120 GW of generating capacity is planned to be completed by the end of fiscal 2032. This portion made up by new power plants to be constructed and planned changes in capacity of existing plants, excluding planned decommissioning, consists of 0.4 GW of hydro, 1.7 GW of thermal power, 7.9 GW of renewables (excluding hydro), and 10.3 GW of nuclear power.

- The Agency for Natural Resources and Energy issued the Guidelines for the Long-term Decarbonized Power Supply Auction in July 2023 to encourage new investments in power sources. In order to achieve greater predictability of investment returns, electricity generation utilities are provided with capacity revenue for 20 years, in principle.

- Plans have been laid out for the enhancement of the electrical grid's interregional interconnections in order to improve infrastructure resilience and realize interregional utilization of distributed energy sources.

- With regard to the cost burden of construction for expanding interregional interconnections, the Act on Power Sources for Green Transformation and Decarbonization has made it possible to use FIT surcharges

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

to offset the costs associated with the decrease in electricity value expected to result from the adoption of renewable energy, and with providing the social benefit of CO_2 emissions reduction. The remainder is covered by general electricity transmission and distribution utilities nationwide and by grants from OCCTO.

V. RETAIL BUSINESS AND TRADING MARKETS

- The number of registered electricity retailers has trended upward since the full liberalization of the retail electricity market in April 2016. As of March 2023, there were 721 retailers, with PPSs accounting for a 17.7% share of the total volume of electricity sold.

- The sharp rise in fuel prices and wholesale power market prices that has persisted since the early fall of 2021 was exacerbated by the Ukrainian crisis, placing electricity retailers under considerable strain. As of March 2023, 195 PPSs had been forced to file for bankruptcy, close, or exit the market.

- In May 2023, seven former general electricity utilities received government approval for rate hikes in order to avoid having the financial pressures on them jeopardize the stable supply of energy. The rate hikes ranged from 14% to 42%.

- The volume of trades on the JEPX spot market in fiscal 2022 was 318.6 TWh (equivalent to approximately 40% of all electric power sold nationwide). The wholesale power market price was 11.49 yen/kWh in August 2023, and has fallen from fiscal 2022 levels due to skyrocketing fuel prices.

- In order to ensure the stable and fair supply of electric power, Japan has four markets that engage in trading other than electricity volume: (a) baseload power market, (b) capacity market, (c) balancing market, and (d) nonfossil value trading market.

- The "long-term decarbonized power supply auction" is scheduled to be held for part of the capacity market in fiscal 2023.

- The Ministry of Economy, Trade and Industry is considering launching a new market in which both spot market procurement and balancing market procurement would occur in parallel.

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.

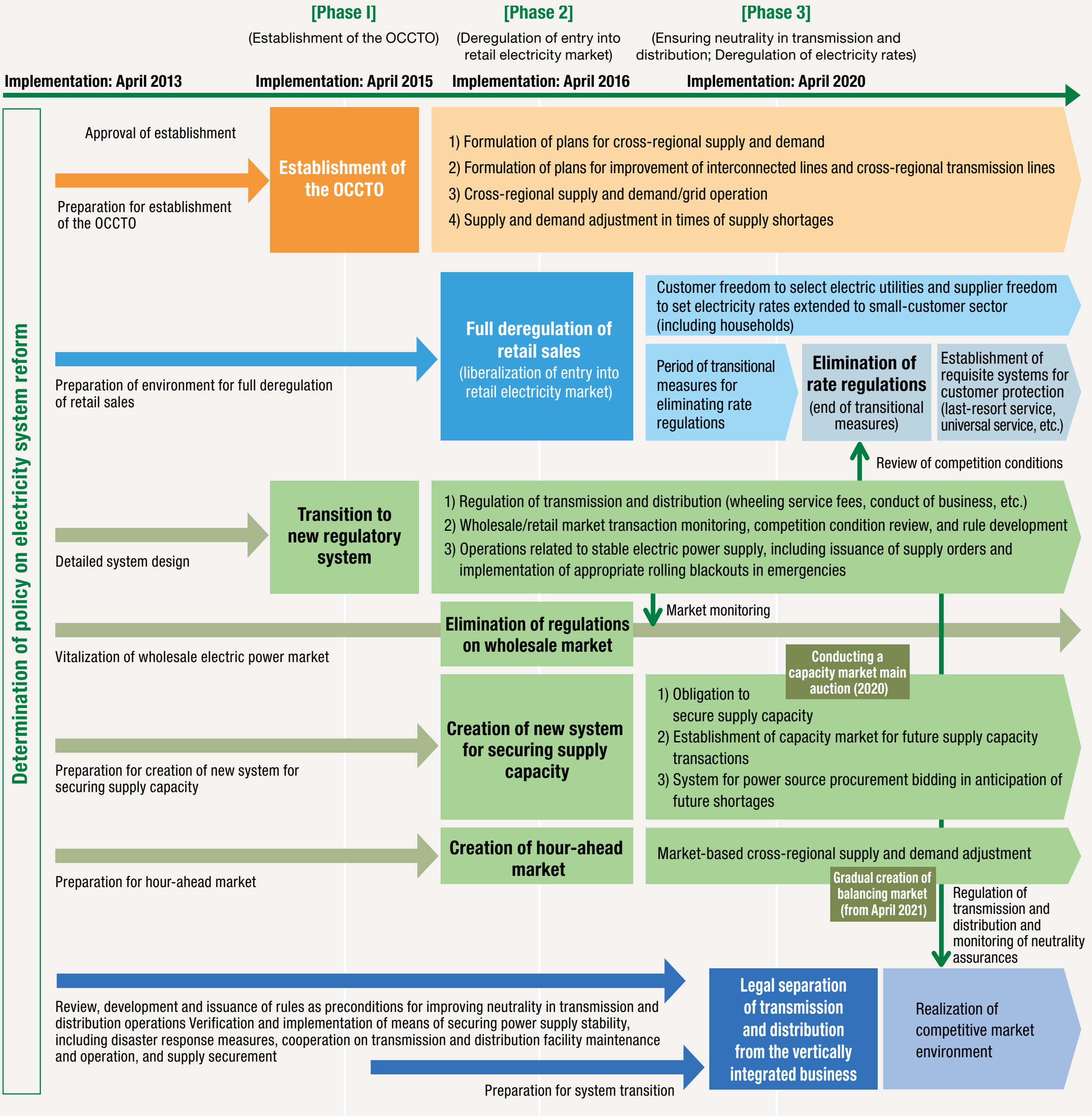
(3) Electricity System Reform

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 Gas Market Surveillance Commission) was established in

Roadmap to Electricity System Reform

Figure 1.1



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

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. The Ministry of Economy, Trade and Industry (METI) is basing its decision on when to abolish the system on criteria such as the degree of public awareness of electricity market liberalization, trends in customer switching, and the sustainability of competitive pressure and the competitive environment. However, as of June 2023, the system remained in effect in all supply areas due to the ministry's determination that the competitive pressure/ environment sustainability requirements had yet to be met (see Figure 1.1 and "1. Electricity Rates" in Section 1, Chapter V).

The necessary legal groundwork for the third phase of electricity system reform was completed with the enactment of revisions to the Electricity Business Act in November 2013, June 2014, and June 2015. As a side note, it came to light in December 2022 that certain former general electricity utilities had been viewing customer data owned by general electricity transmission and distribution utilities. Also, it was discovered in February 2023 that certain former general electricity utilities had been accessing a renewable energy business management system that it provided to general electricity transmission and distribution utilities. In response to METI orders to improve their business practices, the offending utilities have formulated improvement plans and are working to prevent recurrence of similar infractions.

(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 implementation of climate change measures, including 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 were considered, including (1) a baseload power market, (2) a capacity market, (3) a balancing market, and (4) a non-fossil value trading market. Trading has started in those markets. Trading in certain products commenced in (3) in April 2021 and April 2022, and will be gradually expanded to other products. Market (4) was split into two markets in fiscal 2021, a market for achieving the target mandated by the Sophisticated Methods Act, and a renewable energy value trading market. As part of the auctions held in (2), the Long-term Decarbonized Power Supply Auction is scheduled to be conducted in fiscal 2023 (see "Trading Markets" in Section 3, Chapter V).

2. Current Electricity Supply System

(1) Classification of Electricity Utilities

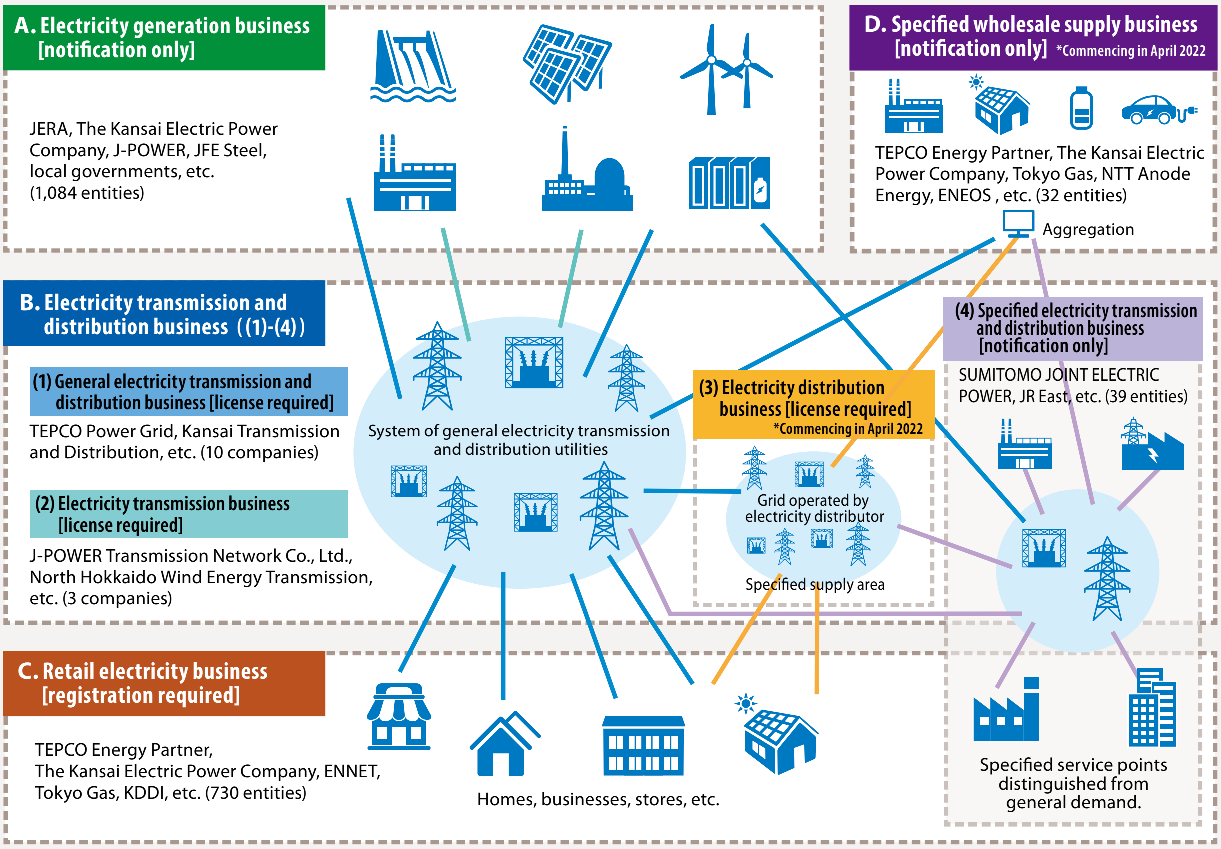
Japan's electricity utilities had been divided into the following five categories: general electricity utilities, wholesale electricity utilities, wholesale suppliers, specified electricity utilities, and power producer and suppliers (PPSs). Subsequently, with the implementation of full liberalization 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. METI's Agency for Natural Resources and Energy imposes necessary regulations for each sector. The 10 general electricity utilities that have historically been engaged in power supply since 1951 are now called "former general electricity utilities" (see Figures 1. 2 and 1. 3).

Data show that 1,084 entities had obtained power generation licenses in the electricity generation sector as of August 1, 2023, and generating capacity was 270 GW[3] as of July 2023. 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. As a result of a partial revision of the Electricity Business Act in May

3 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



Utilities maintaining and operating electricity transmission and distribution facilities
- General electricity transmission and distribution utilities
- Electricity transmission utilities
- Electricity distribution utilities
- Specified electricity transmission and distribution utilities

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.

2022, large storage batteries are now regarded as a power generation business.

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, 39 corporations (as of August 1, 2023), including Sumitomo Joint Electric Power Co., Ltd., are operating as specified electricity transmission and distribution utilities.

In the electricity retail sector, data released by Agency for Natural Resources and Energy show that a total of 730 entities had obtained retail licenses (as of August 1, 2023). In addition to the former general electricity utilities, electricity retailers include telecommunications carriers, trading companies, gas and petroleum companies, steel manufacturers, and subsidiaries of former general electricity utilities. Net system energy demand in fiscal 2022 came to 805 TWh, of which former general electricity utilities accounted for about 80%.

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, effective from April 2022. 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. According to data released by the Agency for Natural Resources and Energy, 57 entities were operating as (1) licensees as of August 7, 2023. (2) licensees balance electricity supply and demand by matching local renewables and power consumers, and engage in other distribution operations in a specified area, using the distribution grid of a general electricity transmission and distribution utility. As of August 1, 2023, no entities had been licensed for (2). (For more information on (2), see section 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 collect reports, 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:

- Securing stable electricity supply on short-, medium-, and long-term basis
  - Collect all supply plans and use this information to perform centralized evaluation of supply-demand balance nationwide
  - Study, design in detail, and run the capacity market, and

study and design in detail the balancing market
- Formulate cross-regional network long-term policy and development plans

■ Promoting the fair, equitable, and efficient use of electricity transmission and distribution facilities
- Formulate/revise guidelines on implementation of transmission/distribution businesses
- Review the methods of interconnection line use
- Accept system impact studies of generation facilities
- Take action to facilitate network use and lower the cost
- Study new rules for network use

■ Monitoring nationwide conditions of supply-demand and network operation
- Monitor supply-demand and network operation conditions 24 hours a day, 365 days a year
- Track nationwide supply-demand balance by managing the annual, monthly, weekly and day-ahead plans
- Instruct electricity companies to transmit or receive power when their supply-demand balance becomes unstable
- Provide training for dealing with supply shortages

■ New functions added by the Act for Establishing Energy Supply Resilience (enacted in June 2020)
- Check the content of disaster response coordination plans
- Operate a mutual assistance system for disaster recovery costs
- Formulate cross-regional network development plans and submit them to the government
- Grant subsidies related to the feed-in tariff (FIT) scheme for renewable energy and grant premiums related to the feed-in premium (FIP) scheme
- Manage the reserve fund for the disposition of solar panels and other hardware components

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, and unveiled the "Green Growth Strategy Through Achieving Carbon Neutrality in 2050" in the following December. This strategy sets ambitious targets for 14 industries with strong growth potential and specifies diverse measures for an all-out commitment to building a carbon-neutral society. 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%. The Sixth Strategic Energy Plan was approved by the Cabinet in the following October to lay out the path toward realizing those goals.

In formulating the Plan, the government reviewed the ten years following the Fukushima Daiichi Nuclear Power Plant accident (hereafter, "the Fukushima Daiichi accident") and affirmed its responsibility to work toward the full recovery of Fukushima Prefecture. It also focused on two key points: addressing climate change and overcoming challenges in the structure of Japan's energy supply and demand. The basic concept of the Plan is to achieve "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 identifies challenges in achieving carbon neutrality by 2050 and defines actions for tackling them, while also outlining policy measures toward reaching the interim goals for 2030.

(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 "(2) Future Plans" in Section 1, Chapter IV). With regard to nuclear power, the Plan states that the necessary amount will be continuously utilized based on the major premise of ensuring public trust and safety.

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 "(2) Future Plans" in Section 1, Chapter IV).

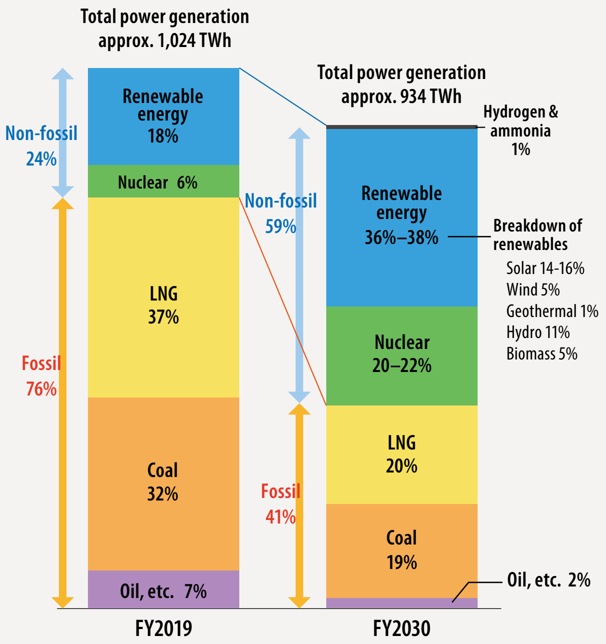
(2) Policy Measures towards 2030

The Plan specifies the following actions for each element of its core concept of S+3E: increase energy self-sufficiency by around 30% (energy security); seek to lower costs in response to an expected rise in surcharge payments driven by greater adoption of renewable energy (economic efficiency); set the energy-related CO_2 reduction rate among greenhouse gas reduction targets to approximately 45% (environment); and work to improve the safety of nuclear energy (safety).

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

Power Generation Mix in Fiscal 2030

Figure 2.1



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

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% (see Figure 2.1).

(3) Strengthening Energy Security

International developments surrounding the crisis in Ukraine have brought into relief the risks posed by dependence on a single country for the supply of fossil fuels and resources. It is imperative for Japan, as a resource-poor country, to put together a well-balanced electric power portfolio that takes into account the characteristics of each type of fuel. Moreover, given that the stable supply of energy is the foundation for many different economic and social activities, carbon neutrality cannot be achieved without energy security. In June 2022, the Cabinet approved the Basic Policy on Economic and Fiscal Management and Reform 2022, which specifies the following actions for strengthening Japan's energy security.

- Accelerating decarbonization efforts and increasing Japan's energy self-sufficiency, under the key premise that the stable supply of affordable energy be secured amid the energy market effects of the Russian invasion of Ukraine. To achieve these aims, Japan will pursue thorough energy conservation measures and make maximum use of renewables, nuclear power, and other energy sources that contribute to energy security and have a high decarbonizing effect.

- At the same time, Japan will strive to reduce its dependence on Russian-supplied fossil fuel and resources and prevent disruption of its energy supply by diversifying suppliers, working with other major energy consumers to encourage producers to ramp up production, and taking action to reduce energy consumption. The policy also recommends strengthening Japan's fuel supply system through measures such as increasing the government's involvement in LNG procurement.

(4) Actions for Advancing GX

Green Transformation, or GX, is an initiative that seeks to shift the structure of industry and society, which has long been heavily dependent on fossil fuels, to an energy mix centered on clean energy that does not emit CO_2. In line with the Sixth Strategic Energy Plan, the Japanese government is striving to realize a decarbonized society by leveraging renewable energy, nuclear power, and other forms of clean energy. However, the global energy situation dramatically changed after Russia invaded Ukraine in February 2022 and many countries retaliated by banning imports of Russian-produced fossil fuels. This led to sharp rises in energy resource prices and electricity rates in Japan, providing a clear reminder of the importance of securing a stable energy supply for this energy-resource-poor country. Working through the GX Implementation Council, the government laid out the Basic Policy for the Realization of GX as a roadmap for realizing both a decarbonized society and the stable supply of energy. To accomplish this, the policy calls for transforming the energy supply and demand structure and for driving economic growth by strengthening Japan's industrial competitiveness in decarbonization and other technologies. As supporting legislation, the Diet passed the Act on Promotion of a Smooth Transition to a Decarbonized Growth-Oriented Economic Structure (GX Promotion Act) on May 12, 2023, and the Act Partially Amending the

Electricity Business Act, etc. to Establish a Resilient and Sustainable Electricity Supply System (Act on Power Sources for Green Transformation and Decarbonization) on the 31st. Also, the Cabinet adopted the Strategy for Promoting Transition to a Decarbonized, Growth-Oriented Economic Structure (GX Promotion Strategy) on July 28 as a strategy for implementing the various GX measures under the GX Promotion Act.

The Basic Policy for the Realization of GX sets forth two key actions for ensuring stable energy supply: thorough implementation of energy efficiency improvements to homes, industries, and other consumers; and making renewable energy the main source of all electric power by fiscal 2030 by increasing its share of the energy mix, including by utilizing nuclear power based on the overriding premise of ensuring safety. Since locations suitable for renewable energy production are geographically limited, the government will also develop the nationwide power grid to support large-volume transmission of renewable electricity to consumer areas.

As another strategy for achieving GX, the government will support related investment and introduce carbon pricing. For details, see "b. Green Transformation" under "4. Global Warming Countermeasures."
In order to ensure the effective implementation of the new measures for realizing GX, the government will work through the GX Implementation Council and other bodies to regularly assess progress in the public and private sectors based on factors such as GX investment progress, economic impacts, and trends in technological development, and will refine the measures if necessary.

2. Nuclear Power Generation

(1) Action on Nuclear Safety

a. Establishment of the Nuclear Regulation Authority

The March 2011 accident at the Fukushima Daiichi Nuclear Power Plant 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).

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 (see 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).
- 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 Tier 3 approves the operational safety program and requires the passing of pre-service inspections.

c. Initiatives by the Private Sector

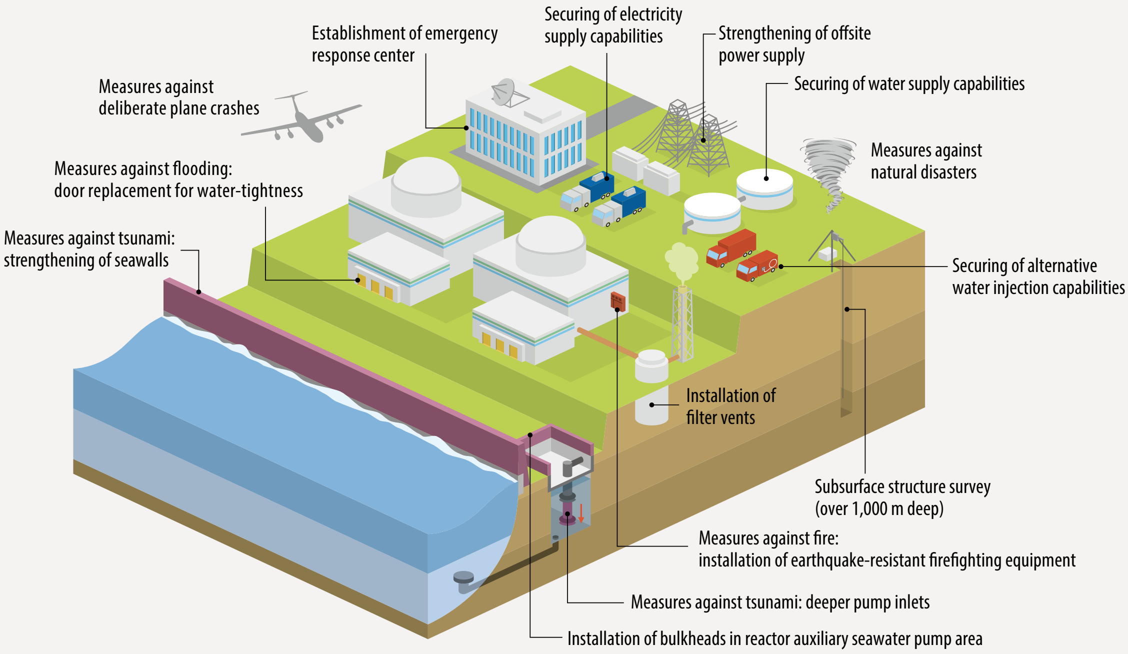
Alongside the measures being taken by the regulatory agencies, in November 2012 the nuclear power industry, seeking to prevent the occurrence of accidents like the Fukushima Daiichi accident, launched the Japan Nuclear Safety Institute (JANSI) as an organization for encouraging nuclear power plant operators to voluntarily strive for safety excellence. 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) Legislation Supporting Nuclear Energy Utilization and Reactor Decommissioning

The Basic Policy for the Realization of GX, approved by the Cabinet in February 2023, calls for replacing the existing

Safety Measures Required by New Regulatory Requirements

Figure 2.2



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

reactors that have been decommissioned or are scheduled for decommissioning with innovative next-generation reactors[4] incorporating new safety mechanisms. The following four related acts were amended in May 2023 to support the utilization of nuclear energy based on the overriding premise of ensuring safety.

- Clarification of principles pertaining to use of nuclear power (Atomic Energy Basic Act)
  Clarification of: the overarching priority of safety; the value of nuclear power use, including its contributions to stable energy supply and GX; and the responsibilities of the government and operators.

- Tightening of regulations on aging nuclear reactors (Reactor Regulation Act)
  Requirement that degradation of equipment of nuclear reactors operating for over 30 years be technically assessed every ten years thereafter, that long-term facility management plans be formulated based on those assessments, and that those plans be approved by the NRA.

- Refinement of regulation of operational life (Electricity Business Act)
  Limiting of nuclear reactor operational life to 40 years, while allowing an extension contingent upon the Minister of Economy, Trade and Industry's approval of the reactor's contributions to stable energy supply and GX, voluntary safety improvements, and continuous improvements to disaster countermeasures. The extension is limited to a maximum of 20 years, but periods of shutdown due to circumstances that the nuclear power plant operator could not readily foresee (such as changes in safety regulations, or the issuance of administrative guidance or provisional disposition order for suspension of operation) are not counted, thus enabling reactors to effectively operate for more than 60 years after their commissioning.

- Efficient and steady decommissioning of reactors (Spent Nuclear Fuel Reprocessing Implementation Act)
  Expansion of the Nuclear Reprocessing Organization of Japan's responsibilities to include general coordination of reactor decommissioning nationwide, joint implementation of R&D, among other duties; requirement for operators to contribute funds for decommissioning.

4 This refers to five types: advanced light-water reactors (LWRs; aimed at entering commercial operation in the 2030s) that add enhanced safety features to existing LWR technology; small modular reactors (SMRs) with a capacity of up to around 300,000 kW that would reduce construction period and cost because many of their components would be factory built; high-temperature gas-cooled reactors that achieve high-temperature output and could be used to produce hydrogen; fast reactors that utilize fast neutrons for highly efficient combustion, resulting in less nuclear waste; and nuclear fusion reactors that would harness the energy released by the nuclear fusion of hydrogen atoms. Examples of advanced LWRs: Mitsubishi Heavy Industries' SRZ-1200 (PWR, 1.20 million kW) and Hitachi-GE Nuclear Energy's HI-ABWR (BWR, 1.35 million kW). Examples of SMRs: Hitachi-GE Nuclear Energy's BWRX-300 (BWR, 0.30 million kW) and Toshiba's MoveluX (heat-pipe reactor, 3,000–4,000 kW).

Current State of Nuclear Plant Reviews and Restarts

Table 2.1

Tier 1 review completed (change in installation license granted) (17 units)	Restarted	**12 units**
	Pending completion of Tier 2 and 3 reviews (construction approval, safety regulations, pre-service inspections), and consents of local communities	5 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

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

Electric Power Company	Plant	Restart date
Kansai	Takahama Unit 1	Aug. 28, 2023
Kansai	Takahama Unit 2	Oct. 16, 2023
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: Pluthermal reactors are highlighted in pink.

Source: Compiled from Japan Atomic Industrial Forum, Inc., "Current Status of Nuclear Power Plants" (October 10, 2023) and other materials

(3) 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 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 October 2023. Of those, 27 (including two under construction) applied for permission for changes in reactor installation under the Tier 1 review. Permission was granted to 17 reactors, and as of October 2023, twelve of them were able to resume operation after passing the Tier 2 and 3 reviews and gaining their local governments' consents (see 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 Cabinet in October 2021.

In 2022, nuclear power accounted for around 6% of Japan's total electricity output, and the capacity factor of nuclear power plants was 18.7%.

(4) 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 uranium recovered (as outlined in the Fifth Strategic Energy Plan approved by the Cabinet in July 2018 and retained as a basic policy of the Sixth SEP). To this end, the Federation of Electric Power Companies of Japan (FEPC) unveiled in December 2020 its new "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[5] by fiscal 2030. In conjunction with the spent MOX fuel reprocessing demonstration research project by 11 power companies, in June 2023 Kansai Electric Power announced a plan to ship 200 tons of spent fuel (including 10 tons of MOX fuel) to France in the latter half of the 2020s.

b. JNFL's Nuclear Fuel Cycle Operations

Japan Nuclear Fuel Ltd. (JNFL), which is owned by electric power companies and other private-sector enterprises, engages in five nuclear fuel cycle operations at its sites in Rokkasho Village, Aomori Prefecture.

- 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 operational 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. Operation resumed in August 2023 following completion of construction of the safety facilities mandated by the New Regulatory Requirements.

- 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. However, a portion of the construction plan remains under review and construction work for adding the required safety features is still underway. JNFL is seeking to complete construction as early as possible in the first half of fiscal 2024.

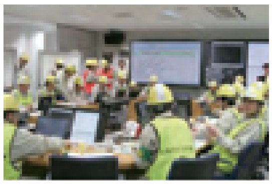
- Construction of the MOX fuel fabrication plant (maximum capacity: 130 tHM/year) started in 2010. Approval of operational changes for complying with the New Regulatory Requirements was received in December 2020. The ongoing construction work is tentatively scheduled for completion in the first half of 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 (LLW) 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



Emergency Countermeasure Center (on-site) (The Japan Atomic Power Co.)

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

5 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.

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 receiving of spent fuel is scheduled to begin in the second half of fiscal 2023 or the first half of fiscal 2024, 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. In October 2020, Suttsu Town and Kamoenai Village in Hokkaido each voted to accept a literature review,[6] which is the first step in the process of host selection. NUMO initiated literature reviews in both municipalities in the following month. As of August 2023, the literature and data collected for each municipality were being used to evaluate and examine its fulfillment of requirements such as the absence of significant stratum changes due to volcanic or fault activity.

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

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). However, in December 2016, the government decided to decommission Monju for several reasons, including poor economic viability. In line with the strategic roadmap for fast reactor development, which was revised by the Inter-Ministerial Council for Nuclear Power in December 2022, the government decided to adopt a sodium-cooled fast reactor for the design of a demonstration fast reactor planned to go into operation in the 2040s. In July 2023, Mitsubishi Heavy Industries (MHI) was selected as the lead company for developing the reactor's conceptual design in fiscal 2024–2028. Meanwhile, the Joyo experimental fast reactor was found to be compliant with the New Regulatory Requirements in July 2023, and construction of the new safety facilities is underway, with the aim of resuming operation in the middle of fiscal 2026.

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 JAEA and MHI were contracted by METI's Agency for Natural Resources and Energy in April 2022 to conduct a hydrogen production demonstration project that is planned until March 2031. In July 2023, the Agency selected MHI as the lead company for development of a high-temperature gas-cooled reactor. MHI will oversee the basic design, production, and construction processes for the demonstration reactor, aiming to launch operation in the 2030s. In July 2023, the UK's National Nuclear Laboratory (NNL), a partner of the JAEA, was selected to carry out the basic design for UK's high-temperature gas-cooled demonstration reactor program. Supported by a £15 million grant from the British government, the NNL plans to complete the basic design and economic viability assessment by March 2025.

(5) 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. Since then, the roadmap has been continually reviewed and revised as needed. Radiation levels in the surrounding area have decreased (see Figure 2.3) and gradual progress was being made in reconstruction and the return of displaced residents. TEPCO is giving top priority to safety and early reduction of risk under an approach that seeks to simultaneously advance both reconstruction and decommissioning work. Phase 3-1 of the roadmap (completion of fuel removal from all reactors by 2031) began in December 2021, and the entire decommissioning project is expected to last for 30 to 40 years (see Figure 2.4).

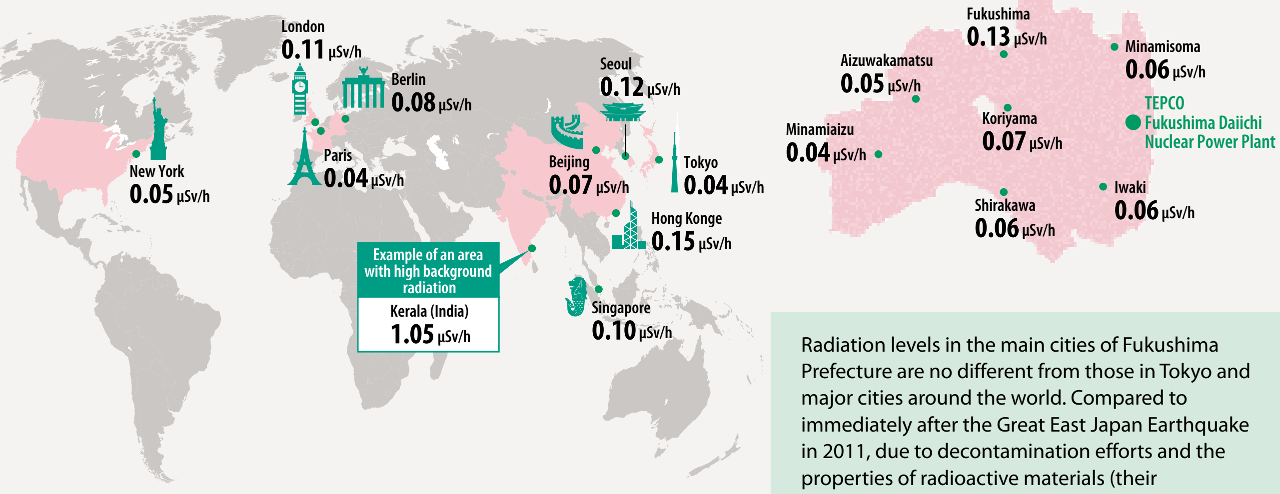
b. Removing Fuel from Spent Fuel Pools

After the accident, it was decided in the interests of risk

6 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.

Comparison of Radiation Air Dose Rates in Fukushima Prefecture with Major Cities around the World

Figure 2.3



Radiation levels in the main cities of Fukushima Prefecture are no different from those in Tokyo and major cities around the world. Compared to immediately after the Great East Japan Earthquake in 2011, due to decontamination efforts and the properties of radioactive materials (their radioactivity gradually decreases), radiation levels in Fukushima Prefecture are coming down. For example, the air dose rate in Fukushima City has dropped to one-twentieth.

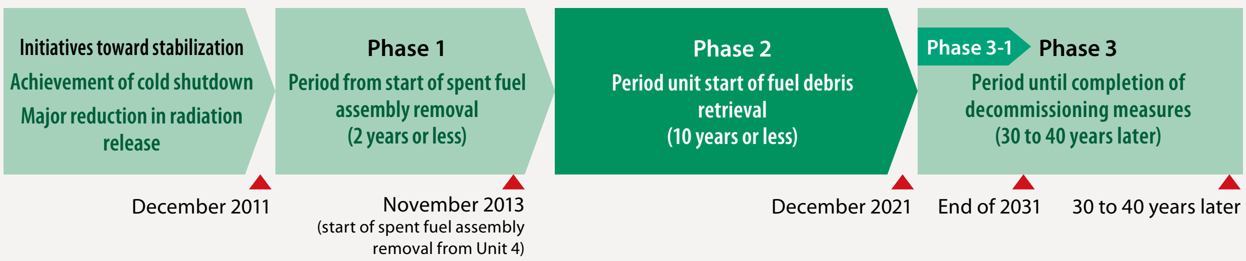
Notes
Sv (sievert): unit expressing the degree of impact radiation has on the human body. Figures are current as of March 2020 for Tokyo, January 2018 for London, January 2019 for New York, September 2019 for Berlin, Singapore, Hong Kong, Beijing, and Seoul, and March 2020 for the various locations in Fukushima Prefecture.
•1,000 μSv (micro sievert) = 1 mSv (millisievert)
•1,000 mSv (millisievert) = 1 Sv (sievert)

"Fukushima Prefecture Strategy for Strengthening Measures to Address Misinformation and Forgetfulness of the Past (4th Edition)"; the figure for Kerala is based on "UNSCEAR 2008 Report".

Source: Reconstruction Agency, "Air Radiation Dose Rates in Fukushima and Overseas"

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)

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, the debris in the Unit 2 reactor will be removed using a robotic arm, with work tentatively scheduled to start in the latter half of fiscal 2023.

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. In July 2023, the IAEA issued a comprehensive report based on findings from the five inspections it conducted in Japan over two years, its six technical reports, and other sources. The report concluded that the plan for discharging the treated water into the sea conformed with the IAEA's safety standards, and that the discharge would have negligible radioactive impact on humans and the environment.

Specifically, TEPCO's plan is to dilute the treated water with a large volume of seawater until the tritium concentration reaches one seventh of the WHO standards for drinking water, and then discharge it via an undersea tunnel bored through the bedrock, with the outlet positioned about one kilometer offshore from the plant. Construction of the tunnel and other components of the discharge facility was completed in June 2023. TEPCO received a certificate of completion of the facility's pre-service inspection from the NRA in July, and commenced the discharging operation in August following final approval from the government. The IAEA plans to maintain a continuous presence at the power plant and provide live online monitoring on its website from the discharge facility.

3. Renewable Energy

(1) Current Status and Targets

The Sixth Strategic Energy Plan, approved by the Cabinet 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 established 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 71.5 GW between the launch of the FIT scheme and the end of December 2022. Including pre-FIT capacity, total installed renewables capacity reached approximately 92.1 GW. Renewables accounted for 20.3% of the 1,032.7 billion kWh of total electric power generated in fiscal 2021. In April 2022, the government launched a feed-in premium (FIP) scheme for large-scale commercial solar power, among other power sources.

(2) Launch of FIT Scheme

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 general 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 2022 onward are shown in Table 2.3. 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 2023 is 1.40 yen per kWh (1.1124 trillion yen for Japan as a whole), or 6,720 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 (the Organization for Cross-regional Coordination of Transmission Operators), which refunds their purchase costs to them in due course (see Figure 2.5).

The scheme also contains a provision that reduces the

Installed Capacity of Renewable Energy [as of end December 2022]

Table 2.2

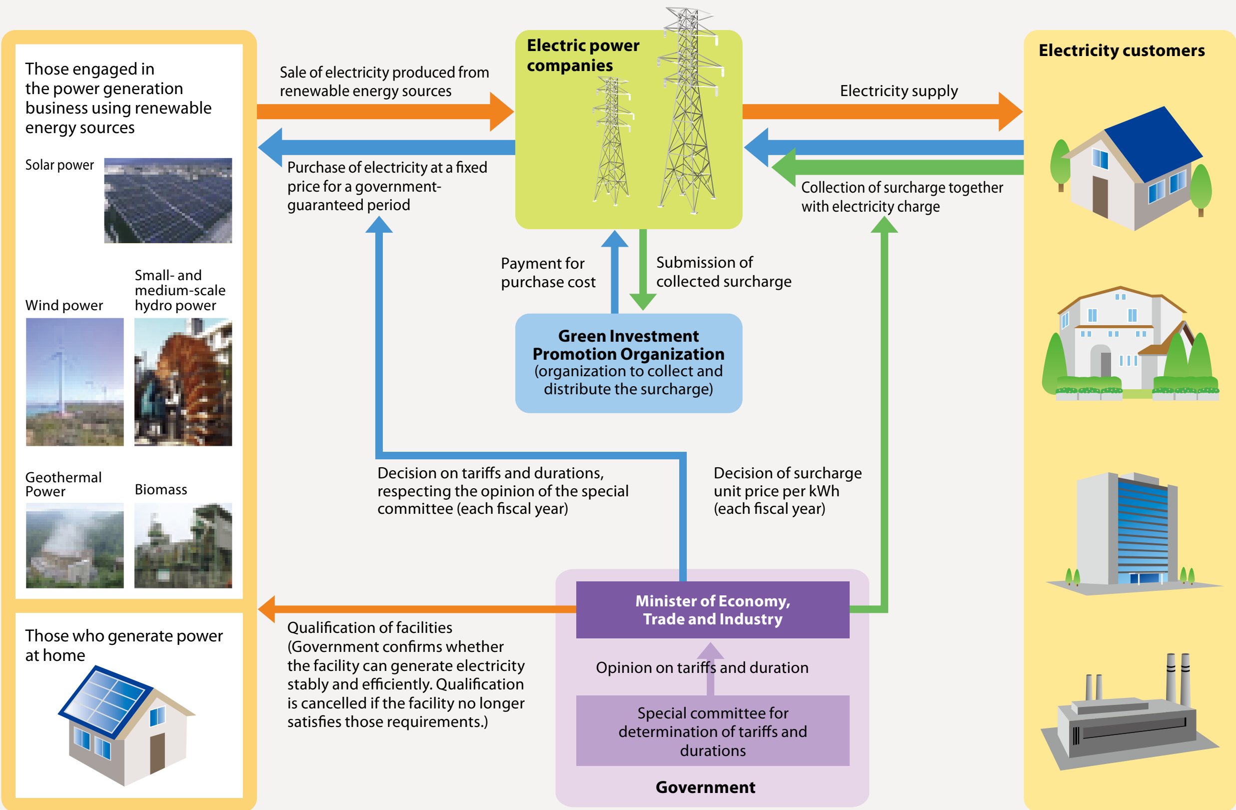
[Unit: MW]

Type	Combined total by end June 2012	Combined capacity installed under FIT	Total
Solar power (residential)	4,700	9,312	14,012
Solar power (non-residential)	900	54,551	55,451
Wind power	2,600	2,284	4,884
Small / medium hydropower	9,600	1,076	10,676
Biomass	2,300	4,148	6,448
Geothermal power	500	95	595
Total	20,600	71,465	92,065

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

Outline of the FIT Scheme

Figure 2.5



Source: Green Investment Promotion Organization website

Purchase Prices and Durations under the FIT Scheme

Table 2.3

<table>
<tr><th colspan="3" rowspan="3">Purchase category</th><th colspan="4">Purchase price [yen/kWh]</th><th>Duration</th></tr>
<tr><th rowspan="2">FY2022</th><th colspan="2">FY2023</th><th rowspan="2">FY2024</th><th rowspan="2">[years]</th></tr>
<tr><th>1st half</th><th>2nd half</th></tr>
<tr><td>Solar (household)</td><td colspan="2">Less than 10 kW</td><td>17</td><td colspan="2">16</td><td>16</td><td rowspan="5">10</td></tr>
<tr><td rowspan="2">Solar (commercial, ground-mounted)</td><td colspan="2">10 kW–50 kW</td><td>11</td><td colspan="2">10</td><td>10</td></tr>
<tr><td colspan="2">50 kW or above, ineligible for bids</td><td>10</td><td colspan="2">9.5</td><td>9.2</td></tr>
<tr><td rowspan="2">Solar (commercial, roof-mounted)</td><td colspan="2">10 kW–50 kW</td><td>11</td><td>10</td><td>12</td><td>12</td></tr>
<tr><td colspan="2">50 kW or above</td><td>10</td><td>9.5</td><td>12</td><td>12</td></tr>
<tr><td rowspan="3">Onshore wind power</td><td colspan="2">Less than 50 kW</td><td>16</td><td colspan="2">15</td><td>14</td><td rowspan="5">20</td></tr>
<tr><td colspan="2">50 kW or above</td><td colspan="4">Bidding system</td></tr>
<tr><td colspan="2">Replacement capacity</td><td>14</td><td colspan="2">13</td><td>–</td></tr>
<tr><td rowspan="2">Offshore wind power
(not covered by the Act on Promoting the Utilization of Sea Areas for the Development of Marine Renewable Energy Power Generation Facilities)</td><td colspan="2">Bottom-fixed offshore wind power</td><td></td><td colspan="2">Bidding system</td><td>–</td></tr>
<tr><td colspan="2">Floating offshore wind power</td><td colspan="4">36</td></tr>
<tr><td rowspan="2">Geothermal</td><td colspan="2">Less than 15,000 kW</td><td colspan="4">40</td><td rowspan="6">15</td></tr>
<tr><td colspan="2">15,000 kW or above</td><td colspan="4">26</td></tr>
<tr><td rowspan="2">Geothermal
(with all facilities upgraded)</td><td colspan="2">Less than 15,000 kW</td><td colspan="4">30</td></tr>
<tr><td colspan="2">15,000 kW or above</td><td colspan="4">20</td></tr>
<tr><td rowspan="2">Geothermal
(with original underground facilities in use)</td><td colspan="2">Less than 15,000 kW</td><td colspan="4">19</td></tr>
<tr><td colspan="2">15,000 kW or above</td><td colspan="4">12</td></tr>
<tr><td rowspan="4">Small & medium-sized hydro</td><td colspan="2">Less than 200 kW</td><td colspan="4">34</td><td rowspan="8">20</td></tr>
<tr><td colspan="2">200 kW–1,000 kW</td><td colspan="4">29</td></tr>
<tr><td colspan="2">1,000 kW–5,000 kW</td><td colspan="3">27</td><td>27</td></tr>
<tr><td colspan="2">5,000 kW–30,000 kW</td><td>20</td><td colspan="2">16</td><td>16</td></tr>
<tr><td rowspan="4">Small & medium-sized hydro using existing conduits*</td><td colspan="2">Less than 200 kW</td><td colspan="4">25</td></tr>
<tr><td colspan="2">200 kW–1,000 kW</td><td colspan="4">21</td></tr>
<tr><td colspan="2">1,000 kW–5,000 kW</td><td colspan="4">15</td></tr>
<tr><td colspan="2">5,000 kW–30,000 kW</td><td>12</td><td colspan="2">9</td><td>9</td></tr>
<tr><td rowspan="8">Biomas</td><td rowspan="2">General wood, etc.</td><td>Less than 10,000 kW</td><td>24</td><td colspan="2">24</td><td>24</td><td rowspan="7">20</td></tr>
<tr><td>10,000 kW or above</td><td>Bidding system</td><td colspan="2">Bidding system</td><td>–</td></tr>
<tr><td rowspan="2">Unused materials</td><td>Less than 2,000 kW</td><td>40</td><td colspan="2">40</td><td>40</td></tr>
<tr><td>2,000 kW or above</td><td>32</td><td colspan="2">32</td><td>32</td></tr>
<tr><td>Construction material waste</td><td>All capacities</td><td>13</td><td colspan="2">13</td><td>13</td></tr>
<tr><td>General waste/other</td><td>All capacities</td><td>17</td><td colspan="2">17</td><td>17</td></tr>
<tr><td>Biogas from methane fermentation</td><td>All capacities</td><td>39</td><td colspan="2">35</td><td>35</td></tr>
<tr><td>Liquid fuel</td><td>All capacities</td><td>Bidding system</td><td colspan="2">Bidding system</td><td>–</td><td></td></tr>
</table>

* Upgrades to electrical facilities and penstocks utilizing existing conduits.

Source: Compiled from METI website
https://www.meti.go.jp/press/2022/03/20230324004/20230324004.html

Results of FIT Tenders in Fiscal 2021 & 2022

Table 2.4

Technology	Timing	Eligible facilities	Successful bids
Solar power	June 2022	250 kW–1,000 kW (FIT eligible)	Total output: 24,764.7 kW (39 bids) Successful bid prices: 9.80–10.00 yen/kWh
Solar power	June 2022	1,000 kW or above (FIP eligible)	Total output: 128,940.0 kW (5 bids) Successful bid prices: 9.85–9.90 yen/kWh
Solar power	August 2022	250 kW–1,000 kW (FIT eligible)	Total output: 11,862.5 kW (18 bids) Successful bid prices: 9.50–9.88 yen/kWh
Solar power	August 2022	1,000 kW or above (FIP eligible)	Total output: 14,322.9 kW (10 bids) Successful bid prices: 9.70–9.87 yen/kWh
Solar power	November 2022	250 kW–1,000 kW (FIT eligible)	Total output: 11,301.4 kW (17 bids) Successful bid prices: 9.50–9.75 yen/kWh
Biomass power	November 2022	Biomass power facilities that generate 10,000 kW or more using general wood material and other biomass / Biomass power facilities that use liquid biomass fuel	Total output: 0 kW (no bids) Successful bid prices: 0 yen/kWh
Onshore wind power	November 2022	Onshore wind power generation facilities	Total output: 1,289,803.9 kW (30 bids) Successful bid prices: 14.80–16.00 yen/kWh
Solar power	March 2023	1,000 kW or above (FIP eligible)	Total output: 16,204.5 kW (9 bids) Successful bid prices: 9.48–9.63 yen/kWh
Solar power	June 2023	500 kW or above (FIP eligible) 250 kW–500 kW (FIT power sources)kWh	Total output: 105,000.0 kW (20 bids) Successful bid prices: 9.00–9.49 yen/kWh

Source: Compiled from Organization for Cross-regional Coordination of Transmission Operators website

Electricity storage technology research site at Komekurayama (Yamanashi Prefecture) (Tokyo Electric Power Company Holdings, Inc.)
TEPCO, the Yamanashi Prefectural Government, and Toray Industries, Inc., established Yamanashi Hydrogen Company (YHC), Inc., Japan's first power-to-gas (P2G) company.
YHC produces, supplies, and sells hydrogen derived from renewable power sources.
It also develops and demonstrates technologies relating to hydrogen production, storage, and transportation and engages in businesses to drive hydrogen energy uptake.

Hydrogen production equipment
Hydrogen production equipment installed at electricity storage technology research site at Komekurayama

Hydrogen transport trailer
Trailers for transport of the hydrogen produced to nearby factories

Results of Tenders under the Act on Promoting the Utilization of Sea Areas for the Development of Marine Renewable Energy Power Generation Facilities

Table 2.5

Technology	Timing	Location	Operators	Installed capacity	Successful bid price	Start of operation
Floating	June 2021	Off the coast of Goto City, Nagasaki Prefecture	Goto Floating Wind Farm LLC (Members: Toda Corporation, ENEOS Corporation, Osaka Gas Co., Ltd., Kansai Electric Power Co., Inc., INPEX Corporation, Chubu Electric Power Co., Inc.)	16.8 MW	See note	–
Bottom-fixed	December 2021	Off the coast of Noshiro City, Mitane Town, and Oga City, Akita Prefecture	Offshore Wind Power Project off the Coast of Noshiro City, Mitane Town and Oga City, Akita Prefecture (Members: Mitsubishi Corporation Energy Solutions Ltd., Mitsubishi Corporation, C-Tech Corporation)	478.8 MW	13.26 yen/kWh	December 2028
		Off the northern/ southern coasts of Yurihonjo City, Akita Prefecture	Offshore Wind Power Generation Project off the Coast of Yurihonjo City, Akita Prefecture (Members: Mitsubishi Corporation Energy Solutions Ltd., Mitsubishi Corporation, Venti Japan Inc., C-Tech Corporation)	819.0 MW	11.99 yen/kWh	December 2030
		Off the coast of Choshi City, Chiba Prefecture	Offshore Wind Power Generation Project off the Coast of Choshi City, Chiba Prefecture (Members: Mitsubishi Corporation Energy Solutions Ltd., Mitsubishi Corporation, C-Tech Corporation)	390.6 MW	16.49 yen/kWh	September 2028

Note: Only one bidder participated in this auction. The bidder's plan was subjected to a review, and was judged to satisfy the criteria set.

Source: Compiled from METI website

surcharge for industrial customers who use extremely high volumes of electricity and who satisfy certain conditions.

As the investment in renewable energies has increased and FIT-approved capacity has grown since 2012, problems have emerged and the government revised the FIT scheme in 2016. This included the introduction of a tender scheme for solar power generation and biomass generation above a certain level of capacity to bring down purchase prices. The results of FIT tenders made in fiscal 2022 and 2023 are shown in Table 2.4.

(3) Transition to the FIP Scheme

Under the FIT scheme, a number of problems emerged with the growing adoption of renewables. For example, the rising cost of purchasing renewables, which reached 4,203.3 billion yen in fiscal 2022, drove the renewable surcharge up to 3.45 yen/kWh, while the increasing number of projects made it difficult for the grid side to receive renewable power. In response, the government decided to overhaul the FIT system in order to integrate renewables into the electricity market as an economically self-sustaining core element of the power generation mix, maintain incentives for investment, and contain the cost burden on the public. 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). Under the amended act, a feed-in premium (FIP) scheme was rolled out in April 2022[7] 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. Similar to the FIT scheme's setting of a fixed unit price per kWh for the purchase of renewable power, the FIP scheme sets a base price through bidding, and a reference price is calculated from this. The reference price represents the expected revenue of electricity generation utilities and is revised monthly by subtracting the balancing cost from the sum of the wholesale power price and the non-fossil value trading market price. The difference between the base price and the reference price is paid to the electricity generation utilities as a premium. On the whole, the revenues for the electricity generation utilities are on par with those under the FIT scheme, but the FIP scheme is expected to provide an incentive for power generation during hours when the market price is high, and to contain the balancing cost, among other benefits. The FIP tender results published in June of fiscal 2022 are shown in Table 2.4.

7 Under the government's plan for a phased transition from the FIT scheme to the FIP scheme, in fiscal 2023 electricity from renewables other than offshore wind power is no longer eligible for FIT certification (FIP certification only) when its installed capacity equals or exceeds the following thresholds: solar, 500 kW; onshore wind, 50 kW; geothermal & small/medium hydropower, 1,000 kW; biomass (general wood, etc.), 2,000 kW; biomass (liquid fuel), 50 kW. Also, operators whose capacity from all power sources is 50 kW or higher can opt to participate in the FIP scheme.

(4) Installation Targets for Offshore Wind Power, and Start of Bidding

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. Accordingly, it has set long-term project creation targets as part of its policy for advancing this form of energy: 10 GW by 2030, and 30–45 GW by 2040. The government enacted the Act on Promoting the Utilization of Sea Areas for the Development of Marine Renewable Energy Power Generation Facilities to lay out, among other things, rules for exclusive occupancy and use of sea 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 promotion zones and selects developers by tender to carry out projects in those areas. Developers were selected in June and December 2021 (Table 2.5).

Following the December 2021 auction, the government proposed changes to bidding rules and gathered stakeholder feedback on the proposal. This led to the adoption of two key revisions: providing an incentive for speeding up project launches by giving higher weight to bids with earlier start-up dates, and a new rule limiting bids

Okuhida-Onsengo Nakao Geothermal Power Station
COD: December 2022 / Owners*: Toshiba Energy Systems & Solutions Corporation (55%), Cenergy Co., Ltd (45%)
*This power station is jointly operated by Cenergy, a wholly owned subsidiary of Chubu Electric Power Miraiz Co., Inc., and by Toshiba Energy Systems & Solutions.

Shimonoseki Biomass Power Station (Kyuden Mirai Energy Company Inc.)
COD: February 2022 / Operators: Kyuden Mirai Energy Company Inc., Nishinippon Plant Engineering and Construction Co., Ltd. and Kyuden Sangyo Co., Inc.
Special note: Shimonoseki Biomass Power Station at night. Biomass power generation can generate electricity steadily for 24 hours regardless of the weather conditions.

Nikaho No. 2 Windfarm (J-POWER)
COD: 2020 / Owner: J-POWER / Capacity: 41,400 kW

Onikobe Geothermal Power Station (J-POWER)
COD: 2023 / Owner: J-POWER / Capacity: 14,900 kW

to a maximum capacity of 1 GW for each bidder. Auctions were resumed under the revised system in December 2022. The first auction covers four locations, all of which are eligible for the FIP program.

As a step toward accelerating the formation of new offshore wind power projects in the future, the government is designing a centralized model whereby it becomes involved in project development from the early stage so that surveys and other preliminary actions can be implemented faster and more efficiently. As a part of this effort, a law was amended to add the implementation of geological and other site surveys to the duties of the Japan Organization for Metals and Energy Security (JOGMEC).

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 various 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.

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, in October 2020 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." 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 the fiscal year 2030 from its fiscal year 2013 levels, setting an ambitious target which is aligned with the long-

Government Action on GHG Reduction Targets — Table 2.6

Date	Trend
December 1997	Kyoto Protocol adopted at COP3. Japan's GHG reduction target set at 6% below 1990 levels.
October 1998	Act on Promotion of Global Warming Countermeasures instituted in response to adoption of the Kyoto Protocol.
April 2005	Kyoto Protocol Target Achievement Plan outlining the measures necessary to attain Japan's 6% GHG reduction target approved at a meeting of the Cabinet.
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.

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 Transformation

Amid the growing global competition in investment toward realizing green transformation (GX), the Japanese government enacted the Act on Power Sources for Green Transformation and Decarbonization and the GX Promotion Act in May 2023 to help Japan to meet its international commitments such as the pledge to achieve carbon neutrality by 2050, while also strengthening its industrial competitiveness and driving economic growth.

The GX Promotion Act requires the government to formulate and refine a strategy for advancing GX, and mandates the issuance of GX Economy Transition Bonds worth 20 trillion yen over a ten-year period starting in fiscal 2023 in order to support initial investment toward realizing that strategy. These funds will be used to support innovative technological development and capital investment that promise to help decarbonize energy and raw materials, improve earnings, and achieve other benefits. The law also calls for the adoption of pro-growth carbon pricing and the creation of a scheme that provides incentives to companies that make an early start in GX. Specifically, from fiscal 2028 onward, fossil fuel importers will be required to pay a fuel surcharge commensurate with the carbon emissions of the fuel imported. Moreover, starting in fiscal 2033, when the total renewable energy surcharge revenue is expected to begin declining, the government will launch a carbon emissions trading scheme in which electricity generation utilities will be allocated carbon emissions allowances on a paid basis. The revenue from these schemes will be applied to the redemption of GX Economy Transition Bonds.

The Act on Power Sources for Green Transformation and Decarbonization aims to promote maximum utilization of renewable energy in harmony with local communities through amendments to the Electricity Business Act and the Act on Renewable Energy Special Measures. In particular, it establishes a framework in which plans for developing critical power transmission lines are subject to approval by the Minister of Economy, Trade and Industry, and it provides projects contributing to the use of renewable energy with earlier access to the cross-regional development subsidy funded by renewable energy surcharges—starting from the construction stage, rather than operational start-up as previously designed. The new law is also aimed at encouraging follow-on investments for achieving maximum utilization of existing renewable energy assets. Specifically, it seeks to promote early follow-on investments (upgrades and expansions) in solar power generation facilities by creating a system that applies new purchase prices to follow-on investments separately from the portion for existing facilities, with the premise that those investments will be in harmony with the local community and will ensure smooth disposal of decommissioned equipment.

c. Asia Zero Emission Community

One important key to achieving carbon neutrality globally is the decarbonization of Asia, where energy demand is expected to rise with economic growth. In January 2022, Prime Minister Kishida proposed the establishment of the Asia Zero Emission Community (AZEC) as a framework for decarbonizing all of Asia under a common ideal of achieving economic growth while advancing decarbonization measures tailored to Asia's own circumstances. The Japanese government hosted AZEC's first ministerial meeting on March 4, 2023, bringing together ministers from Japan, Australia, Indonesia, Malaysia, the Philippines, and other countries for discussion of action policies and specific initiatives. They issued a joint statement affirming their agreement to collaborate in efforts toward decarbonization/carbon neutrality under a shared commitment to: (1) ensuring energy security while pursuing decarbonization, (2) achieving both carbon neutrality and economic growth, and (3) carrying out an energy transition tailored to the circumstances of each country.

(2) GHG Emissions and Efforts by the Private Sector

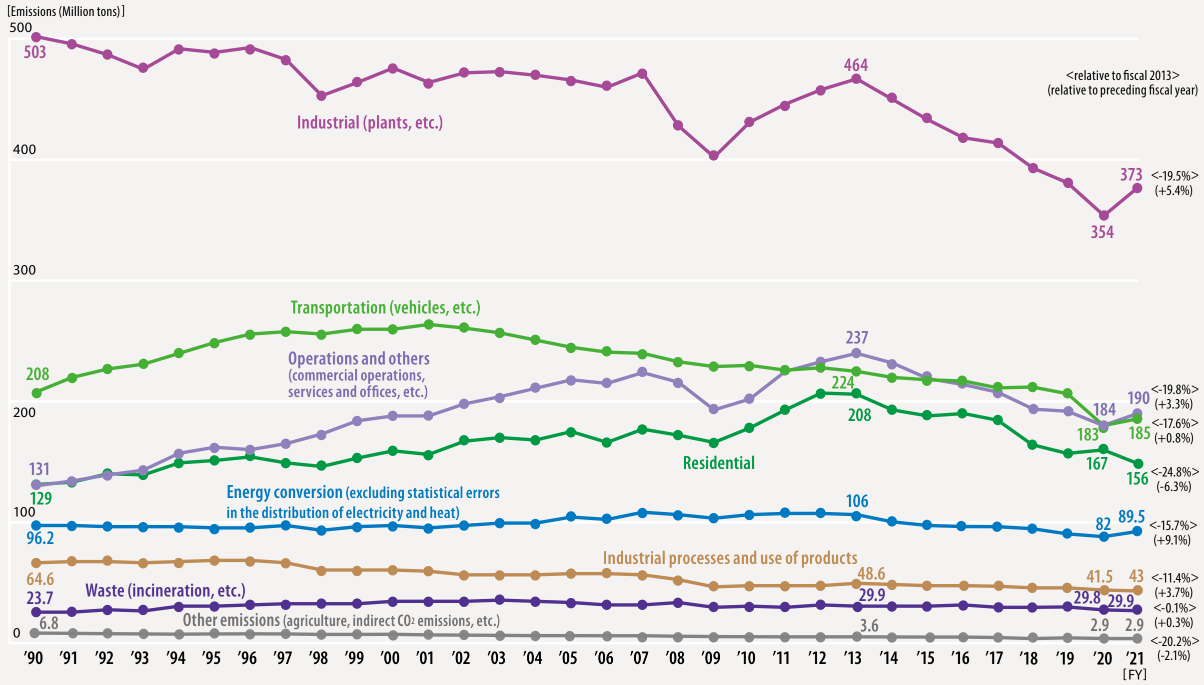
a. GHG Emissions in Japan

In fiscal 2021, Japan's GHG emissions measured 1,170 million tons (CO_2 equivalent), and emissions of CO_2 accounted for 90.9% (1,064 million tons) of this total. CO_2 emissions decreased by 19.2% versus fiscal 2013 (see Figure 2.6).

CO_2 emissions in individual sectors began trending downward in 2013, declining by 19.5%, 19.8%, and 24.8% respectively in the industrial sector, the commercial sector, and the residential sector between fiscal 2013 and 2021. 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. The industrial and commercial sectors subsequently saw a rise in their CO_2 emissions in conjunction with the economy's recovery from the downturn brought on by the coronavirus pandemic in fiscal 2020–2021.

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 2020 (Final Figures)" (2022)

b. CO2 Emission and Global Warming Countermeasures Implemented by the Electric Power Industry

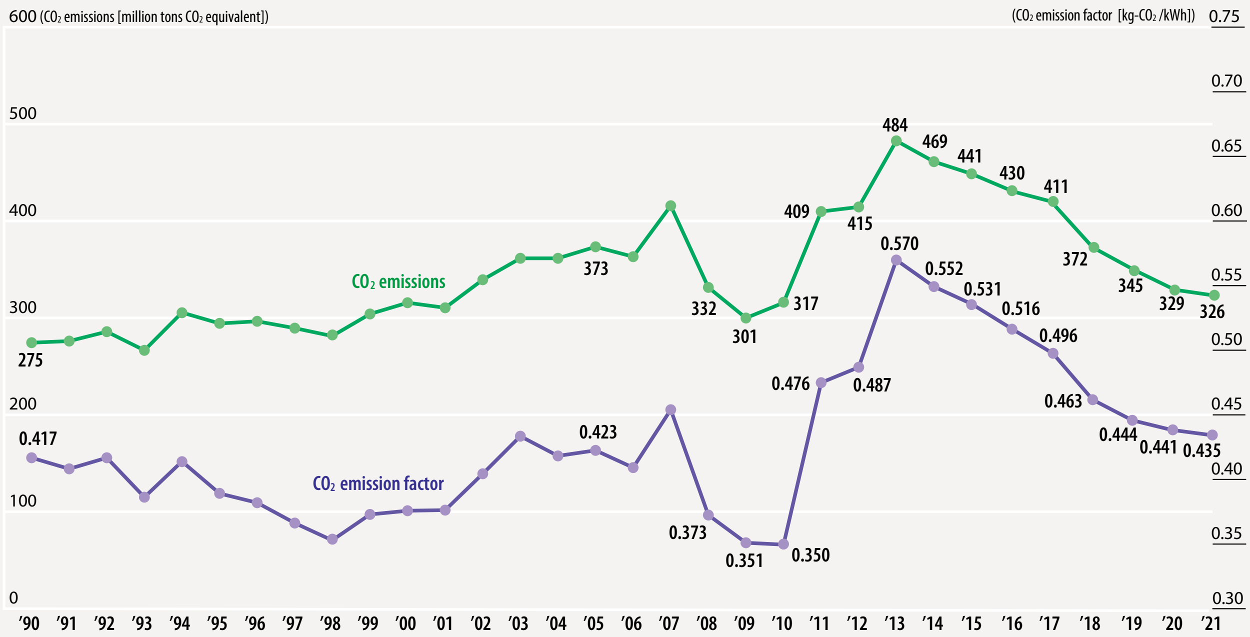
Both the Act on Rationalizing Energy Use (Energy Efficiency Act) and the Act on Sophisticated Methods of Energy Supply Structures (Sophisticated Methods Act) require the electric power industry to reduce its CO2 emissions. The Energy Efficiency Act, which targets electricity generation utilities, specifies benchmarks for thermal power generating efficiency (for each fuel type and overall) and requires those utilities to achieve them. The Sophisticated Methods Act mandates that electricity retailers whose sales volume exceeds a certain level work to increase the non-fossil share of the electricity they supply to at least 44% in 2030. The government has established a market for achieving that target through trading in non-fossil fuel certificates, as a way to help the utilities reach the target level.

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 CO2 emission factor in the electricity in fiscal 2030 of approximately 0.37 kg-CO2/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 generation utilities as a whole. According to data released by ELCS, CO2 emissions in fiscal 2021 (final figures) came to 326 million tons-CO2 and the CO2 emission factor was 0.435 kg-CO2/kWh.

For some time, ELCS 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 decision to raise the emissions reduction target, ELCS announced that it would step up its efforts. In June 2022, ELCS partially revised the

CO_2 Emissions in the Electric Power Industry

Figure 2.7



Note: Reflected adjustments made for Kyoto Mechanism credits

Source: Compiled from FEPC and ELCS

Commitment to a Low-Carbon Society in the Electricity Industry to indicate its intention to contribute to the achievement of the nationwide reduction goal for 2030 (46% decrease from fiscal 2013) by striving to attain the government's ambitious emissions factor target (around 0.25kg-CO2/kWh). Recognizing that the government's support is essential for reaching that target, ELCS has stressed the importance of having the government establish a clear positioning for nuclear power within its policies, and having the government directly take part in awareness-raising efforts for acquiring the understanding and cooperation of local governments and other stakeholders in communities hosting nuclear power plants. ELCS has already been promoting the use of nuclear power under a firm commitment to ensuring safety, and endeavoring to maximize the use of renewables such as hydro, geothermal, solar, wind, and biomass power. Going forward, it will also pursue low-carbon and decarbonization approaches such as co-firing with hydrogen or ammonia as promising next-generation fuels. On the demand side, ELCS will strive to reduce the CO2 emissions of customers by promoting the efficient use of electricity, including efforts to spread the use of high-efficiency electrical equipment and to encourage customers to adopt energy-saving and emissions-reducing practices.

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 contribute to the achievement of carbon neutrality in 2050 by realizing smooth and flexible grid access and utilization for renewables, etc. This will involve efforts to secure the proper balancing, inertial, and synchronization capacity necessary for maintaining quality, develop grid codes, and establish demand control technologies utilizing demand response, VPP, and other distributed energy resources (DER).

Figure 2.7 shows CO2 emission trends in the electric power industry.

III. SUPPLY AND DEMAND

1. Electricity Demand and Peak Load

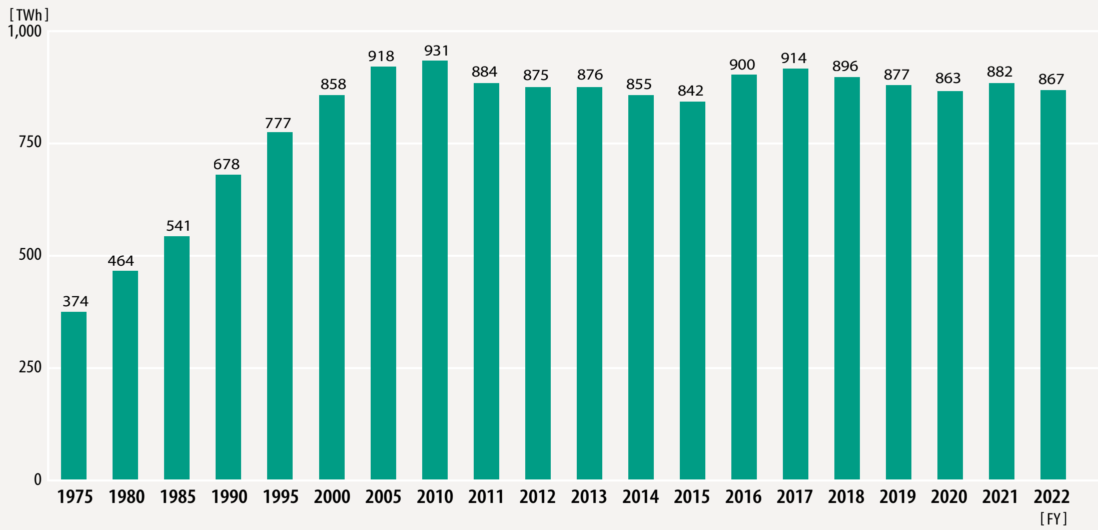
Japan's annual electricity demand increased more or less consistently up through the early 2000s, reaching a record high of 959.7 TWh in fiscal 2007. Since then, it has either declined moderately or remained mostly unchanged. Meanwhile, the real GDP growth rate in fiscal 2022, a year in which social and economic activity began returning to normal levels following the lifting of COVID-19 pandemic restrictions, was 1.4% versus the preceding year (for comparison, it was -4.5% in fiscal 2020). Electricity demand[8] for fiscal 2022 totaled 866.5 TWh (down 1.7% from previous fiscal year) (see Figure 3.1). Peak national demand has also remained largely unchanged since fiscal 2011 and the average of the three highest daily loads in fiscal 2022 came to 160.5 GW (down 1.1% from previous fiscal year). These trends are attributable to several factors, including the slowing of economic growth, improved energy conservation, and 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.

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 2021 breaks down by use as follows: 27% residential demand, 35% commercial demand, and 36% industrial demand (see 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 nonindustrial sectors, namely the residential and commercial sectors. Growth in consumption in the commercial sector has been propelled by growth in offices and commercial facilities triggered by development of a service economy and the accompanying use of air conditioners and other appliances. In the residential sector, the rapid spread of heating and cooling appliances, such as air conditioners and electric carpets and other household appliances, driven by rising living standards, ensured that power consumption continued to grow until fiscal 2005. Growth then leveled off as the population continued to decline, appliance ownership reached a saturation point, and appliances became more energy efficient. In fiscal 2011, increased awareness of the importance of saving electricity in the aftermath of the

Changes in Electricity Demand, 1975–2022

Figure 3.1



Source: Compiled from Agency for Natural Resources and Energy, "Handbook of Electric Power Industry" (2022) and "Surveys and Statistics of Electricity" (2023)

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

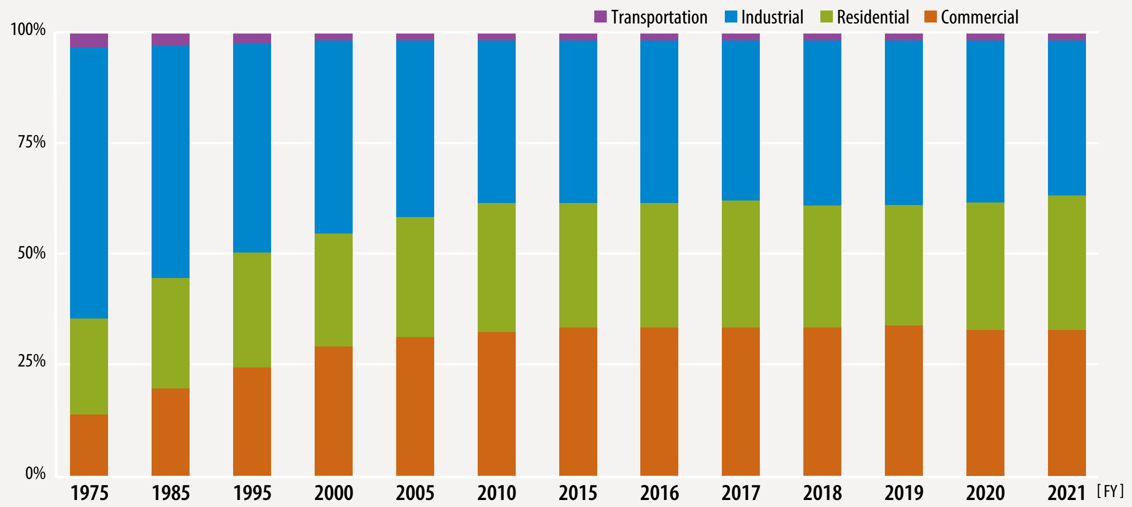
Fukushima Daiichi accident caused consumption to go into decline. In fiscal 2021, non-industrial consumption accounted for 62% of final power consumption.

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

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.,

Breakdown of Power Consumption by Sector, 1975–2021

Figure 3.2

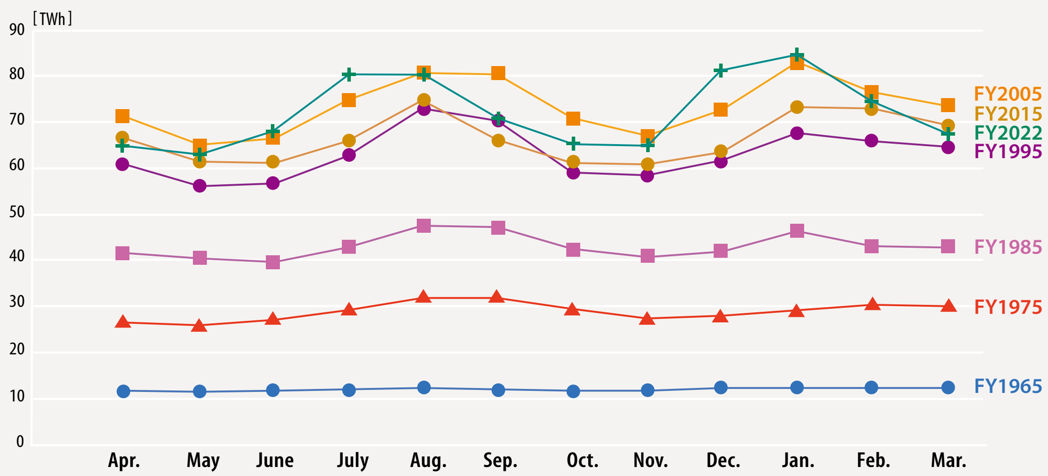


Note: The method of calculation was changed from fiscal 1990.

Source: Agency for Natural Resources and Energy, "Energy Balance in Japan" (2023)

Electric Power Consumption over the Course of a Year

Figure 3.3

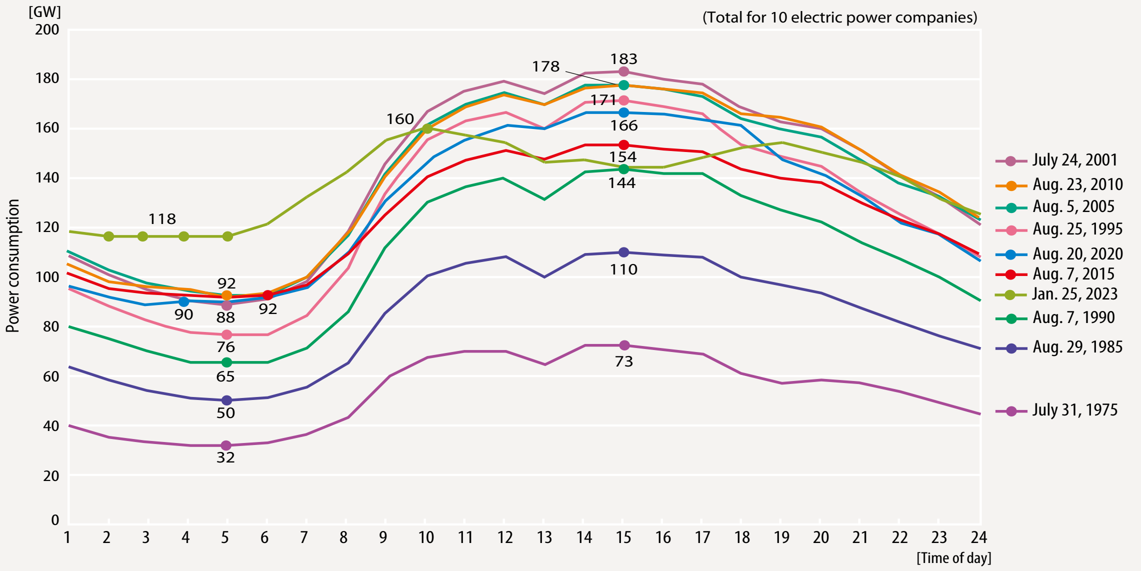


Note 1: Figures for fiscal 1975 and 1985 exclude Okinawa Electric Power Co.
Note 2: Figures are totals for 10 electric power companies through fiscal 2015, and for 10 areas in fiscal 2016.

Source: Compiled from FEPC, "Electricity Demand" up to fiscal 2015, and OCCTO, "Information on Electricity Supply and Demand" from fiscal 2016 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 was largely due to the introduction of electricity rates designed to level loads and nighttime electricity use. However, the annual load factor started trending downward again from fiscal 2016 onward, mainly due to the spread of renewable energy with low utilization efficiency. In fiscal 2020, a year when social and economic activity were significantly reduced by the impact of the coronavirus pandemic, it fell below 60%. Peak load was driven upward in fiscal 2022 by extremely hot weather and other influences, but the annual peak load factor again dropped slightly below 60% due to factors such as a mild winter and a slow recovery of manufacturing levels (see Figure 3.5).

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

Figure 3.4

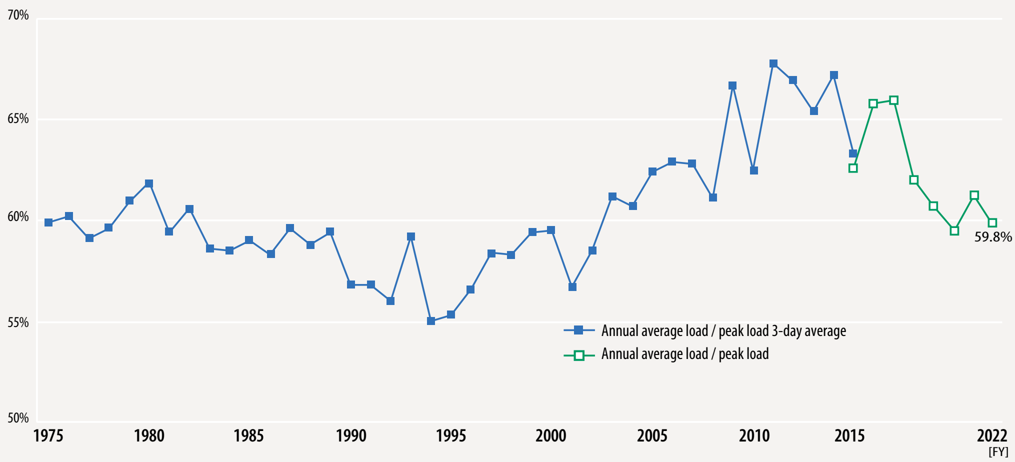


Note: Figures for fiscal 1975 exclude Okinawa Electric Power Co.

Source: Compiled from Japan Atomic Energy Relations Organization, "Graphical Flip-chart of Nuclear & Energy Related Topics" (2023), and OCCTO, Cross-regional Organization System, "Supply/demand-related Information"

Annual Load Factor, FY1975–FY2022

Figure 3.5



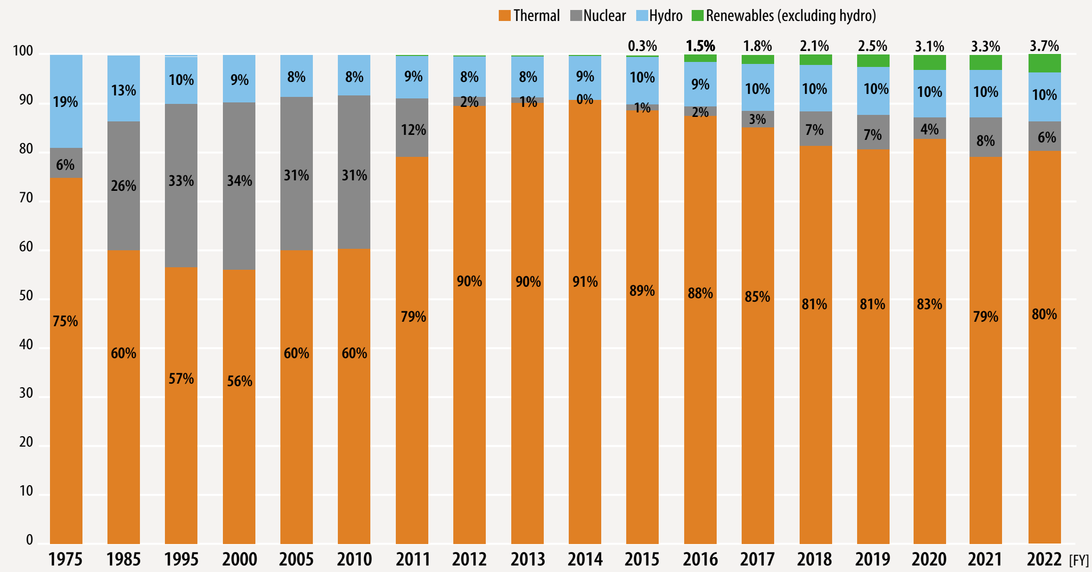
Source: Compiled from Agency for Natural Resources and Energy, "Handbook of Electric Power Industry" for annual average load / peak load 3-day average (up to fiscal 2015); and OCCTO, "Outlook of Electricity Supply-Demand and Cross-regional Interconnection Lines" for annual average load / peak load (from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

2. Electric Power Generated

Electric power generated[9] came to 832.7 TWh in fiscal 2022 (3.6% decrease from previous fiscal year). The progressive shutdown of nuclear power plants following the March 2011 Fukushima Daiichi Nuclear Power Plant accident increased dependence on thermal power plants and caused thermal's share of power generated to hover around 80% during the past several years (see 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

Power Generation Mix, FY1975–FY2021

Figure 3.6

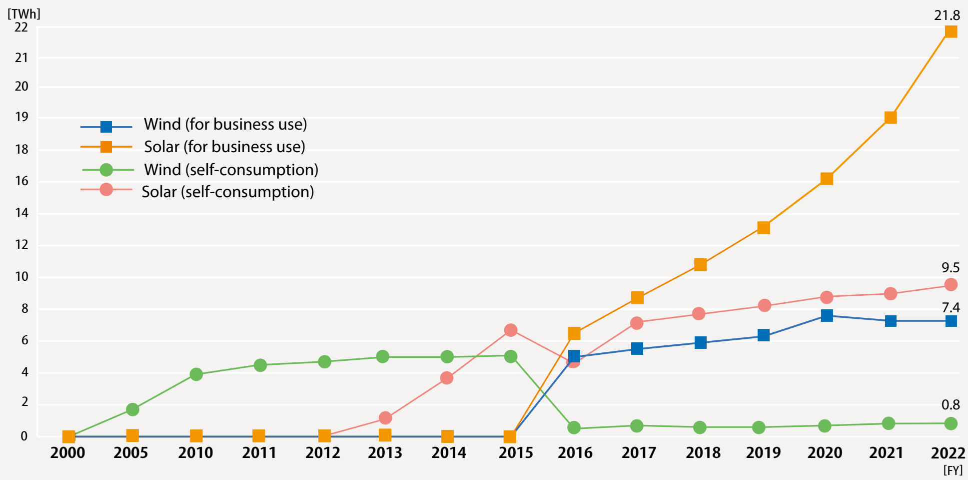


Note: Figures on electric power generated for electric utilities are generation-end figures through fiscal 2015, and transmission-end figures from fiscal 2016.

Source: Compiled from Agency for Natural Resources and Energy, "Handbook of Electric Power Industry 2022" and "Surveys and Statistics of Electricity 2022" (both published in 2023)

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 2022" and "Surveys and Statistics of Electricity 2022" (both published in 2023)

9 Electric power generated by electricity utilities.

back online. As a result, nuclear's share of power generated in fiscal 2022 rose to 6.4%.

On the other hand, the construction of renewable energy installations such as wind and solar power plants has increased. In fiscal 2022, 7.4 TWh of electric power was generated by wind power, and 21.8 TWh by solar power (see 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

More than a decade since the Great East Japan Earthquake, Japan's electricity supply and demand situation is improving. Due to the prolonged shutdown of many 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 increased trading in the wholesale electricity market and the growing volume of electricity generated from renewable energy have given rise to a very challenging business environment for the power generation sector, leading to a spate of thermal power plant closures and idlings. The authorities have responded by instituting, ahead of the launch of the capacity market, auctions for covering supply shortages during periods of high demand, and by establishing a system requiring electric power plant operators to file advance notice before closing or idling their plants. Also, some other remedies have been proposed, such as changing the timing of inspection and maintenance of generation facilities, and ensuring supply capacity by leveraging markets, demand response, and interregional electric power sharing. Notably, demand-side measures include expanding the deployment of demand response and encouraging customers to conserve electricity during supply tightness by awarding them points for their efforts.

Electricity supply was strained in the early half of 2022 by abnormal weather events that occurred outside the summer and winter peak demand periods. Unseasonal cold and heat waves prompted the government to issue an electricity supply warning[10] in March and an advisory in June. The warning was made partly due to damage to electric power facilities by an earthquake that occurred off the coast of Fukushima Prefecture earlier in March, and the advisory reflected the potential impact of power plant inspections and maintenance scheduled in preparation for the high-demand months of July and August.

Along with the increased adoption of renewables, power balancing during periods of low demand is done through approaches such as curtailment of thermal power plant output and utilization of interregional interconnections, and in cases where these are not enough to prevent excess surplus, the output of renewable power is controlled.

b. Supply and Demand Projections

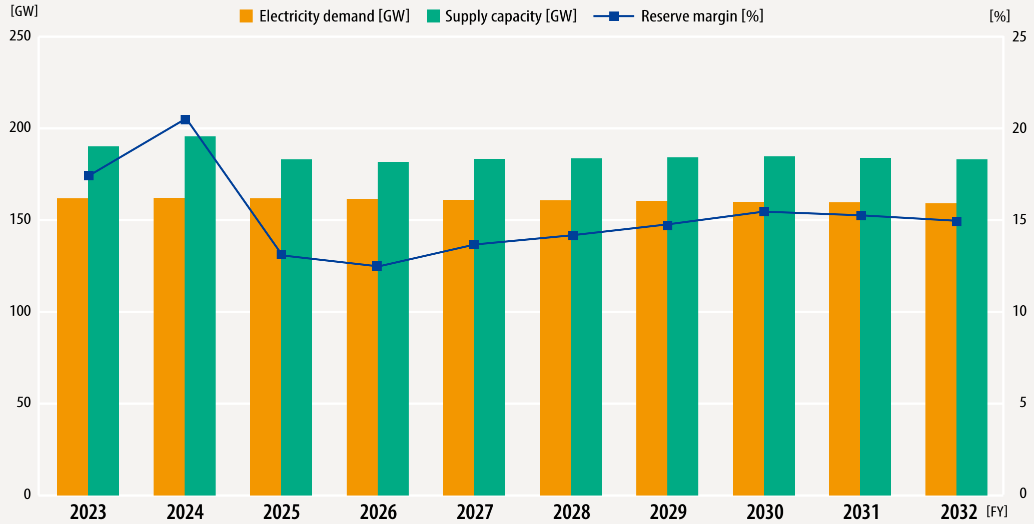
As for the electricity supply and demand situation, it has remained possible in recent years to maintain the minimum 3% reserve margin needed to ensure supply continuity in all areas of Japan. However, there is concern that power reserves could fall below the 3% margin in some service areas during the actual power supply planning or a one-in-ten-year weather event. Measures for addressing this concern are being taken, including the implementation of kW/kWh auctions. The average rate of change in both electricity demand and supply capacity over the 10-year period from fiscal 2023 to fiscal 2032 will be almost 0%, and electricity demand and supply capacity are expected to remain at current levels (see Figure 3.8).

Japan experienced a severe electricity supply crunch starting in mid-December 2020 due to a chain of factors, despite a forecast in October that a sufficient reserve margin could be secured for the winter. First, LNG-fired power plant production had to be ramped up due to an unexpectedly strong cold wave in mid-December, resulting in a nationwide shrinkage in LNG inventories. This was compounded later that month by a supply facility problem in one of Japan's LNG suppliers, leading to curtailment of LNG-fired power plant operation. Moreover, several coal-fired power plants had technical issues that resulted in unscheduled stoppages. In January, a second cold wave hit the country, driving power demand to above once-in-ten-year levels on the 8th and 12th. The supply crunch persisted up through late January due to the continuation of the LNG fuel shortage and further unscheduled stoppages of coal-fired production. The uncertainties surrounding Japan's fuel procurement

10 Electricity supply advisories are issued when the area's power supply reserve margin is between 3% and 5%. Warnings are issued when the margin falls below 3%.

Projected Electricity Demand and Supply Capacity

Figure 3.8



Source: OCCTO, "Aggregation of Electricity Supply Plans for FY2023[11]" (2023)

capabilities were made murkier by the February 2022 Russian invasion of Ukraine. In response, the Japanese government plans to launch a new scheme in December 2023 that aims to ensure a stable supply of LNG by enabling energy companies to secure surplus inventories. From December through the following February, certain businesses certified by METI (power/gas companies, etc.) will be able to use a new fund established at the Japan Organization for Metals and Energy Security (JOGMEC) by the ministry to acquire monthly LNG procurements at levels above normal (approx. 70,000 t). During normal conditions, they will be able to sell their surpluses to foreign markets mainly in Asia, and during emergencies they will be able to sell to the Japanese market. This scheme will thus enable the domestic power industry to prepare for the risk of LNG supply shortages or stoppages. Losses incurred by the certified traders will be offset by the fund, and profits will be paid back into it.

(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 2023, 10,680 MW of power source I and 126,900 MW of power source II were procured. In addition, 3,410 MW of power source I' was procured, of which 2,280 MW of demand was met by demand response.

In fiscal 2021, a balancing market was established as a platform for facilitating efficient procurement and operation of cross-regional balancing capacity. The market launched trading in capacity for balancing errors in renewable energy predictions in April 2021. Trading in all other balancing capacities is being phased in, with completion of this process scheduled for 2024.

11 This refers to the supply plans prescribed by Article 29 of the Electricity Business Act.

IV. ELECTRIC POWER FACILITIES

1. Power Generation Facilities[12]

Total generating capacity in Japan was 318.6 GW at the end of fiscal 2022. This consisted of 47.5% thermal power (15.9% coal, 24.8% LNG, and 6.8% oil), 10.4% nuclear power, 15.4% hydro, and 26.0% renewables (excluding hydro). Figure 4.1 shows the breakdown of total generating capacity by power source at the end of fiscal 2022.

(1) Power Generation Facilities for Electric Utilities

a. Thermal Power

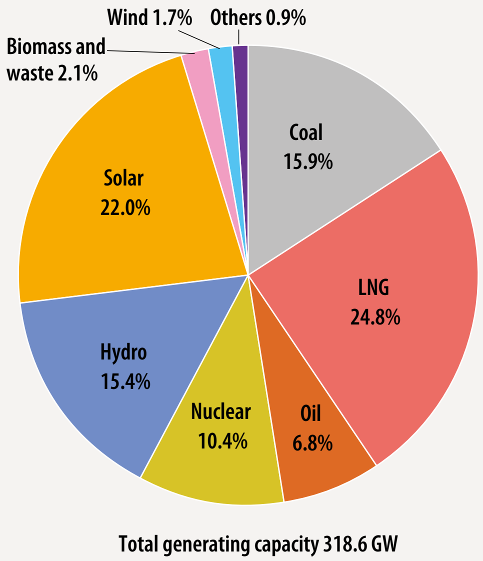
The total installed capacity of thermal power plants was 151.4 GW as of the end of fiscal 2022. This accounts for 47.5% of Japan's total generating capacity, making thermal power the predominant source of electricity. In recent years, the increasing deployment of variable renewable energy (solar power) 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 (see Figure 4.2).

Coal-fired generating capacity came to 50.7 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. In fiscal 2021, the government began calling on inefficient coal power plants to curtail power generation through the capacity market (curtailing the average annual capacity factor to no more than 50%, beginning in fiscal 2025). As another step for phasing out inefficient coal power, the government will establish in fiscal 2023 a new index only for coal power in the power generation efficiency benchmark system based on the Act on the Rational Use of Energy, adding to the existing weighted average index for thermal power as a whole.

LNG-fired generating capacity totaled 79.1 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[13] 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 21.6 GW. Oil plays a measurable role in power supply during peak demand and balancing.[14]

Breakdown of Commercial Power Generation Facilities by Power Source (FY2022) Figure 4.1



Source: OCCTO, "Aggregation of Electricity Supply Plans for FY2023"

b. Hydro Power

Hydro power generating capacity stood at 49.2 GW at the end of fiscal 2022. Hydro power plants have been promoted in Japan to take advantage of the country's abundant rainfall. Conventional hydro accounted for 21.8 GW and pumped storage for 27.4 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

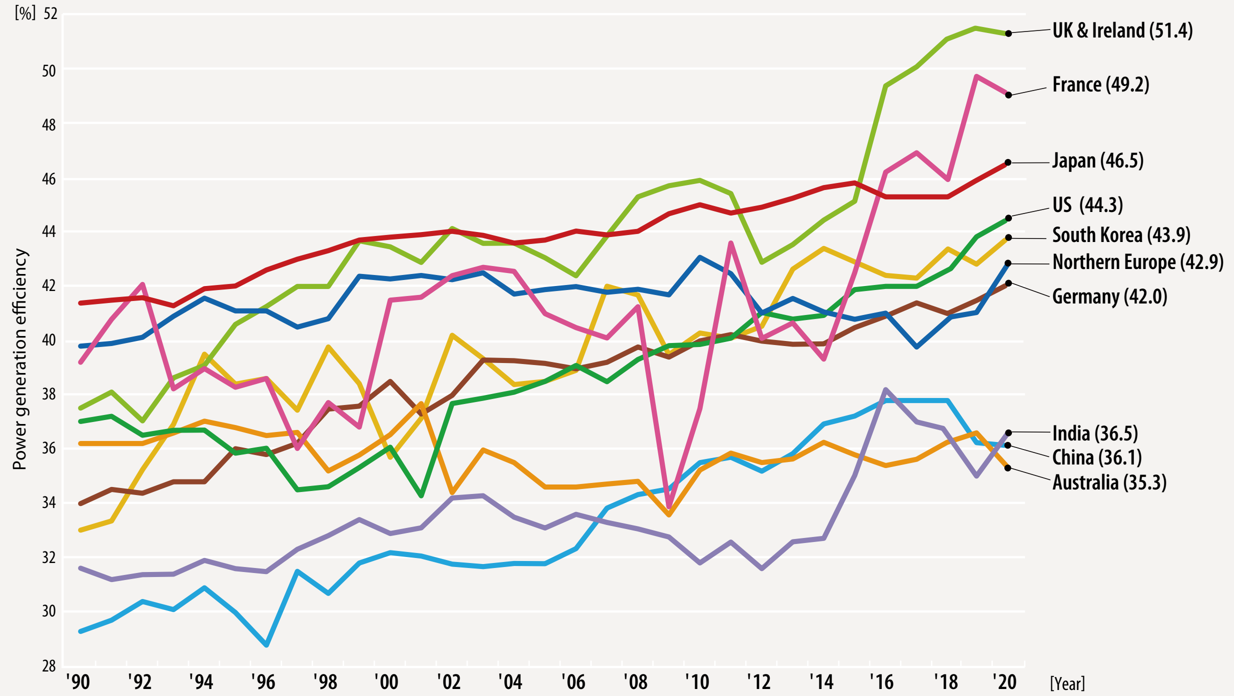
12 The data on power generation facilities include facilities owned by electricity generation utilities and those owned by entities other than electricity generation utilities from which electricity retailers and general electricity transmission and distribution utilities procure electricity (such as facilities generating electricity under the FIT scheme).

13 JERA Co.'s Nishi-Nagoya Thermal Power Station Group 7-2 (operation started in March 2018)

14 No new oil-fired plants have been constructed since the IEA declared in 1979 that the use of coal would be expanded.

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

Figure 4.2

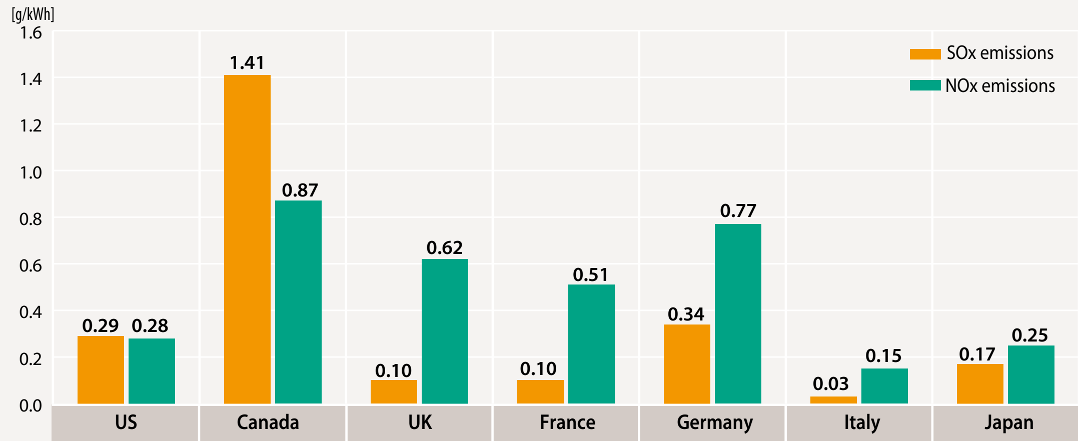


Note: 1. Power generation efficiency is generation-end weighted average of power generation efficiencies of coal, oil, and gas (low heating value basis).
2. Covers facilities of electricity generation utilities whose main business is selling electricity to third parties.
3. Figures for Japan are for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

Source: FEPC, "INFOBASE 2022" (2022)

Comparison of SOx and NOx Emissions per Unit of Power Generated at Thermal Power Plants of Major Countries (2020)

Figure 4.3



Source: FEPC, "INFOBASE 2022" (2022)

energy as they are able to control their input power flexibly during pump operation. Possibilities are being studied for maintaining and strengthening pumped storage power generation as a means of ensuring balancing capacity while decarbonizing electricity and promoting the adoption of intermittent renewable energy.

c. Renewable Energy

• Solar

Installed solar power generating capacity at the end of fiscal 2022 was 70.1 GW. The deployment of renewable energies, mainly solar power, has been progressing in Japan. Solar power makes up 84.9% of total FIT-certified renewable power generating capacity. As a result, decrease in net demand[15] in the morning and increase in net demand in the evening 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 was curtailed in the Kyushu area in 2018, and as of the end of fiscal 2022 renewable energy output was being curtailed in Tohoku, Kansai, Chugoku, Shikoku, and Kyushu (see Figure 4.4).[16] Resolution of this fluctuating output challenge is a critical task for advancing the further deployment of solar power.

• Wind

Wind power generating capacity was 5.3 GW as of the end of fiscal 2022. 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 190 MW of capacity is offshore. However, the FIT-certified capacity of offshore wind power has trended upward, reaching 685 MW at the end of fiscal 2022.

• Biomass and waste

Biomass and waste generating capacity at the end of fiscal 2022 came to 6.7 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.

• Storage batteries

The installed capacity of storage batteries was 0.16 GW as of the end of fiscal 2022. The growing adoption of intermittent renewable energy such as wind and solar has made the need to ensure balancing capacity a pressing challenge, elevating the importance of grid-scale storage batteries as one means of balancing capacity. As part of the May 2022 revisions to the Electricity Business Act, grid-scale storage battery facilities with a capacity of 10 MW or higher are now treated as power generation facilities in the form of energy storage stations. As a step toward the wider adoption of grid-scale storage batteries, conditions are being considered to facilitate the connection of energy storage stations to the grid.

d. Nuclear Power Generation

Total nuclear power generating capacity at the end of fiscal 2022 was 33.1 GW (33 units, excluding 3 under construction and 24 scheduled for decommissioning). 12 nuclear reactors (all PWRs) have resumed operation as of October 2023 (see "Nuclear Power Generation" in Section 2, Chapter II).

[2] Future Plans

a. Transition of Power Generating Capacity and Power Development Plans

In March 2023, OCCTO published the "Aggregation of Electricity Supply Plans for FY2023."[17] Figure 4.5 shows the trends in generating capacity by power source, and Table 4.1 shows the breakdown of power development plans up to the end of fiscal 2032 (new installation, uprating/derating, and retirement plans).[18]

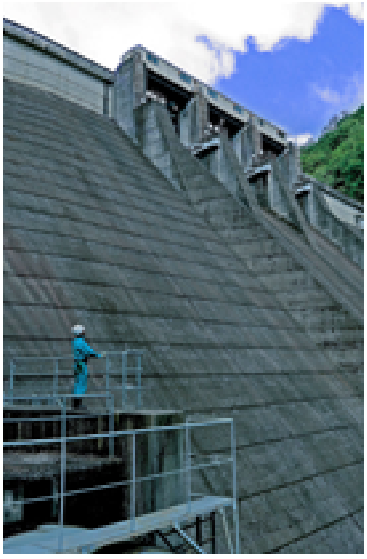
Looking forward, coal-fired generating capacity will trend upward overall as construction of new plants will outweigh ongoing decommissioning. As the global trend to reduce GHG emissions continues, however, the withdrawal of plans for new coal-fired power plants and the shift to gas-fired power plants are observed in Japan. Decommissioning of oil-fired power plants will continue and their generating capacity will shrink. Note that net gas-fired generating capacity will increase because the number of new gas-fired power plant construction projects exceeds the number of decommissionings. Renewable generating capacity will increase driven by construction of new solar power plants and wind farms, and hydro power generating capacity will increase marginally.

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

16 As of July 2023, renewable energy output had been curtailed in all areas except the Tokyo area.

17 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.

A large-scale storage battery (a redox flow battery) (Hokkaido Electric Power Network Co., Ltd.))
COD: April 1, 2022 / Owner: Hokkaido Electric Power Network Co., Ltd. / Site: Minami-Hayakita Substation, Hokkaido Electric Power Network / Power: 17,000 kW; Capacity: 51,000 kWh



Available storage capacity doubled by heightening dam (Chugoku Electric Power Co.)
Site: Odomari Dam / Completion: July 1935 / Height increase: April 1959

Hydro turbine runner suspended for repowering (Chugoku Electric Power Co.)
Site: Takiyamagawa Power Station / COD: January 1959 / Output: 52.5 MW

Anegasaki Thermal Power Station (New Units 1, 2, 3) (JERA Co., Inc.)
COD: August 2023 (New Unit 3) / Owner: JERA
Anegasaki Thermal Power Station (New Units 1, 2, 3) is a LNG-fired power station that utilizes a gas turbine combined-cycle power generation system (GTCC). The generating capacity is approximately 650 MW per unit (1,950 total) and will contribute to stable electricity supply. As a world-leading high efficiency power station, it mitigates environmental impact by reducing CO2 emissions.

Shin-Katsurazawa Power Plant (Hydropower) (J-POWER)
COD: 2022 / Owner: J-POWER / Capacity: 16,800 kW

b. Actions toward Achieving Carbon Neutrality in 2050

The Sixth Strategic Energy Plan **(see "1. Strategic Energy Plan" in Chapter II)** adopted 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.

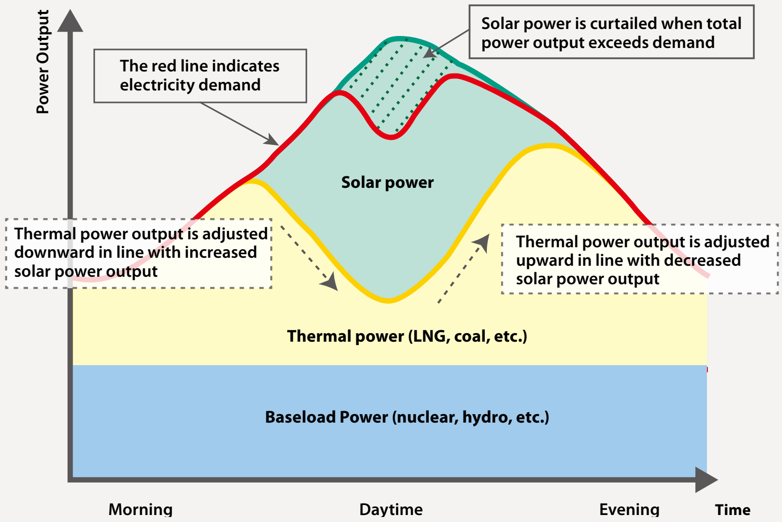
• Hydrogen and Ammonia

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

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

Schema of Renewable Energy Output Curtailment

Figure 4.4



Source: Kyushu Electric Power Transmission and Distribution Co., Inc. website

equipment 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. In addition to the established mixed combustion rates used in hydrogen- and ammonia-fired power generation, a wide range of rates, including 100% firing, are to be realized. Specifically, a goal has been set to introduce and promote 30% hydrogen co-firing with gas, 100% hydrogen firing, and 20% ammonia co-firing with coal by 2030.

Regarding hydrogen, METI formulated the "Basic Hydrogen Strategy" in 2017 and the "Hydrogen and Fuel Cell Strategy Roadmap" in March 2019. The Basic Hydrogen Strategy was revised in June 2023. Among other goals, this plan aims to commercialize hydrogen power generation by around 2030, and ammonia power generation in the latter half of the 2020s, as part of actions for advancing decarbonization and strengthening energy security. It also 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.[19]

• 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 in ways that capture CO_2 from the exhaust gas generated by power plants and other emission sources and combine 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.

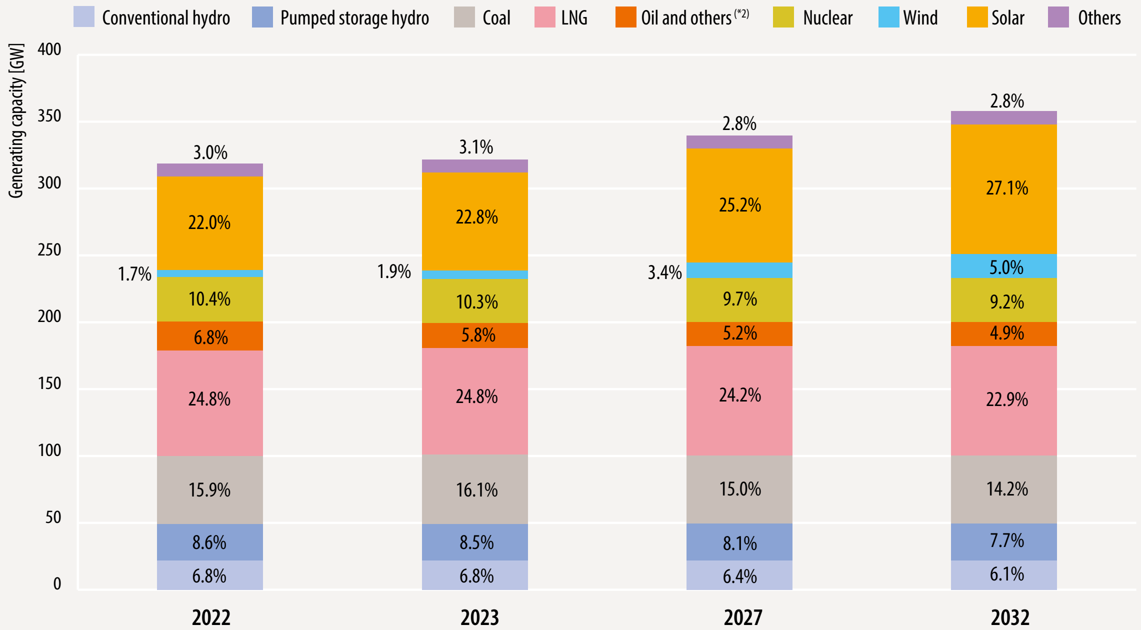
• Long-term Decarbonized Power Supply Auction

The Agency for Natural Resources and Energy issued the Guidelines for the Long-term Decarbonized Power Supply Auction in July 2023. This auction seeks to encourage new investments in decarbonized power sources such as natural gas-fired power plants. It will introduce bidding on new investments in addition to the established capacity market auction, under a scheme that will make it easier for utilities to visualize long-term returns on the enormous initial investments required, and will provide consumers with value

19 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, 2022–2032 (*1)

Figure 4.5



*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 FY2023"

Power Development Plans up to FY 2032 by Stages

Table 4.1

[Output: MW]

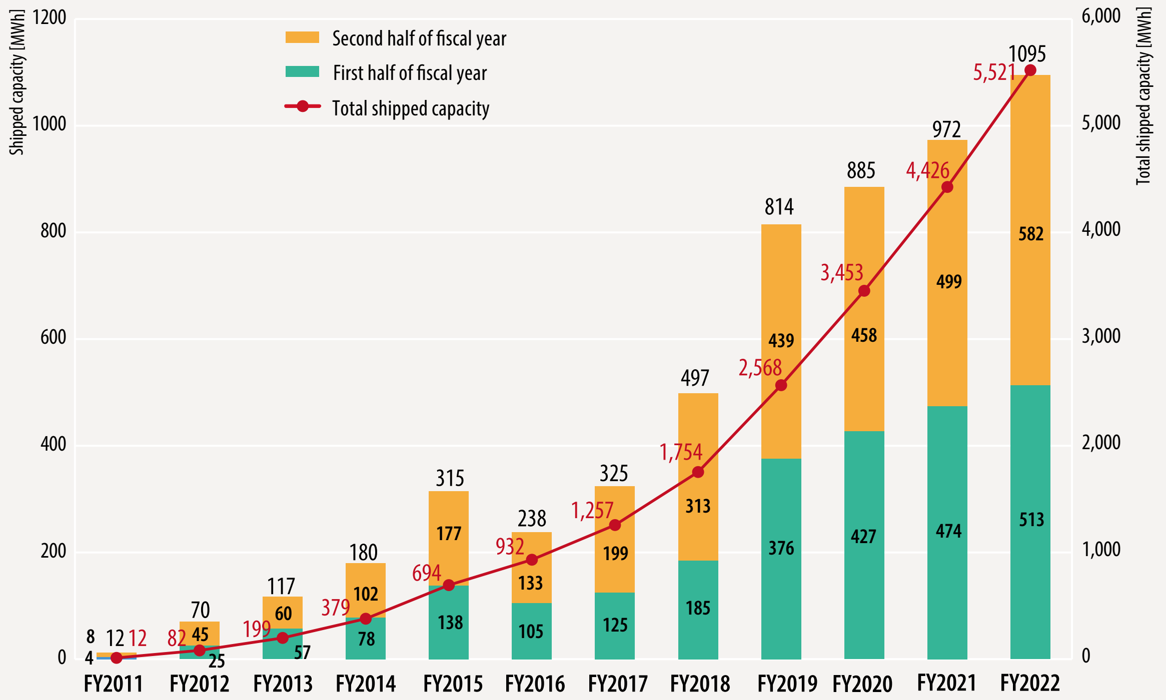
Power source		New installation plan		Updating/derating plan		Retirement plan		Total
		Output	Sites	Output	Sites	Output	Sites	Output
Hydro		**516**	**62**	**44**	**64**	**-153**	**28**	**407**
	Conventional	516	62	44	64	-153	28	407
	Pumped storage	–	–	–	–	–	–	–
Thermal		**8,067**	**28**	–	–	**-6,321**	**29**	**1,746**
	Coal	1,800	3	–	–	-850	5	950
	LNG	6,237	14	–	–	-2,075	6	4,162
	Oil	30	11	–	–	-3,396	18	-3,366
Nuclear		**10,180**	**7**	**152**	**1**	–	–	**10,332**
Renewables		**8,685**	**403**	**-6**	**2**	**-826**	**66**	**7,853**
	Wind	3,515	90	–	–	-674	52	2,841
	Solar	3,773	262	–	–	-2	2	3,771
	Geothermal	75	5	–	–	-24	1	51
	Biomass	1,220	41	–	–	-53	4	1,167
	Waste	46	3	-6	2	-74	7	-34
	Storage batteries	55	2	–	–	–	–	55
Total		**27,448**	**500**	**190**	**67**	**-7,300**	**123**	**20,338**

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, FY2023"

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

Figure 4.6



Source: Compiled from the Japan Electrical Manufacturers' Association, "Self-reported Statistics on Stationary Lithium-Ion Storage Battery Systems" (FY2022).

in the form of decarbonized electricity. It is also intended to shield profits by containing medium- to long-term risks concerning supply stability and price increases.

The auction will involve bidding[20] on decarbonized power sources using a mixed-source approach. The successful bidders will receive capacity revenues based on a fixed cost level for 20 years in principle. The first auction will take tenders on a total of 4 million kW in capacity from decarbonized power sources. A cap of 1 million kW will be placed on each of three categories: projects for upgrading existing thermal power plants, storage battery systems, and pumped storage hydropower. Prices will also be capped at amounts calculated using each supply area's balancing coefficient for 3-hour continuous operation. Advance registration for each category will begin around October 2023, and the auction is scheduled to be held in January 2024.

• Storage Batteries

METI is also seeking to further expand the adoption of renewable energy[21] by using storage batteries and other technologies to address the power output fluctuations related to intermittent renewables.

The use of battery storage systems is rising. A cumulative total of over 770,000 stationary lithium-ion battery storage systems with a capacity in excess of 5.5 GWh were in use in fiscal 2022 (see Figure 4.6). Meanwhile, METI is conducting experimental projects using battery storage systems. Themes selected for these projects include the adoption of large-scale electricity storage systems for grid stabilization against variable renewable power 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. Also, a demonstration project was conducted at Hokkaido Electric Power's Minami Hayakita Substation up through 2019 to test the use of a redox flow battery to provide balancing capacity for renewable energy output fluctuations.

20 The bid prices include 10% of construction costs as reserve against the risk of increased construction costs, and 5% as business compensation.

21 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, and 132 kV transmission lines. The maximum transmission voltage is 500 kV for the 10 general electricity transmission and distribution utilities except Hokkaido Electric Power Co. (275 kV) and Okinawa Electric Power Co. (132 kV). As of the end of March 2023, these transmission lines had a circuit length of approx. 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 2023, Japan's ten general electricity transmission and distribution utilities had 7,125 substations with a total installed capacity of approx. 875,000 MVA (Table 4.2). Almost all substations are now unmanned, with remote monitoring and control.

Transmission and Distribution Facilities — Table 4.2

FY	1975	1985	1995	2005	2015	2018	2019	2020	2021	2022
Circuit length of transmission lines [km]										
220kV or above	14,167	23,486	29,107	35,209	36,949	36,986	37,021	37,216	37,205	37,352
110kV Under 220kV	28,913	35,106	36,952	35,962	35,588	35,390	35,441	35,457	35,431	35,452
Under 110kV	69,361	78,660	88,648	95,176	106,167	106,494	106,784	107,058	107,286	107,359
Total	112,441	137,252	154,707	166,347	178,704	178,870	179,246	179,731	179,922	180,163
Transformation facility capacities										
Substation output capacity (MVA)	234,748	447,866	657,536	778,740	833,112	846,638	850,313	868,556	872,552	874,504
Total Number of substations	3,466	5,152	5,814	6,570	6,718	6,783	6,786	7,137	7,125	7,125
Circuit length of distribution lines [km]										
Overhead	2,623,787	3,179,970	3,661,963	3,918,743	4,005,974	4,031,278	4,038,426	4,046,028	4,052,015	4,058,023
Underground	14,358	25,348	50,371	65,287	70,733	72,735	73,420	73,995	74,494	75,091
Total	2,638,145	3,205,318	3,712,334	3,984,030	4,076,707	4,104,013	4,111,846	4,120,023	4,126,509	4,133,114

Source: FEPC, "Electricity Statistics Information"

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.

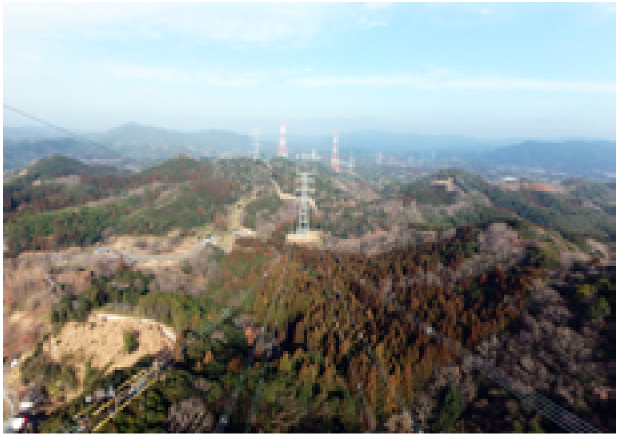
(3) Distribution Facilities

Distribution lines are classified into extra-high voltage lines (33/22 kV), high voltage lines (6kV), and low voltage lines (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 2023, the total length of distribution lines in Japan was approx. 4,133,000 km. Of this, approx. 75,000 km (approximately 1.8%) consisted of underground lines (Table 4.2).

Removing snow from power distribution lines (Hokkaido Electric Power Network)

Power transmission line maintenance (Tohoku Electric Power Network)
Maintenance of transmission and distribution equipment for stable power supply

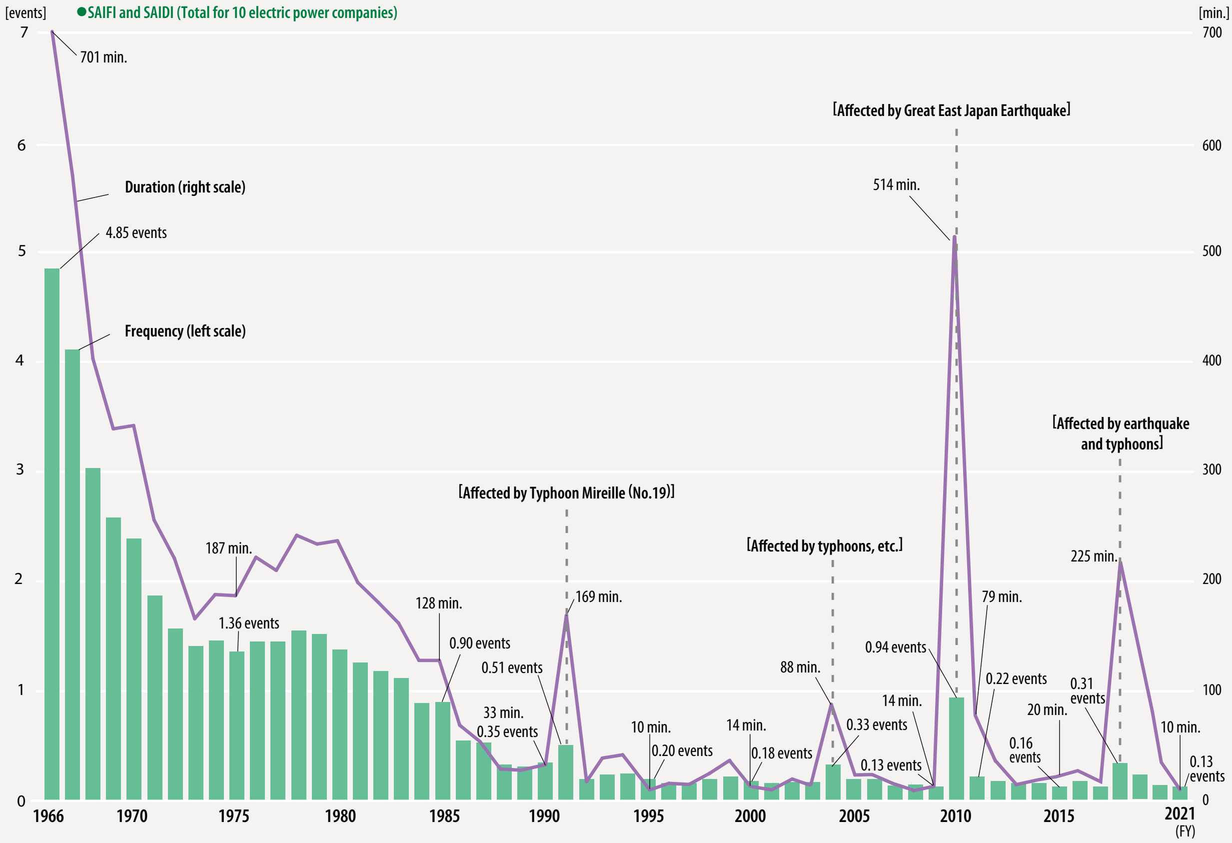
Assist Arms (Hokuriku Electric Power T&D)
Hokuriku Electric Power T&D utilizes "Assist Arm" robots jointly developed with universities and manufacturers to aid power distribution workers. In the near future, these will reduce labor requirements and improve efficiency by automating some work.



The 500,000-V Hyuga Trunk Line (Kyushu Electric Power Transmission and Distribution)
Construction: June 2022 / Operators: Kyushu Electric Power Transmission and Distribution Co., Inc.
Special note: The 500,000-V Hyuga trunk line was constructed to build the 500,000-V loop system in the area between northern and southern Kyushu. The facility aims to prevent widespread power outages during planned updates to aging 500,000-V infrastructure.

SAIFI and SAIDI Trends

Figure 4.7



Note: 9 electric power companies up to FY1988

Source: FEPC, "INFOBASE 2022" (2022)

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

Smart meters for 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 91.1% of low voltage customers (including households) had been provided with smart meters as of the end of March 2022. 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 (see Figure 4.7).

In fiscal 2021, the System Average Interruption Frequency Index (SAIFI) was 0.13 interruptions and the System Average Interruption Duration Index (SAIDI) was 10 minutes. The national averages were lower than in fiscal 2020 despite severe damage inflicted by Typhoon Chan-hom (No. 14) in mainly Kyushu, Chugoku, and Shikoku in September 2021 (in

Kyushu, approx. 350,000 households were without power at the peak, and service was completely restored 3 days after the peak).

(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 partially revise the Electricity Business Act and other legislation with the aim of securing 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 collaboration during disasters, and to update local governments and other authorities on the status of power supply service during disaster recovery.
- Create a mutual assistance system in which general electricity transmission and distribution utilities accumulate in advance the costs related to temporary recovery, etc. and general electricity transmission and distribution utilities that incur damage from a disaster can receive the costs.

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 (a "push" approach to development).
- Require general electricity transmission and distribution utilities to carry out planned upgrades of existing facilities.[22]
- 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

- Place in law a distribution business that is able to operate regional distribution networks that include distributed power supply systems during normal times and operate their network independently during emergencies; also approve independent operation of distribution networks in cases where it would improve the stability/efficiency of electric power supply to mountainous and other remote regions.
- Introduce an electricity distribution licensing system to help newcomers enter the electricity distribution market by enabling them to lease or take over the distribution networks formerly operated by general electricity transmission and distribution utilities.

The provisions for (a) and (b) were phased into effect starting in July 2020, while those for (c) went into effect in April 2022.

(6) Digitalization in the Transmission and Distribution Sector

To address challenges such as aging facilities 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 and distribution utilities are seeking to shrink manpower needs and improve maintenance techniques through the development and deployment of solutions such as an "Autonomous Flight System for Transmission Line Inspection Drones" that enables drones to autonomously follow and photograph transmission lines, and systems that use imaging analysis and AI tools to automatically detect failures from photographs of facilities.

In addition, utilities are considering other possibilities for expanding the adoption of renewables, including the use of dynamic line rating to achieve flexible operation of transmission capacity through accurate calculation of transmission wire temperature based on weather conditions.

22 In December 2021, OCCTO issued a set of guidelines on the upgrading of aging facilities that included standard methods for processes such as facility risk assessments. The guidelines present a unified approach to the concepts and methods of facility upgrades with the aim of helping general electricity transmission and distribution utilities to appropriately and rationally carry out their improvements, and thus ensure resilience while containing the cost burden on the public.

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[23]. 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.

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 2023, 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 (see Figure 4.8).

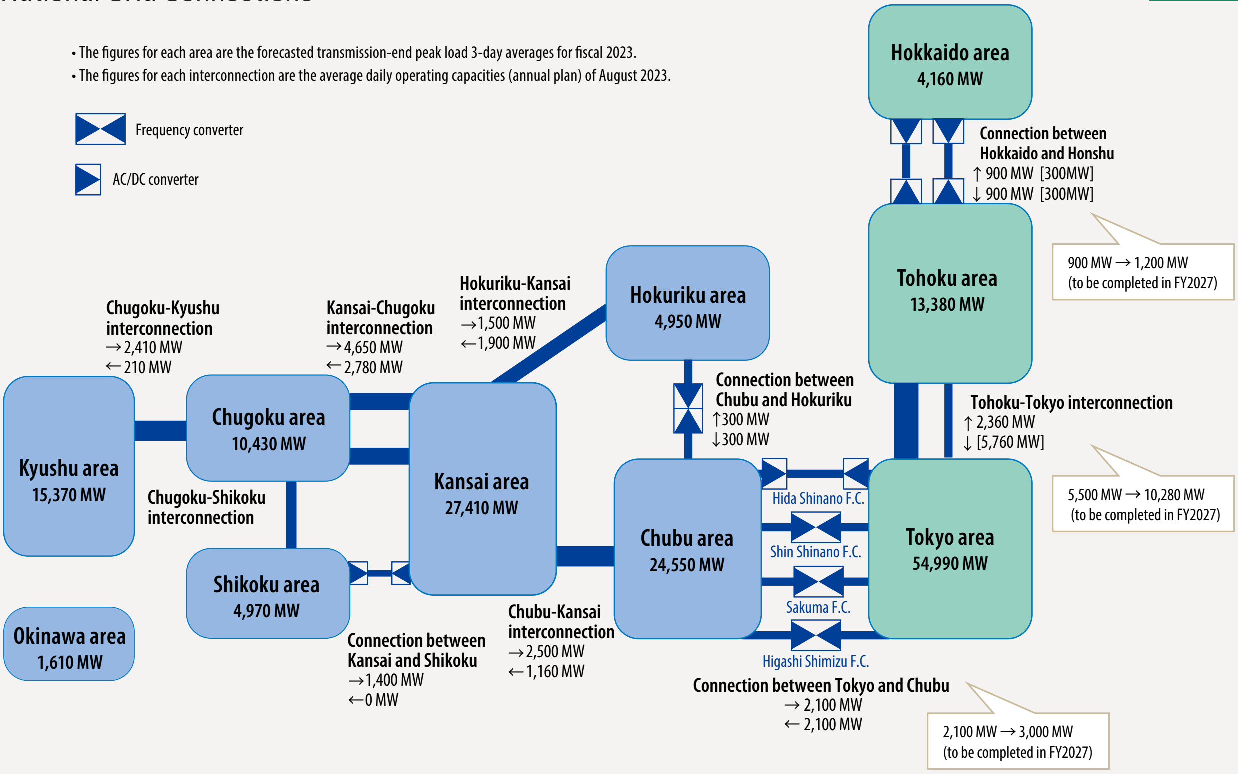
Along with the increasing large-scale adoption of distributed energy sources in recent years, OCCTO has been studying and formulating plans to enhance these interconnections, taking into account points raised by itself and the general electricity transmission and distribution utilities and requests from the government. In line with a plan developed by OCCTO, 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). OCCTO also established plans for increasing the capacity of the Tokyo-Tohoku interconnection by 4.8 GW by fiscal 2027 and for expanding the Hokkaido-Honshu interconnection's capacity by 300 MW, and construction for both projects is currently underway.

FIT surcharge revenues will be used to cover the portions of

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

National Grid Connections

Figure 4.8



Figures in brackets indicate minimum operating capacity during work involving a deactivation of electric power system facilities.

Source: Compiled by the authors from Agency for Natural Resources and Energy, "Developing Next-generation Electric Power Networks" (2023), and OCCTO, "Grid Operating Capacity in FY2023–FY2032 (Annual & Long-term)" (2023)

the interconnection capacity expansion construction costs that are expected to contribute to the public benefit by lowering electricity prices and CO_2 emissions through the adoption of renewable energy. The remainder will be covered by all general electricity transmission and distribution utilities and through OCCTO subsidies.

(3) Long-term Policy for Cross-regional Interconnections

OCCTO formulates and periodically reviews[24] a long-term policy that sets a course for developing and upgrading Japan's cross-regional interconnection systems on a nationwide scale. In March 2023, it issued a new long-term policy as a master plan based on re-examination of the concrete long-term vision for cross-regional interconnections that support the achievement of carbon neutrality in 2050, and of the measures for realizing that vision.

(1) Long-term Vision for Cross-regional Network Development

The master plan seeks to shift from the established "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 in a manner that takes into account the potential of each power source. In formulating the long-term vision for development of cross-regional interconnections, OCCTO studied measures for strengthening the nationwide grid, carrying out cost-benefit analysis[25] that considered factors such as the amount of time needed to implement grid improvements and the prospects for future adoption of power sources (see Figure 4.9). The analysis showed that a commitment to making grid improvements that could realize the transition to renewables as the main energy source for power generation while increasing the electric power network's resilience would entail an investment of around seven trillion yen, but benefits exceeding this outlay could be expected.[26]

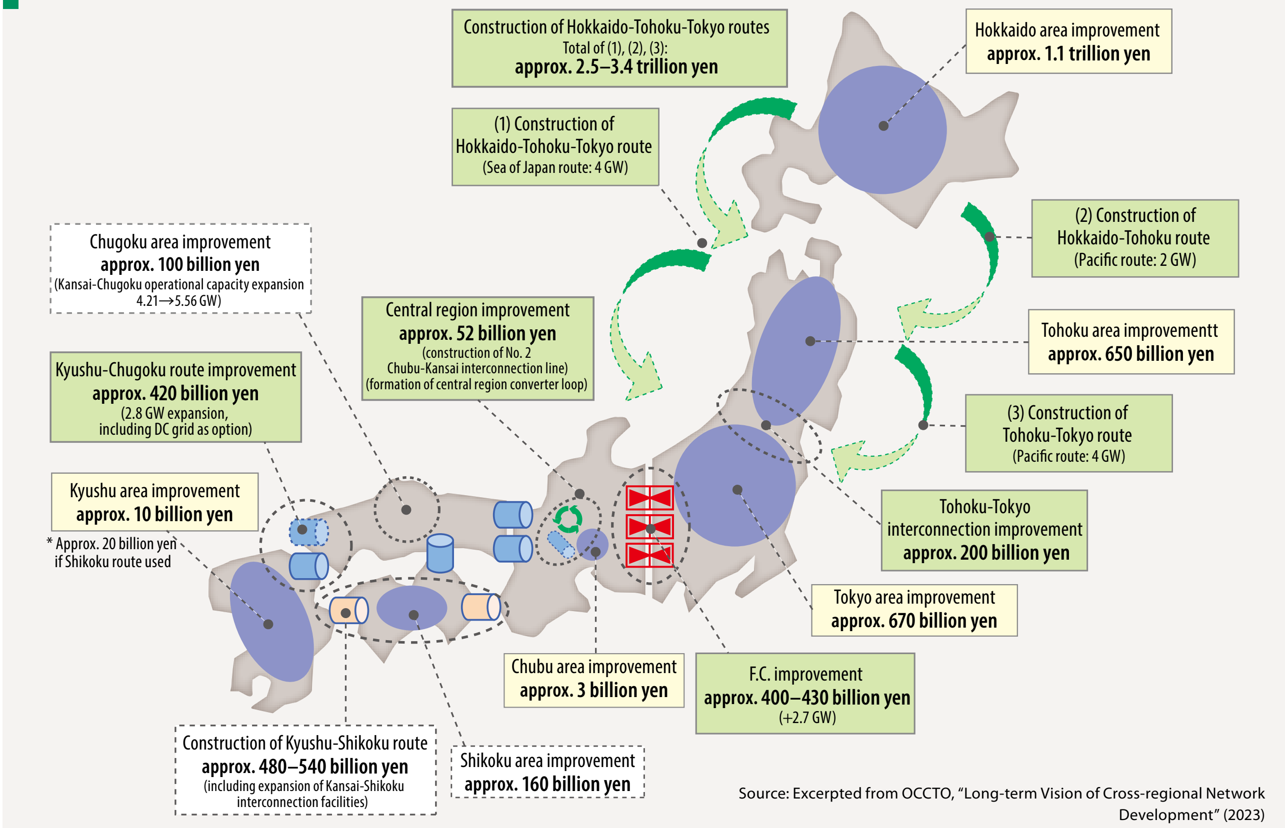
(2) Measures for Realizing the Long-term Vision

In order to carry out the grid development projects in line with the long-term vision, a mechanism for grid use

24 The reviews are conducted in roughly five-year intervals. The preceding review was carried out in March 2017.
25 The analysis compared the cost of strengthening grid points prone to congestion versus the expected benefits of those improvements.
26 The analysis also found that the outlay could outweigh the benefits depending on the scale of the improvements and fuel prices.

Grid Improvements under the Long-term Vision for Cross-regional Network Development

Figure 4.9



Source: Excerpted from OCCTO, "Long-term Vision of Cross-regional Network Development" (2023)

premised on congestion needs to be firmly established. To that end, the following three actions that make effective use of existing infrastructure are being implemented as a "Japan-style connect and manage" approach.[27]

(i) Rationalization of estimated power flow

This is an approach for calculating the available capacity of transmission lines 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 April 2018.

(ii) N-1 inter-trip scheme

This scheme, which is applicable to new power sources connecting to grids, is a method of instantly limiting their power output to secure stable transmission capacity in the event of N-1 failure.[28] Rollout began in October 2018 with application to power sources connecting to extra-high or higher voltage grids. In July 2022, the scheme started to be applied to all power sources, including existing ones, to provide a mechanism for expanding operational capacity.

(iii) Non-firm access

This is a method of allowing fresh access on condition that output is limited while other power sources are in operation.[29] It has started to be phased in, beginning in January 2021 with power sources connected to the bulk power system, transmission systems other than this system and distribution systems without available capacity, and followed in April 2022 by power sources with bulk power system-class receiving voltage. Since April 2023, non-firm access has been applied to new grid-connected power sources regardless of voltage class or capacity availability but excluding low voltages below 10 kW.

OCCTO's selection of power source mixes and locations for the long-term vision was based on certain assumptions informed by the government's policy discussions. For this reason, further investigation is needed to determine the optimal scale and timing for implementation of each particular improvement project, taking into account factors such as trends in power source development.

27 This is an approach for answering the interconnection needs of new power sources, while improving the efficiency of transmission and distribution facilities through maximum utilization of existing facilities. It tailors the "connect and manage" model used in the UK and elsewhere to Japan's circumstances.

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

29 Since this approach does not require expansion of the bulk power system, it enables power sources to access transmission and distribution lines without having to construct additional facilities.

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 2023, 46.60 million low voltage customers (68% of the total) paid regulated rates.

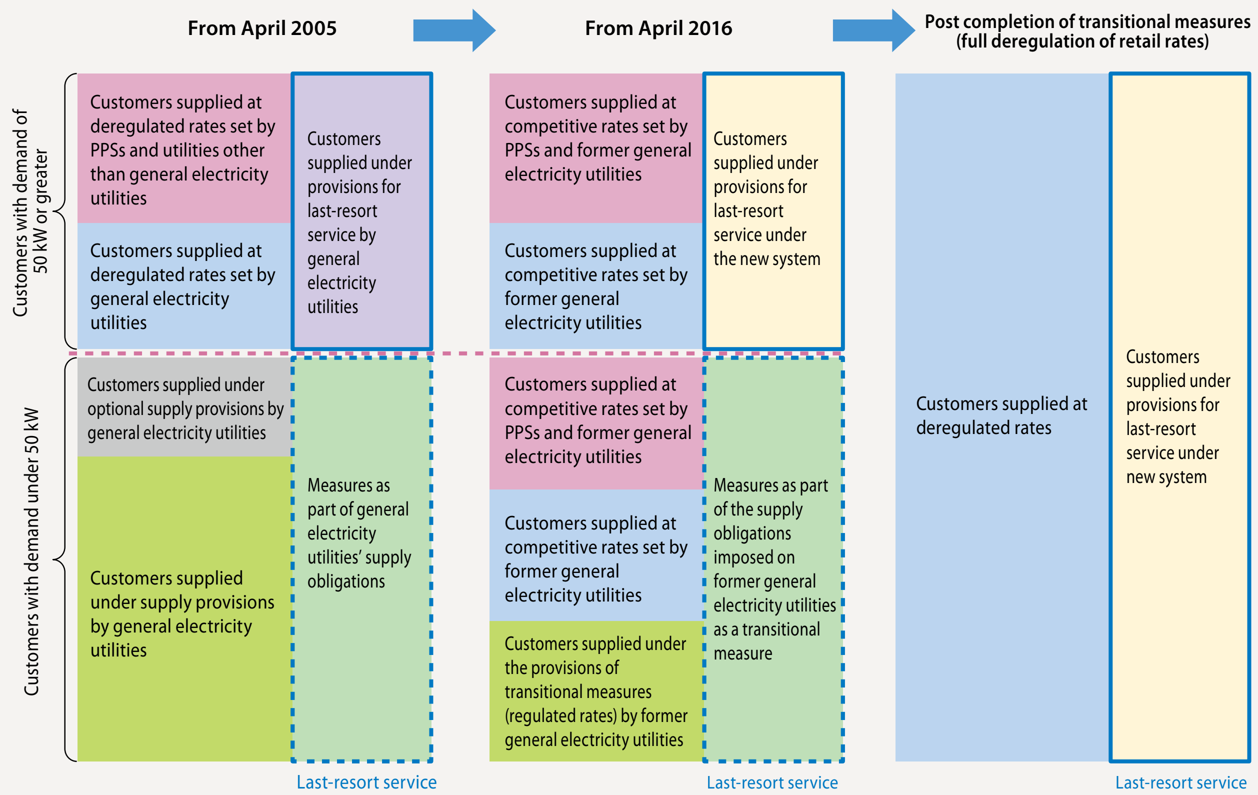
Regulated rates were originally to be discontinued at the end of March 2020. However, as competition had not developed sufficiently, METI decided in July 2019 to maintain regulated rates from April 2020 onwards. Discontinuation of regulated rates will continue to be considered, while paying close attention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

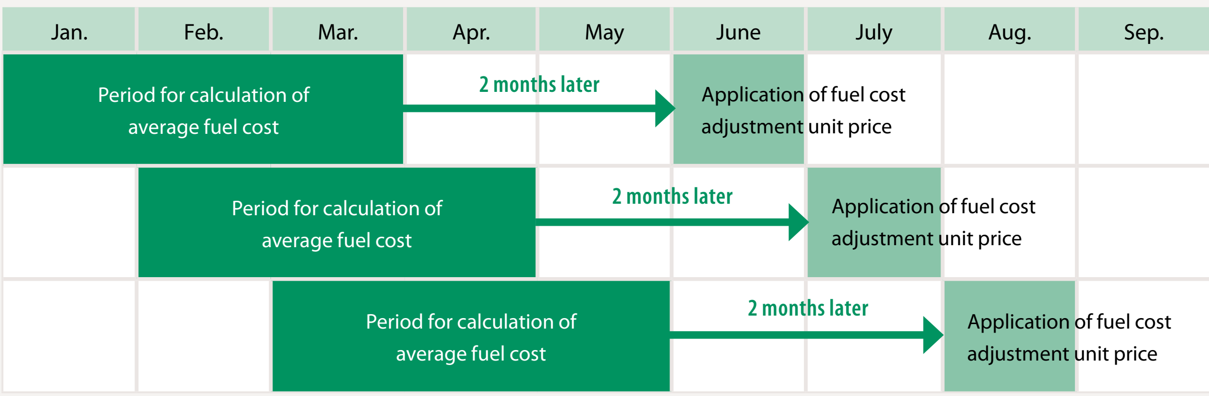
At present, the period (time gap) before fuel price fluctuations are reflected in electricity prices is set to two months in order to level rate fluctuations, and fuel price three-month averages are reflected in the electricity rates charged each month (see Figure 5.2). Also, as a measure for reducing the impact of large fuel price increases on customers, a cap is set on upward adjustments of the automatically adjusted rate (standard fuel price + 50%).

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) was 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

Fuel-Cost Adjustment Timing [Example: June, July, August]

Figure 5.2



Source: Compiled from FEPC materials

calculated in proportion to the volume of use by customers that constitutes one component of electricity rates (see "Renewable Energy" in Section 3, Chapter II).

(2) Unregulated Rates

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

(3) Trends in Unit Electricity Rates

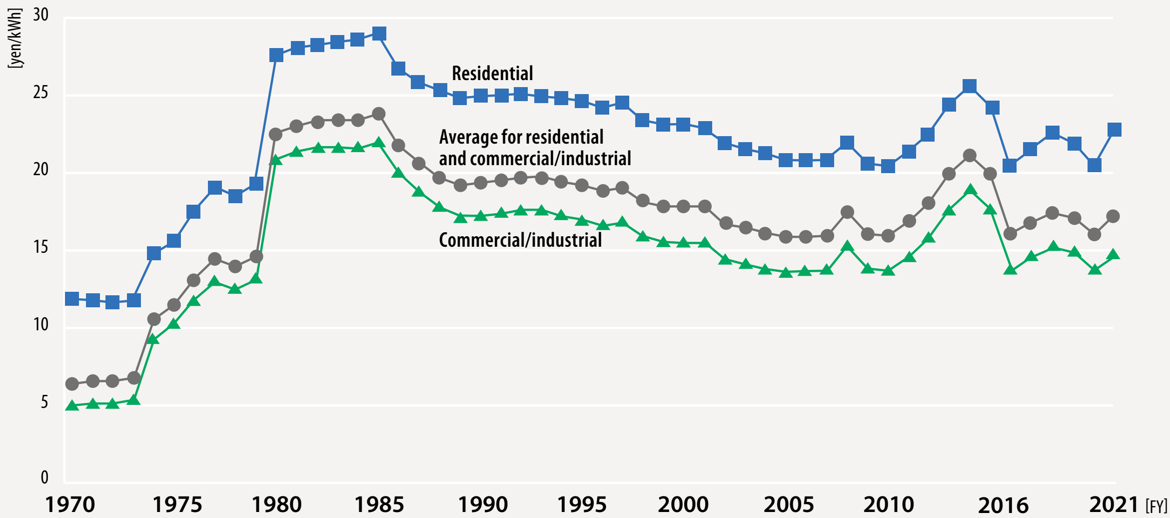
Electricity rates in Japan climbed sharply in the 1970s and early 1980s due to the oil crises, but subsequently entered a long-term decline, owing in part to operational streamlining efforts by the former general electricity utilities. Since the Great East Japan Earthquake in 2011, however, rates have again risen due to the increased cost of generating power at thermal power plants resulting from the shutdown of nuclear power plants and escalating fuel prices. Electricity rates fell from 2015 due to lower fuel costs, but began rising again in 2017, and then started declining again in fiscal 2019 (see Figure 5.3). The rates climbed in fiscal 2021 due to skyrocketing fuel prices.

(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. Up through fiscal 2022, the wheeling charges were 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, and were then opened to public comment prior to final adoption. However, a revision that went into effect from fiscal 2023 instituted a new system that places caps on the revenues of the transmission and distribution

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, "FY2021 Annual Report on Energy" (2022) utilities for each period, based on considerations such as each utility's investment plans. The cap is designed to encourage the utilities to make efforts to improve their cost efficiencies within the framework. By enabling general electricity transmission and distribution utilities to achieve greater cost efficiency while also securing the investments they need, the new system seeks to advance the adoption of renewables as the main power source and to strengthen resilience.

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 on those islands is mainly generated by thermal power plants, and the cost of provision of universal service for the 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."

(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, promote efficient use of transmission and distribution networks, and encourage electricity generation utilities to pursue business development in a manner mindful of network costs. To do this, the scheme would also have power generation-side operators, as grid users, bear some of the costs, with their share based on their level of revenue. The Strategic Energy Plan indicated that further discussion would be pursued on levying such a fee, including with regard to whether it was necessary. However, the details of this scheme are already being worked out, with an eye on launching it in fiscal 2024.

(6) Impact of Increases in Fuel Prices and Wholesale Electricity Market Prices

Fuel prices and wholesale electricity market prices have been rising steeply since early fall of 2021, placing electricity retailers in a tight squeeze. Of the roughly 700 PPSs that had registered to operate as of April 2021, 195 (approx. 28%) became insolvent, closed down, or left the market by March 2023. Moreover, many PPSs and former general electricity utilities have stopped taking new contracts for the unregulated high-voltage rate plans. As a result, customers looking for a new provider have increasingly turned toward final guaranteed supply contracts. The number of these contracts began surging upward in March 2022, rising to 46,000 as of October of that year. As originally conceived, final guaranteed supply contracts function as a safety net for high-voltage contracts, offering service at rates around 20% above the standard plans set by the former general electricity utilities, and were not intended to be long-term contracts. However, in some cases, these contracts became cheaper than unregulated rate plans as utilities sought to counter the sharp rise in fuel prices by reflecting power procurement costs in the unregulated rates. As a result, customers began shifting to the lower final guaranteed supply rates. In response, METI decided to implement a scheme whereby a correction linked to wholesale electricity market prices will be added to final guaranteed supply rates. The correction is calculated as the sum of the area price (including loss rate and consumption tax) and the wheeling metered charge unit price, less the current final guaranteed supply metered charge unit price (including fuel-cost adjustment). This was put into effect by the general electricity transmission and distribution utilities in September 2022, leading to a drop in the number of final guaranteed supply contracts to 14,000 as of July 2023.

In October 2022, all former general electricity utilities reached the ceiling set by the fuel-cost adjustment scheme. In May 2023, the government approved requests by seven of those utilities to raise their electricity rates, on the grounds that the stable supply of energy would be threatened if the utilities became unable to stay afloat. Those seven subsequently implemented rate hikes ranging from 14% to 42%, with the new rates going into effect on June 1.

Meanwhile, discounts have been applied to electricity consumption from January 2023 onward as a result of the government's measures for tempering sharp fluctuations in electricity and gas prices. Initially, the discounts were 7 yen/kWh for low voltage and 3.5 yen/kWh for high voltage, and changed to 3.5 yen/kWh and 1.8 yen/kWh, respectively, for electricity consumed in September and later. This relief will be provided through December 2023.

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 721 retailers as of March 2023.

As of March 2023, PPSs accounted for a roughly 17.7% share of the total volume of electricity sold. Of that share, approximately 23.8% was made up by sales to households and other low voltage customers **(see 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 approx. 3.3% to the total.

(2) Activities of Electricity Retailers

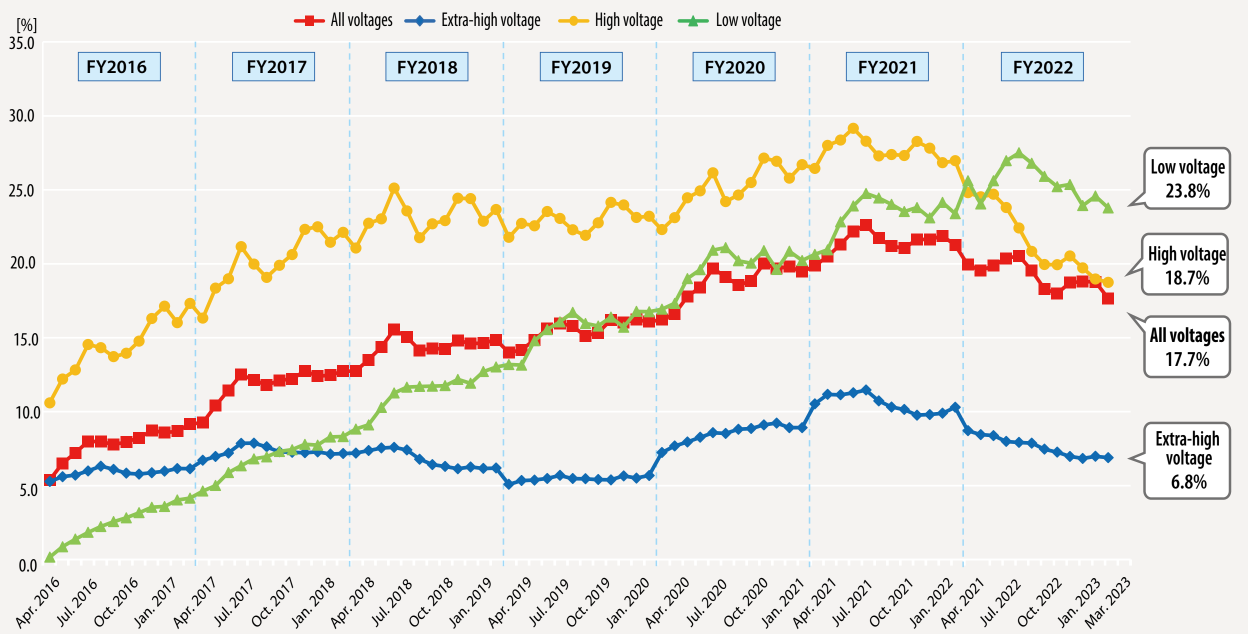
Electricity retailers supply extra-high voltage and high voltage customers in accordance with contracts and unit prices negotiated on the basis of projected electricity usage and actual circumstances. Former general electricity utilities are working to strengthen their business capacity by establishing 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, 100% renewable energy plans that add environmental value to electricity, point-based loyalty programs, and membership websites. Services that utilize information on electricity usage obtained from smart meters are also emerging.

Electricity retailers have also been working to promote onsite and offsite PPAs, through which power is supplied from solar panels or other generation facilities installed on the customer's roof or adjoining land (onsite), or from

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" remote generation facilities via a public transmission/distribution network (offsite). Japan's first offsite PPA was announced on March 31, 2021, and the number of these contracts is expected to grow going forward. The retailers are also collaborating with local governments and businesses in urban development projects aimed at achieving carbon neutrality.

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.

b. Additional Services and Discounts for Bundled Goods

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

(3) Rate Comparison Sites

Amid the aforementioned diversification of rate plans offered by electricity retailers, rate comparison websites have been launched by service providers to help customers choose the plans that best meet their needs. Also, with the recent stream of exits from the retail electricity market, such websites have also been offering in-depth information on contract procedures to customers in search of a new electricity provider.

(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 August 1, 2023, there were 285 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.

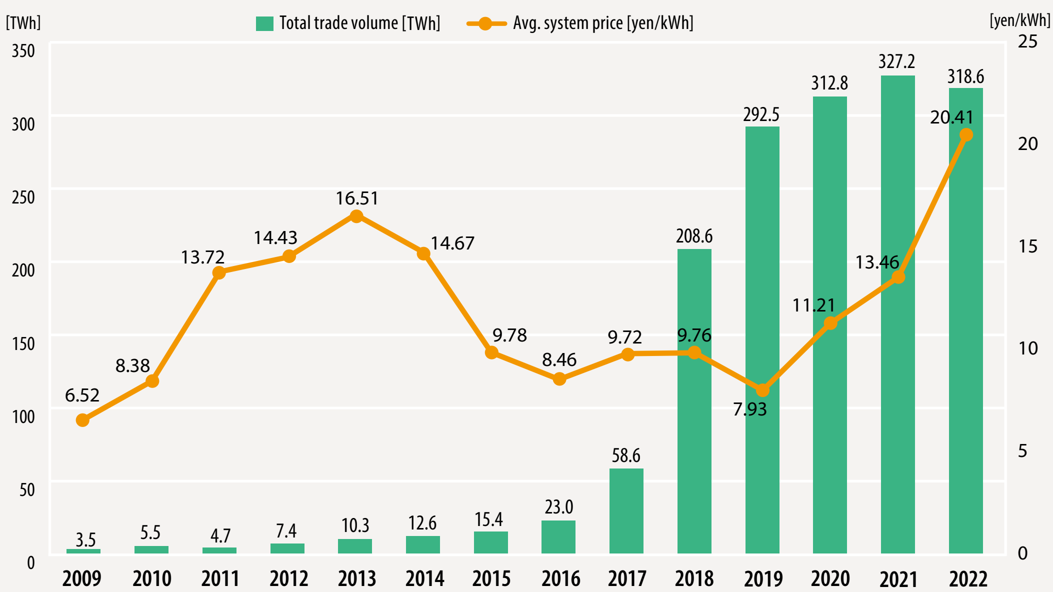
The spot market is the largest of the above four markets in trading volume and is a particularly important market. Trading is done through a blind single-price auction system. It is blind because participants cannot see other participants' bids when they make their bids. A single-price system is one 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 continued to rise from fiscal 2016 to 2021, but fell in fiscal 2022 due to a reduction in supply capacity caused by an earthquake that occurred off the coast of Fukushima Prefecture in March 2022 (see Figure 5.5). Approximately 40% of all electricity sold in Japan is sold through the spot market, and PPSs procure roughly 80% of their electricity from the spot market. The annual average system price hovered between 7 and 10 yen/kWh from fiscal 2015 to 2019, but climbed to 11.21 yen/kWh in fiscal 2020 due to an extremely sharp price surge that was driven by a supply crunch stemming from fuel procurement risks in winter. In fiscal 2021 it further rose to 13.46 yen/kWh due to the effects of reduced supply capacity from limited access to fuel, soaring fuel prices, and the aforementioned earthquake, and reached 20.41 yen/kWh in fiscal 2022 amid

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" (2022), and JEPX data the continued skyrocketing of the wholesale electricity market price. In August 2023, the wholesale price stood at 11.49 yen, having dropped with the falling price of fuel, but METI indicated that it could rapidly rise again, noting the uncertainty of global fuel prices going forward.

Amid the steep rise in prices, some electric power companies and other operators have started to cut back on add-on purchases from the spot market by leveraging demand response to make efficient use of electricity. Due to fuel procurement risks, supply shortages are expected to occur throughout fiscal 2023. In response, the Agency for Natural Resources and Energy has indicated that it will promote demand response in collaboration with other authorities and the private sector.

(2) Other Markets

Apart from electricity volume trading, Japan also has other markets that engage in trading for purposes such as securing stable power supply, achieving the sustainable, efficient, and equitable supply of electricity, and actualizing environmental value. These mainly include 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 baseload power sources (coal-fired, run-of-river hydro, nuclear, and geothermal) due to the tendency for the scale of development to grow, and the large number of bilateral contracts between largescale electricity generation utilities and former general electricity utilities. In order to energize competition in the retail power market, a system was created to help new entrants access electricity produced by baseload power plants. This was done by establishing in July 2019 a market dedicated to the trading of electricity produced by baseload power plants, and by institutionalizing a requirement for large-scale electricity generation utilities (electricity generation utilities, etc. that have a nationwide generation capacity of 5 million kW or greater) to contribute electricity to JEPX under a set ceiling price. This market is divided into three geographical areas (initially, Hokkaido, Eastern Japan, and Western Japan), and trading is done at an annually fixed price for each area. Compared with the spot market, which tends to be highly volatile due to the risk of fuel price fluctuations, the baseload power market is seen as having a hedging function since annual trading is done at a fixed price. However, rising fuel prices in the wake of Russia's invasion of Ukraine prompted discussion of the creation of a system whereby the balance of fuel costs, instead of the fixed prices, would be settled later. In the fiscal 2023 auction, a new system was adopted in which products were divided into two classes, the established one-year products, whose fixed price would be settled as done previously, and a new category, two-year products, whose fuel cost balance would be settled later. In addition, the three market areas were redefined for 2023 onward: Hokkaido was folded into Eastern Japan, and Kyushu was spun out of Western Japan as a separate area.

b. Capacity Market

The predictability of the payback on investment in power generation businesses is likely to decline, depending on the increasing competition and changes in environmental trends. Likewise, if the adoption of renewables expands the power generation operating rate of thermal power would fall since Japan's current system starts curtailing thermal power output before the curtailment of solar and wind power, which means that thermal power plant investments would become unable to reap satisfying returns. Consequently, the pace of new investments in power plants would likely stall. Given this situation, a capacity market was established in 2020 for the purpose of (1) ensuring a greater degree of predictability of investment returns, (2) the replacement of old power plants with new ones and (3) the securing of supply capacity (installed capacity) through market mechanisms..

The capacity market is operated by OCCTO and comprises several auctions: a main auction for securing capacity four years in advance; a follow-on auction held afterwards if OCCTO deems it necessary; and a long-term decarbonized power supply auction intended to help power generation utilities secure long-term revenue on their massive investments in new facilities and replacements for advancing decarbonization..

The power sources targeted by the main auction are largely divided into three categories: stable power sources that can be expected to consistently supply capacity of 1 MW or greater; variable power sources comprising wind, solar, and certain run-of-river hydro power sources; and on-demand power sources, including demand response (this category is subject to a procurement cap). Changes incorporated in the 2023 auction (for delivery in 2027) include raising the on-demand procurement cap, and an option to bid on capacity of storage batteries (discharge duration of at least 3 hours)

Power Sources Targeted by Long-term Decarbonized Power Supply Auction

Table 5.2

Category	Applicable Power Sources
New Installation & Replacement	Solar
	Onshore wind
	Offshore wind
	Hydro
	Hydro
	Storage batteries
	Geothermal
	Biomass
	Nuclear
	Hydrogen (10% or more)
	LNG
Improvement of Existing Facilities	Improvements for enabling hydrogen co-firing of 10% or more
	Improvements for enabling ammonia co-firing of 20% or more
	Improvements for existing thermal power plants that replace all fossil fuel capacity with biomass capacity

Source: Compiled by the authors from METI System Review Working Group , "Interim Report No. 11"

Balancing Capacity Market Products

Table 5.3

Product	Response Time / Continuous Operation Duration	Major Issues Rectified
Primary balancing capacity	**within 10 sec. / within 5 min.**	Short-term demand fluctuation; power drop
Secondary balancing capacity (1)	**within 5 min. / at least 30 min.**	Short-term demand fluctuation; power drop
Secondary balancing capacity (2)	**within 5 min. / at least 30 min.**	Errors in demand forecasts; errors in renewable energy forecasts
Tertiary balancing capacity (1)	**within 15 min. / 3 hr.**	Errors in demand forecasts; errors in renewable energy forecasts; power drop
Tertiary balancing capacity (2)	**within 45 min. / 3 hr.**	Errors in renewable energy forecasts

Source: Compiled from OCCTO; "Methods of Ensuring Balancing Capacity in the Simultaneous Procurement Market, and Their Timing "

as either an on-demand power source (as previously done) or a stable power source.

The long-term decarbonized power supply auction is intended to serve as a safeguard against a decline in capacity due to market exits or stalling of new investment. It will do this by providing power generation utilities with revenue for 20 years in principle, thereby enabling them to better visualize their investment returns. The first auction is scheduled to be held in January 2024 and will target the power sources listed in Table 5.2.

Discussion is currently underway on whether to include the cost of safety measures for restarting existing nuclear power plants in the scope of the long-term decarbonized power supply auction.

c. Balancing Market

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

Subsequently, a balancing market was established in April 2021 to enable greater efficiency in supply-demand balancing operation by augmenting auction-based procurement of balancing capacity with cross-regional procurement. The market is operated by the general electricity transmission and distribution utilities of each area. Its major products are listed in Table 5.3.

Trading began for tertiary balancing capacity (2) in April 2021 and for tertiary balancing capacity (1) in April 2022. The other products will start trading in 2024 or later.

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. The market initially limited buying to only electricity retailers, and some customers voiced the desire to be able to directly purchase non-fossil fuel value, and called attention to the high price of non-fossil value (the minimum is 1.3 yen/kWh). To answer this need, the market was divided into two markets that began trading in November 2021: a renewable energy value trading market in which consumers can directly participate in trading (market dealing in FIT renewable energy certificates; minimum/maximum prices: 0.3 yen/kWh, 4.0 yen/kWh), and a market for achieving the target[30] mandated by the Sophisticated Methods Act regarding the non-fossil share of the power generation mix (market dealing in non-FIT renewable energy certificates[31]; minimum/maximum prices: 0.6 yen/kWh, 1.3 yen/kWh[32]). Both hold multi-price auctions, in which all successful bidders pay the price at which they bid, and thus bidders can maximize their profits by predicting the highest successful bid. In the renewable energy value trading market, the clearing volume-weighted average price was the minimum price of 0.3 yen/kWh in all four auctions held in fiscal 2022. This reflects the market's design, which, as indicated above, incorporates variability in the minimum price to enable procurement of non-fossil value at low prices. METI changed the minimum price to 0.4 kWh from fiscal 2023 onward out of concern that maintaining the previous price amid the rising fuel costs of recent years could slow down investment in renewables. In the market for achieving the target mandated by the Sophisticated Methods Act, two of the four auctions in fiscal 2022 closed at maximum clearing price of 1.3 yen/kWh, which indicates a lack of the balance in non-FIT renewable energy certificate supply/demand that is needed to achieve the Act-mandated target. METI is continuing to explore avenues for improving the system.

In addition, there is an electricity futures market whose purpose is to reduce electricity price fluctuation risks. The European Energy Exchange (EEX) began trading in Japanese electricity futures on May 18, 2020, and the Tokyo Commodities Exchange (TOCOM) commenced permanent trading in April 2022, following a trial period that started in 2019. As of 2023, the market's trading volume is small in comparison with JEPX, and improvements are being studied, including with regard to future challenges.

(3) New Market under Consideration

Under the current trading system, the spot market and the balancing market are operated separately, and METI has looked at the issue of how this arrangement leads to inefficient operation since it does not take into account the startup characteristics of each power plant. As a solution, the ministry is now studying how to create a new market that would enable simultaneous procurement of energy (kWh) and balancing capacity (ΔkW). As this would likely involve a sweeping overhaul of the current system, the new market is not expected to launch until 2028 at the earliest.

30 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.

31 The environmental value derived from FIP power sources will be traded in the market for achieving the target mandated by the Sophisticated Methods Act. As noted in Chapter II, the non-fossil value trading price is subtracted when calculating the FIP reference price.

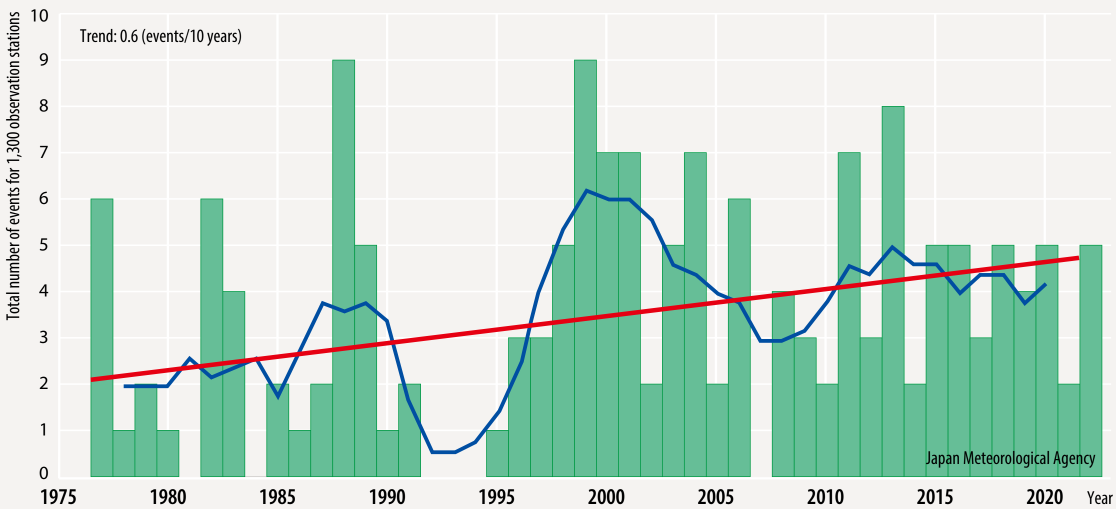
32 As a result of a revision made in November 2021, electricity retailers are to achieve the Act-mandated target through non-FIT non-fossil certificates only, and for this reason the ceiling price was set lower than that for FIT power sources. The minimum price was set based on past trading performance, among other considerations, and discussion of how to fix the price gap with the renewable energy value trading market is currently underway.

TOPICS: Electric Power Company Initiatives for Strengthening Disaster Prevention and Resilience

Japan is a country prone to natural disasters, and over the years electric power companies have responded by implementing various disaster prevention measures. In recent years, the frequency and severity of natural disasters have increased, as seen in climate change effects such as torrential rainfall and extreme heat, necessitating additional action for strengthening disaster prevention and resilience (see Figure 1, Table 1). Accordingly, electric power companies are pursuing diverse initiatives for enhancing disaster prevention and resilience, supporting mutual cooperation during disasters, preventing nuclear disasters, and making other improvements. This feature looks at their initiatives pertaining to transmission and distribution facilities, focusing on cross-regional coordination and inter-area cooperation, utilization of IoT technology, operation of community microgrids, utilization of self-owned equipment, and streamlining of restoration operations and maintenance inspections.

Annual Frequency of Hourly Precipitation of 100 mm or Greater (nationwide AMeDAS data)

Figure 1



Note: The frequency of heavy rainfalls has been trending upward. The annual frequency of hourly precipitation of 100 mm or greater for the most recent 10-year period (2013–2022) is roughly double that for the first 10-year period after the Japan Meteorological Agency (JMA) began tracking this statistic (1976–1985).

Source: Japan Meteorological Agency

Estimated Damage from Major Earthquakes Predicted to Occur in the Future

Table 1

	Nankai Trough earthquake	Tokyo inland earthquake	Trench-type earthquakes in the vicinity of the Japan and Chishima Trenches	For comparison: Great East Japan Earthquake (March 11, 2011)
Magnitude	9.0–9.1	7.3	8	9
JMA seismic intensity scale	7	7	6 Upper	7
Fatalities & missing persons (approx.)	323,000	23,000	2,700	22,000
Buildings destroyed/ burned (approx.)	2,386,000	610,000	35,000	122,000
Direct economic damage (approx.)	¥169.5 trillion	¥47 trillion	¥1 trillion	¥16.9 trillion

Note: As of 2020, the Nankai Trough earthquake, considered to be potentially the most devastating of the predicted earthquakes, was forecast to occur in the next 30 years with a probability of 70–80%.

Source: Ministry of Land, Infrastructure, Transport and Tourism

Annual Totals of Power Interchange Instructions Issued by OCCTO to General Electricity Transmission and Distribution Utilities (nationwide)

Table 2

(No. of occasions)

FY2015	FY2016	FY2017	FY2018	FY2019	FY2020	FY2021
2	2	10	25	6	226	21

Source: FY2022 OCCTO Annual Report

1. Cross-regional Coordination and Inter-area Cooperation

(1) Establishment of OCCTO

The March 2011 Great East Japan Earthquake resulted in an electrical supply shortage of roughly 10 million kW in the Tokyo metropolitan area, prompting planned outages in the TEPCO service area over a 10-day period. Although the nationwide supply capacity was large enough to cover the shortfall, interchange of power from other areas was not possible due to insufficiencies in transmission infrastructure and coordinating systems, making the outages unavoidable.

The Organization for Cross-regional Coordination of Transmission Operators (OCCTO) was established in April 2015 as part of a number of institutional reforms for addressing challenges brought to the forefront by the March 2011 earthquake. OCCTO coordinates the supply/demand plans and grid plans submitted by electric power companies, advances the development of transmission/distribution networks spanning multiple supply areas, and balances supply and demand nationwide in both normal times and emergencies. This includes issuing power interchange instructions on different occasions each year, as shown in Table 2.

(2) Expansion of frequency converters and interconnections

Electricity is supplied at different frequencies in eastern Japan (50 Hz) and western Japan (60 Hz). Work is being done to enhance the infrastructure for power interchange between these two areas. Deliberations by a government research commission in April 2012 resulted in the setting of a goal to increase the capacity of frequency converters to 2.1 million kW by the end of fiscal 2020, and thereafter to 3 million kW as early as possible.

As part of a project responding to the goal of raising frequency converter capacity to 2.1 million kW, Chubu Electric Power Grid has built Hida Converter Station (AC/DC, 900,000 kW, on 60 Hz side) in Gifu Prefecture, and TEPCO Power Grid has added to the AC/DC conversion facilities of the existing Shin-Shinano Substation (900,000 kW, on 50 Hz side) in Nagano Prefecture. Hida-Shinano HVDC Link, which connects those two facilities, began operating in March 2021.

There are three frequency converters for power interchange between eastern and western Japan: Shin-Shinano, Sakuma (300,000 kW), and Higashi-Shimizu (300,000 kW). Their total installed capacity stood at 1.2 million kW prior to March 2021, and rose to 2.1 million kW as a result of the aforementioned project. Also, work is underway to expand the combined capacity of Sakuma and Higashi-Shimizu, which will raise the total installed capacity of the east-west interconnections to 3 million kW by the end of fiscal 2027.

The cross-regional network development plan formulated by OCCTO includes ongoing construction for boosting the capacity of the Kitahon HVDC Link connecting Hokkaido and Honshu from 900,000 kW to 1.2 million kW, and a plan for advancing the development of the interconnection between Tohoku and Tokyo.

(3) Establishing systems for cooperation during disasters

Over the years, electric power companies whose operations were impaired by a major disaster requested other power companies to assist them by dispatching power supply vehicles and personnel. In July 2019, ten electricity transmission utilities took a step toward strengthening their framework of cooperation with one another by introducing a push-style system of assistance dispatching. This is a proactive system of support in which the utilities voluntarily provide assistance to other power companies in neighboring disaster areas before being requested to do so, with the aim of accelerating the recovery process.

In the system's first line of response to the power outages caused in TEPCO Power Grid's supply area by Typhoon Faxai (No. 15)[33] in September 2019, Tohoku Electric Power and Chubu Electric Power Grid were able to dispatch some 1,200 recovery workers and 20 high-voltage power supply vehicles. Ultimately, a total of 10,009 recovery workers and 174 high-voltage power supply vehicles were sent to the affected area by power companies across Japan, realizing support on a very large scale.

Also, in July 2020 the ten transmission utilities jointly formulated an interconnection coordination plan for disasters, and standardized the specifications for recovery resources and the operational procedures for power supply vehicles in order to facilitate recovery operations in support of one another.

2. Utilization of IoT Technology

(1) Providing information to customers via an app during disasters

TEPCO Power Grid, Inc. operates PREP, a comprehensive disaster information app whose services include providing integrated access to power outage information from the seven general electricity transmission and distribution utilities (Hokkaido Electric Power Network, Inc.; Tohoku Electric Power Network Co., Ltd.; TEPCO Power Grid, Inc.; Chubu Electric Power Grid Co., Inc.; Hokuriku Electric Power Transmission & Distribution Co.; Chugoku Electric Power Transmission & Distribution Co., Inc.; and Okinawa Electric Power Co, Inc.). Users are able to receive disaster information for their area through push notifications on their smartphones.

Electric power companies also provide disaster-related information to people in their service area via their own disaster information apps, LINE (a messaging app widely used in Japan), and email services.

(2) Preventing electrical fires at home using IoT devices

Adachi City in Tokyo has a large concentration of wooden homes, putting the area at risk for fires triggered by major earthquakes. Tokyo Electric Power Company Holdings, Inc., TEPCO Power Grid, Inc., and the Adachi City government are conducting a demonstration test from January 2022 through March 2024 of a service for preventing electrical home fires and communicating disaster information. An IoT device that senses warning signs of arc tracking, a cause of electrical fires, is installed in each participating home's distribution board. When warning signs are detected, a technician is sent to the home to address the issue and thus prevent an electrical fire from occurring. The test is also examining the effectiveness and convenience of the IoT device's function as an information hub that can be used to communicate disaster-related information from the city government and to notify the fire department, city government, and other authorities regarding the occupants' safety status in the event of a disaster or other emergency.

3. Operation of community microgrids

Drawing lessons from the extensive power outages caused by the Hokkaido Eastern Iburi earthquake,[34] Hokkaido Electric Power Network, Inc. began operating a community microgrid in the Akancho district of Kushiro City in May 2023 under a consortium formed with the municipal government and local businesses. In the event of a large-scale blackout caused by a disaster or other problem, the microgrid is designed to isolate a portion of the district from other grids and supply that area with electricity sourced from renewable energy.

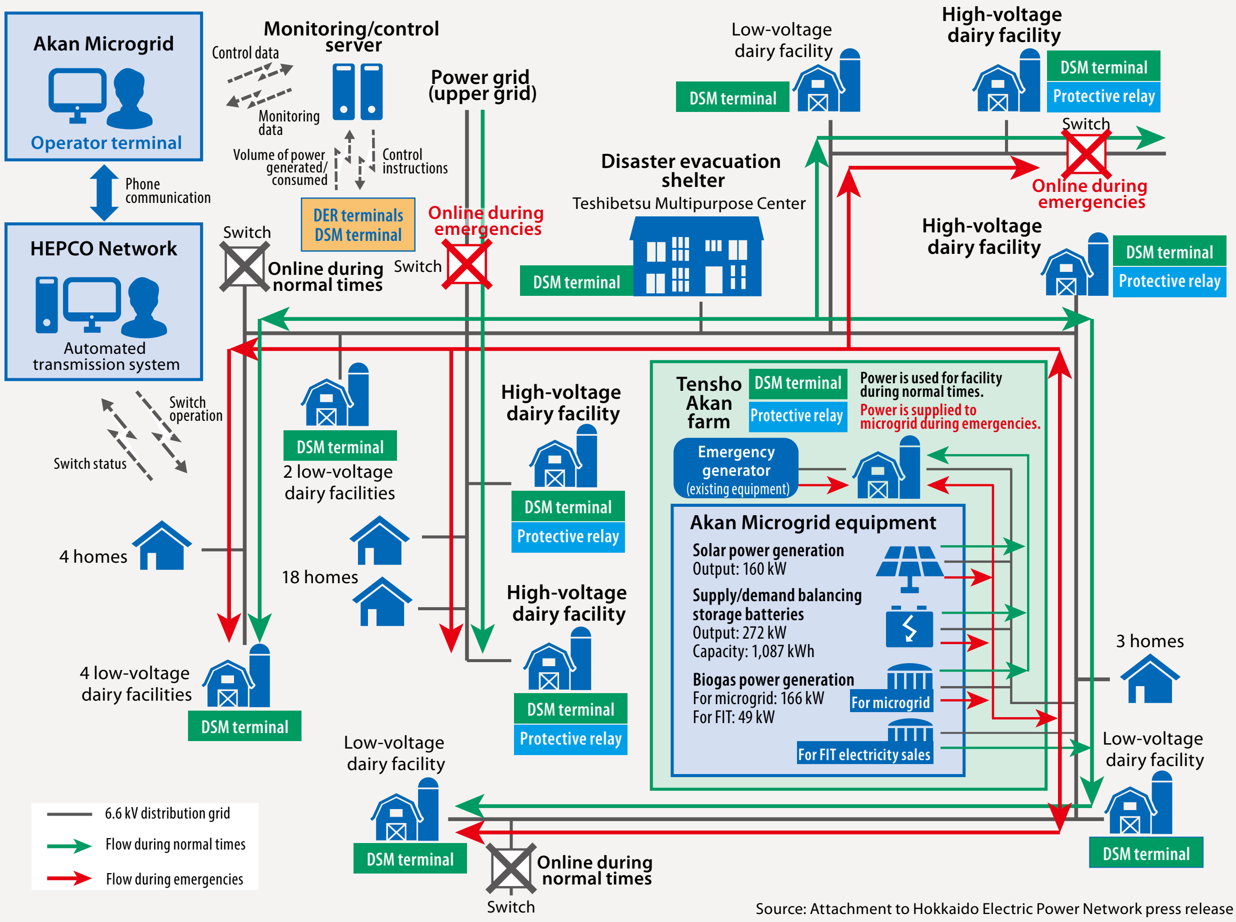
Community microgrids are systems that can isolate a specific area from other power grids and supply it with electricity during a large-scale blackout caused by a disaster or other trouble. The electricity is supplied by local renewable energy power sources and transmitted via the existing transmission network.

33 Typhoon Faxai (No. 15) made landfall near Chiba City on September 9, 2019. The city measured record-breaking winds with peak gusts of 57.5 meters per second. Nationwide, casualties numbered 3 fatalities and 150 severe/slight injuries, while property damage included 391 homes completely destroyed, 76,483 partially destroyed or damaged, and 230 flooded above or below floor (according to the Cabinet Office's Disaster Management in Japan website). Also, the TEPCO supply area experienced the collapse of two power transmission towers and breakage of around 2,000 utility poles, resulting in massive power outages that affected approximately 930,000 households at peak and required roughly two weeks for a full recovery. A research commission set up by TEPCO attributed this lengthy recovery span to an insufficient number of personnel for inspecting equipment across such an extensive disaster area, and the resulting delay in ascertaining the extent of damage.

34 A magnitude 6.7 earthquake that occurred on September 6, 2018 in the central-eastern part of Hokkaido's Iburi region and measured 7 on the JMA seismic intensity scale. The earthquake and resulting landslides caused 42 deaths and 762 injuries. Property damage included 462 homes completely destroyed, 1,570 partially destroyed, and 12,600 damaged. The earthquake also triggered a massive blackout that affected all of Hokkaido for approximately eleven hours. Power was restored to half of the affected area after roughly 30 hours elapsed, and Hokkaido Electric Power announced recovery of service at around 64 hours after the blackout started. However, local power outages were not completely resolved until October 5. Hokkaido's large dairy industry incurred significant losses because milking machines and milk refrigerators were inoperable during the outages.

Details of the community microgrid system

Figure 2



Source: Attachment to Hokkaido Electric Power Network press release

This project covers an area of around 20 square kilometers, and uses a solar power generation facility (160 kW), biogas power generators that utilize methane sourced from fermented cattle excreta (166 kW + 49 kW), a power storage facility (272 kW), a monitoring and control server, and an energy management system terminal. In emergencies, power can be supplied to the community's evacuation shelter, 14 dairy facilities, and 25 homes.

4. Utilization of Self-owned Equipment

(1) Emergency broadcasts via utility poles (Kyushu Electric Power)

Following the deregulation of utility pole sharing and use of facilities such as transmission towers, this equipment has been increasingly utilized for disaster prevention purposes.

One example is Toho Village in Fukuoka Prefecture, which was devastated by torrential rainfall in July 2017. This disaster revealed several issues stemming from the village's limited number of community wireless system installations, such as the difficulty of hearing emergency broadcasts. While outdoor PA broadcasts via such systems represent an important means of communicating emergency information to elderly persons and children, etc., who generally do not own smartphones or other mobile devices, the high cost poses a heavy burden to communities.

In January 2020, Kyushu Electric Power Transmission and Distribution Co., Inc. launched a demonstration project in Toho in which speakers were installed on the company's utility poles there in order to broadcast emergency information from the village government. The new system makes it possible to broadcast disaster information for specific areas via the nearest utility poles, with improved sound quality. The use of existing utility poles lowers costs, thus reducing the burden on the village government. In addition, since computer tablets can be used anywhere to transmit information over the system, the personnel responsible for issuing emergency information do not need to go to the village office to use the control console.

The paid service for similar systems began in March 2022, and proposals are being formulated in other municipalities to further expand the installation of the systems.

(2) Utilization of transmission towers

Electric power companies are leasing space on their transmission towers to national/local government agencies, telecommunication businesses, and other users for purposes that significantly serve the public good. For example, the towers are used to host equipment such as cellular base stations, emergency broadcast speakers, monitoring cameras, and weather sensors. The towers are well suited for purposes such as damage assessment and information broadcast because of their broad distribution across diverse locations, including residential areas and mountainous terrain, and their heights of tens of meters.

5. Streamlining of Restoration Operations and Maintenance Inspections

(1) Utilization of vehicle-to-grid (V2G) in disaster areas

Following Typhoon Faxai (No. 15), TEPCO, with the support of automakers, dispatched 67 electric vehicles (EVs, PHVs, FCVs) and 45 power supply units to disaster areas with persistent blackouts. TEPCO employees drove the vehicles around those areas to supply electricity to homes, community centers, nurseries, and other facilities.

(2) Adoption of automatic switches

Tokyo Electric Power Company Holdings, Ltd. is planning to install automatic switches at 300 sites in Chiba Prefecture in order to speed up the restoration of power supply following outages. The conventional approach to power restoration involves dispatching work crews to manually reset switches on utility poles. The project will automate this process by installing remotely operated receivers on utility poles.

(3) Use of drones

The use of aerial drones to inspect power transmission and distribution equipment promises to not only streamline routine operations, but also help resolve various challenges in the future, such as damage assessment in disaster areas and personnel shortages. Here are some examples of how electric power companies are experimenting with the adoption of drones.

Kansai Electric Power Company announced in February 2019 that it would work with Toshiba Digital Solutions Corporation and Alps Alpine Co., Ltd. to establish technology for inspection of overhead ground wires using a drone with automatic tracking, and to experimentally deploy the technology toward full-scale operation in the future. Conventional inspection of overhead ground wires involves video imaging via a camera device that autonomously travels on the wires. However, this takes time to perform in mountainous terrain and other areas difficult to access, and the process of mounting the camera devices on the wires is hazardous to workers. The drone used in the project has an automatic tracking feature that enables it to maintain a set distance from ground wires, even when the lines sag or are swung by wind.

Meanwhile, Tohoku Electric Power Company announced in October 2019 that it would launch a pilot project for drone inspection of transmission lines using auto-tracking camera software developed for drones by NEC Corporation. Also, TEPCO Power Grid, Inc. jointly established Grid Sky Way LLP in March 2020 with NTT DATA Corporation and Hitachi Ltd. toward the development, demonstration, and deployment of a system for patrol/inspection using drones operating beyond visual line of sight.

STATISTICAL DATA

Electric Power Generation*

[TWh]

FY	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Hydroelectric	**84.9**	**86.9**	**91.4**	**84.6**	**90.1**	**87.4**	**86.3**	**86.3**	**87.6**	**85.0**
Electric Utilities	68.6	70.3	74.9	81.9	87.9	85.0	84.3	84.5	85.8	83.2
Industry-owned	16.3	16.7	16.5	2.7	2.3	2.4	2.0	1.8	1.8	1.8
Thermal**	**987.3**	**955.4**	**908.8**	**877.0**	**861.4**	**823.6**	**792.9**	**790.0**	**776.0**	**757.4**
Electric Utilities	743.1	717.8	675.7	794.4	777.5	726.2	696.2	697.9	681.4	664.7
Industry-owned	244.2	237.6	233.1	82.6	83.9	97.4	96.7	92.1	94.6	92.7
Nuclear	**9.3**	**–**	**9.4**	**17.3**	**31.3**	**62.1**	**61.0**	**37.0**	**67.8**	**53.5**
Electric Utilities	9.3	–	9.4	17.3	31.3	62.1	61.0	37.0	67.8	53.5
Industry-owned	–	–	–	–	–	–	–	–	–	–
Wind Power	**5.2**	**5.0**	**5.2**	**5.5**	**6.1**	**6.5**	**6.9**	**8.3**	**8.2**	**8.2**
Electric Utilities	0.2	0.0	0.1	5.0	5.5	5.9	6.3	7.6	7.4	7.4
Industry-owned	5.0	5.0	5.1	0.5	0.7	0.6	0.6	0.7	0.8	0.8
Solar	**1.2**	**3.8**	**6.8**	**11.1**	**15.9**	**18.5**	**21.4**	**25.0**	**27.9**	**31.3**
Electric Utilities	0.1	0.1	0.1	6.5	8.7	10.8	13.2	16.2	19.0	21.8
Industry-owned	1.1	3.7	6.7	4.6	7.2	7.7	8.2	8.8	8.9	9.5
Geothermal	**2.6**	**2.6**	**2.6**	**2.2**	**2.1**	**2.1**	**2.1**	**2.1**	**2.0**	**2.0**
Electric Utilities	2.4	2.4	2.4	2.2	2.1	2.1	2.0	2.0	2.0	1.9
Industry-owned	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Others	**–**	**–**	**–**	**0.3**	**0.3**	**0.2**	**0.2**	**0.2**	**0.2**	**0.2**
Electric Utilities	–	–	–	0.3	0.3	0.2	0.2	0.2	0.2	0.2
Industry-owned	–	–	–	–	–	–	–	–	–	–
Total	**1,090.5**	**1,053.7**	**1,024.2**	**997.9**	**1,007.3**	**1,000.4**	**970.8**	**949.0**	**970.0**	**937.6**
Electric Utilities	823.7	790.6	762.6	907.6	913.2	892.2	863.2	845.4	863.5	832.7
Industry-owned	266.8	263.2	261.6	90.4	94.1	108.2	107.6	103.6	106.5	104.9

*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, "Electric Power Generated" (2023) and "Electric Power Generated for Self-consumption" (2023)

Electric Power Consumption

[TWh]

	FY	2011	2012	2013	2014	2015	2016
Low Voltage	Residential	289.0	286.2	284.3	273.1	266.9	272.9
	Commercial and Industrial	44.9	43.7	42.8	40.5	39.2	37.9
Specified-Scale Demand*	High Voltage	545.6	541.0	544.4	537.8	531.5	308.3
	Extra-High Voltage						231.4
Specified Supply**		0.0	0.0	0.0	0.0	0.0	6.0
Self-Consumption		4.3	4.4	4.5	3.9	4.0	43.2
Supplied by Electric Utilities		**883.8**	**875.3**	**876.0**	**855.4**	**841.5**	**899.8**
Power Generated and Consumed by Privately-owend Power Facilities		118.7	116.3	116.6	114.1	113.8	70.8
Total Consumption		**1,002.4**	**991.6**	**992.6**	**969.4**	**955.3**	**970.6**
Others (Last Resort Supply and Isolated Area Supply)		–	–	–	–	–	2.3

	FY	2017	2018	2019	2020	2021	2022
Low Voltage	Residential	280.4	271.4	267.7	278.0	278.1	270.3
	Commercial and Industrial	38.4	37.1	35.7	35.4	34.8	34.2
Specified-Scale Demand*	High Voltage	310.6	307.8	302.8	290.3	296.5	283.5
	Extra-High Voltage	233.8	236.3	229.9	214.9	225.5	218.7
Specified Supply**		6.1	6.3	6.2	5.5	6.1	6.2
Self-Consumption		45.1	37.4	34.9	36.8	38.1	38.1
Supplied by Electric Utilities		**914.4**	**896.2**	**877.1**	**863.2**	**881.6**	**851.0**
Power Generated and Consumed by Privately-owend Power Facilities		70.0	77.2	75.6	66.3	68.4	68.9
Total Consumption		**984.3**	**973.4**	**952.7**	**929.5**	**950.0**	**919.9**
Others (Last Resort Supply and Isolated Area Supply)		2.3	2.3	2.2	2.4	2.4	15.6

*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, "Electric Power Generated" (2023) and "Electric Power Generated for Self-consumption" (2023)

Installed Generating Capacity*

[MW]

FY	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Hydroelectric	**48,932**	**49,597**	**50,035**	**50,058**	**50,014**	**50,037**	**50,033**	**50,033**	**49,924**	**50,007**
Electric Utilities	44,676	45,403	45,786	49,521	49,562	49,582	49,635	49,635	49,528	49,612
Industry-owned	4,256	4,194	4,248	536	452	455	398	398	396	395
Thermal**	**191,258**	**193,356**	**190,805**	**193,910**	**193,462**	**193,026**	**189,784**	**191,758**	**188,247**	**187,937**
Electric Utilities	141,901	143,777	143,040	174,392	173,261	171,469	168,760	170,260	167,474	166,379
Industry-owned	49,357	49,579	47,765	19,517	20,201	21,557	21,024	21,498	20,773	21,558
Nuclear	**44,264**	**44,264**	**42,048**	**41,482**	**39,132**	**38,042**	**33,083**	**33,083**	**33,083**	**33,083**
Electric Utilities	44,264	44,264	42,048	41,482	39,132	38,042	33,083	33,083	33,083	33,083
Industry-owned	–	–	–	–	–	–	–	–	–	–
Wind Power	**2,646**	**2,750**	**2,808**	**3,203**	**3,483**	**3,498**	**3,951**	**4,119**	**4,254**	**4,411**
Electric Utilities	82	30	50	2,893	3,091	3,165	3,580	3,750	3,862	4,025
Industry-owned	2,563	2,720	2,758	310	391	332	371	369	392	386
Solar	**1,559**	**4,085**	**5,624**	**9,110**	**12,592**	**14,974**	**16,522**	**19,028**	**21,034**	**23,146**
Electric Utilities	67	81	87	5,655	7,318	8,922	10,549	12,408	14,124	16,152
Industry-owned	1,492	4,005	5,536	3,455	5,274	6,052	5,973	6,620	6,910	6,994
Geothermal	**512**	**508**	**517**	**526**	**471**	**473**	**481**	**487**	**487**	**437**
Electric Utilities	477	473	473	511	466	463	463	469	469	419
Industry-owned	35	35	43	15	5	11	18	18	18	18
Others	**–**	**–**	**–**	**64**	**54**	**43**	**43**	**43**	**60**	**60**
Electric Utilities	–	–	–	64	54	43	43	43	60	60
Industry-owned	–	–	–	0	0	0	0	0	0	0
Total	**289,171**	**294,560**	**291,836**	**298,352**	**299,209**	**300,093**	**293,897**	**298,550**	**297,088**	**299,081**
Electric Utilities	231,468	234,028	231,484	274,519	272,885	271,685	266,112	269,648	268,599	269,730
Industry-owned	57,703	60,532	60,352	23,834	26,324	28,407	27,785	28,903	28,489	29,351

* Figures represent the total amount generated by power plants with a generating capacity of 1,000 kW 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, "Number and Output of Electricity Utility Power Plants" (2023)

Transmission, Substations and Distribution Facilities of General Electricity Transmission and Distribution Utilities (As of March 31, 2022)

Voltage [kV]	Transmission Lines [km]				Substations	
	Route length		Circuit length		Number	Output Capacity [MVA]
	Overhead	Underground	Overhead	Underground		
500	8,168	113	15,850	201	85	231,150
275	7,440	612	14,709	1,533	162	177,115
220	2,570	61	4,934	125	70	44,500
187	2,756	15	5,366	35	49	19,335
110–154	15,487	1,066	28,072	1,979	758	162,542
66–77	38,374	7,531	68,605	13,572	4,658	229,482
≦55	13,801	6,151	15,036	10,146	1,343	10,380
Total	**88,596**	**15,549**	**152,572**	**27,591**	**7,125**	**874,504**

Distribution Lines [km]				Transformers	
Route length		Circuit length		Output Capacity [MVA]	
Overhead	Underground	Overhead	Underground	Overhead	Underground
1,292,652	45,955	4,058,023	75,091	356,177	38,469

Source: FEPC, "Electricity Statistics Information: Transmission facility, Substation facility, Distribution facility" (2023)

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

FY	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Peak Load [GW]	157.2	161.6	154.3	164.5	155.9	155.5	164.8	164.6	166.5	164.6
Supply Capability [GW]	176.9	179.5	179.8	183.5	177.6	177.2	187.5	185.8	186.1	188.0
Annual Electricity Demand [TWh]	914.7	917.5	898.9	888.2	890.5	900.9	896.5	878.4	867.8	885.2
Reserve [GW]*	19.7	17.9	25.6	18.9	21.8	21.7	22.7	21.2	19.6	23.4
Reserve Margin [%]*	12.6	11.1	16.6	11.5	14.0	13.9	13.8	12.9	11.8	14.2
Load Factor [%]**	66.4	64.8	66.5	61.6	65.8	66.0	62.1	60.7	59.5	61.4

* Reserve= Supply Capability-Peak Load Reserve Margin= Reserve/Peak Load×100
**Load Factor= Annual Electricity Demand / (Peak Load ×365(366)×24hours) ×100
* Figures for 2015 onward are for summer only.

Source: Japan Electric Power Survey Committee (2011-2014), OCCTO (2016-2021)

Summarized Comparative Table Classified by Country for the Year 2020

	USA	UK	France	Germany	Russia	China	India*	Japan
Total Installed Capacity [MW]	**1,229,860**	**75,854**	**136,211**	**233,662**	**270,200**	**2,202,040**	**442,297**	**298,550**
Hydroelectric	101,037	4,366	25,732	14,172	52,300	370,280	45,807	50,033
Thermal	823,055	42,540	18,935	80,800	185,600	1,246,240	305,307	191,758
Nuclear	103,075	8,141	61,370	8,114	29,400	49,890	6,780	33,083
Renewables and others	202,693	20,807	30,175	130,575	2,900	535,630	84,403	23,677
Total Energy Production [GWh]	**4,009,617**	**312,261**	**500,100**	**573,641**	**1,090,000**	**7,626,400**	**1,576,740**	**948,979**
Hydroelectric	285,100	8,404	65,100	18,322	214,000	1,355,300	156,049	86,310
Thermal	2,416,393	125,701	37,600	234,295	656,000	5,177,000	1,253,707	789,725
Nuclear	789,355	50,278	335,400	64,382	216,000	366,200	46,472	37,011
Renewables and others	518,770	127,876	61,900	256,642	3,700	727,900	120,512	35,637
Capacity Factor [%]	–	41.7	41.9	27.9	–	42.8	53.4	45.0*
Total Energy Production per Capita [kWh]	12,399	4,654	7,680	6,897	7,442	5,405	1,178	7,541
Domestic Energy Supplies [GWh]	4,056,931	313,761	460,000	–	1,085,000	6,523,200	–	–
Energy Sales [GWh]	3,717,674	258,508	–	418,626	–	6,158,100	1,248,086	820,897
Number of Customers [At year-end; thousand]	156,523	31,505	–	–	–	645,737	314,423	88,747
Maximum Demand [MW]	789,219	48,945	83,200	–	150,400	–	190,198	166,450
Annual Load Factor [%]	59.9	65.7	62.9	–	78.2	–	–	59.5
Thermal Efficiency [%]	–	32.0	–	44.8	39.5	40.3	–	–
Loss Factor (Transmission and Distribution) [%]	4.9	8.4	7.7*	–	–	5.6	20.5	4.6
Total Consumption per capita [kWh]	–	4,179	6739*	5,868	6,755	5,331	932	7,434

*Figure for 2019
**Figures other than Capacity Factor and Maximum Demand represent the actual figures for 2019.

Source: JEPIC, "Overseas Electric Power Industry Statistics: Comparative Table Classified by Country" (2022)figures for 2019.

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
JERA	Brady Thermal IPP Project	USA	Oil/Gas	1,633	100	–
Chubu	Eavor Technologies Inc.	Canada	Geothermal	–	–	2022
Kansai	Aviator	USA	Onshore Wind	525	48.5	2020
Kyushu	South Field Energy Gas-Fired Power Plant	USA	Power Plant	1,182	18.1	2021
Kyushu	Thermochem, Inc.	USA	Geothermal Services	–	(Private)	–
Kyushu	Enernet Global Inc.	USA	Microgrid	–	(Private)	–
Kyushu	Persistent Energy Capital LLC	USA	Enterprise Support	–	(Private)	–
J-POWER	Jackson	IL, USA	CCGT	1,200	51	2022
J-POWER	Refugio	TX, USA	Solar	400	25	2024
Hokkaido	PV project in Mexico	Mexico	PV	290	12	2018
Chugoku	South Field Energy	USA	CCGT	1,182	10	2021
Shikoku	South Field Energy	USA	CCGT	1,182	8.9	2021
Shikoku	Huatacondo	Chile	PV	98	30	2019

Europe

Company	Project	Location	Type	Capacity [MW]	Equity [%]	COD
Tokyo	Zenobe	UK	Battery Storage	435	0.6	2019
Tokyo	TetraSpar floating offshore wind demonstration project	Norway	Floating offshore wind	4	30	2021
Tokyo	Power transmission project for Triton Knoll Offshore Windfarm	UK	Offshore Transmission	–	20	2022
Tokyo	Flotation Energy	UK	Offshore wind	–	100	2022
Tokyo	NeuConnect Interconnector Project	UK, Germany	Offshore transmission	–	6.5	2028
JERA	Parkwind	Belgium	Renewable	600**	100	–
Chubu	Eneco Group	Netherlands	Integrated Energy Business	–	20	2020
Chubu	Eavor Erdwarme Geretsried GmbH	Germany	Geothermal	–	40	2022
Kansai	Piiparinmaki	Finland	Onshore Wind	211	15	2022
Kansai	NeuConnect	UK-Germany	Interconnector	–	17.5	2028
Kansai	Triton Knoll Offshore Wind Farm	UK	Offshore Wind	857	16	2022
J-POWER	Triton Knoll Offshore Wind Farm	UK	Offshore Wind	857	25	2022

*Not an exhaustive list
** Includes a project under construction

Asia

Company	Project	Location	Type	Capacity [MW]	Equity [%]	COD
Tokyo	DEEP C Green Energy	Vietnam	Power distribution, Retail and RE supply	–	50	2018
Tokyo	Greenway Grid Global	Singapore, Philippines, Cambodia	Investment and Incubation	–	44	2018
Tokyo	Corporate Solar PPA Project in Thailand	Thailand	Rooftop solar	3.8	49	2022
Chubu	New Clark City	Philippines	Distribution and Retail	–	9	2019
Chubu	Bitexco Power Corporation	Vietnam	Hydro/Solar	–	20	2021
Chubu	OMC Power Private	India	Mini-grid business	–	22	2022
JERA	Gia Lai Electricity	Vietnam	Renewable	503***	35.1	–
JERA	Cirebon Coal Thermal IPP Project	Indonesia	Coal	1,000	10.0	2023
Tohoku	Rantau Dedap Geothermal Power Plant Project	Indonesia	Geothermal	98.4	20	2021
Tohoku	Nghi Son 2 BOT Thermal Power Plant Project	Vietnam	Coal (SC)	1,200	10	2022
Hokuriku	Sun-eee	Cambodia	Distribution and Retail	–	25.01	2022
Kansai	Nam Ngiep 1	Laos	Hydro	290	45	2019
Kansai	New Clark City	Philippines	Distribution and Retail	–	9	2019
Chugoku	Pakkat	Indonesia	Hydro	18	25	2016
Chugoku	Feng Ping Xi	Taiwan	Hydro	37.1	25	2027
Shikoku	Phu Yen	Vietnam	PV	214	15	2019
Kyushu	Senoko Energy Pte. Ltd.	Singapore	Electric Business	2,382	15	––
Kyushu	EGCO	Thailand	Electric Business	6,202	6.1	–
Kyushu	Philippine Microgrid Project of PowerSource Group	Philippines	Microgrid	0.1 – 2.1	(Private)	–
Kyushu	Syrdarya Gas-Fired Power Generation	Uzbekistan	Power Plant	1,600	14.3	(Private)
Kyushu	Shizen International	Japan	Capital Cooperation	–	–	–
Kyushu	Petro Green Energy Corporation	Philippines	Electric Business	80	25	–
J-POWER	Batang	Indonesia	Coal-fired (USC)	2,000	34	2022
J-POWER	Rooftop Solar (GJP1) (9 projects)	Thailand	Solar	11.2	60	2021-2024
J-POWER	EGCO Cogen (Replacement)	Thailand	CCGT	74	20	2024
J-POWER	Lake Mainit	Philippines	Hydro	24.9	40	2023
J-POWER	Bulanog Batang	Philippines	Hydro	33.5	40	2030
J-POWER	Turga Pumped Storage (Detailed Design and Supervision)	India	Consulting	–	–	–

*** Includes a project under construction

Others

Company	Project	Location	Type	Capacity [MW]	Equity [%]	COD
Chubu	Project for Improvement of Energy Loss Reduction on Distribution Network	Mozambique	Technical Cooperation	–	–	2020
Chubu	Capacity Development Project for Improvement of Protection of Transmission Systems	Uganda	Technical Cooperation	–	–	2020
Chubu	Power Energy Sector Advisor for Regional Collaboration	Jordan	Technical Cooperation	–	–	2023
Hokuriku	Fujairah F3 IPP	United Arab Emirates	CCGT	2,400	19.6	–
Chugoku	Energy Fiji Limited	Fiji	Electric Company	327	44.0	–
Chugoku	Project for Introduction of Hybrid Power Generation System	Cabo Verde	Consultation	–	–	2021 -2024
Shikoku	Hamriyah	United Arab Emirates	CCGT	1,800	15	2023
Kyushu	Project for Introduction of Hybrid Power Generation System	Cabo Verde	Consultation	–	–	2021
Kyushu	Execution of Agreement on "The Project for Capacity Development of Power Transmission Systems in Kenya" with JICA	Kenya	Consultation	–	–	2021
Kyushu	Participation in Al Dur 1 IWPP	Bahrain	Water & Power Plant	1,234	19.8	2021
Kyushu	Abu Dhabi HVDC Subsea Transmission Project	United Arab Emirates	Subsea Transmission Project	–	–	2025
J-POWER	Kidston Stage-3 Wind	Australia	Wind	258	53.9	2026
J-POWER	K2-Hydro	Australia	Hydro (Pumped-storage)	250	7.7	2024
J-POWER	Bulli Creek	Australia	Solar/Storage	2,000	53.9	–
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	Consulting	–	–	2017-2023

Hokkaido Electric Power Co.

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

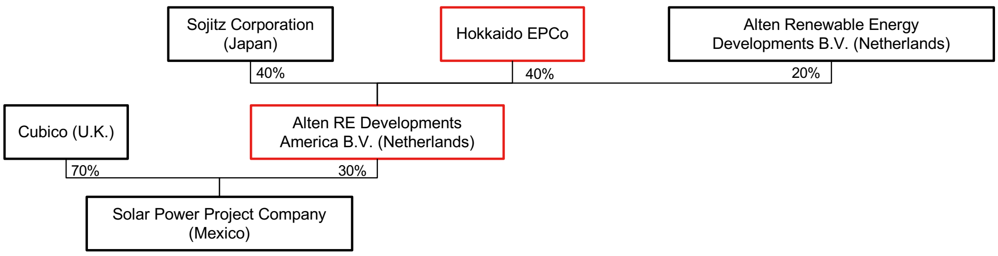
  Cubico Alten Aguascalientes Uno (Project 1)
  Cubico Alten Aguascalientes Dos (Project 2)

- 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

Power Plant Overview

■ Purpose

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

■ Facilities

Location	South Sumatra, Indonesia
Type	Geothermal
Capacity	98.4MW (49.2MW×2units)
Equity	20%
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

Power Plant Overview

■ Purpose

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

■ Facilities

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

■ Special Notes

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

Tokyo Electric Power Company Holdings

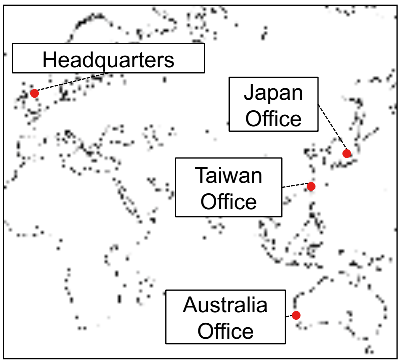
TEPCO RP acquisition of Flotation Energy

- In November 2022, TEPCO RP acquired a Scottish offshore wind power company, Flotation Energy Limited (FE).
- Its founders developed Kincardine, the world's largest floating windfarm.
- FE is growing rapidly, with 4 projects under development in the UK, and several pipelines in the Europe/Asia Pacific region.

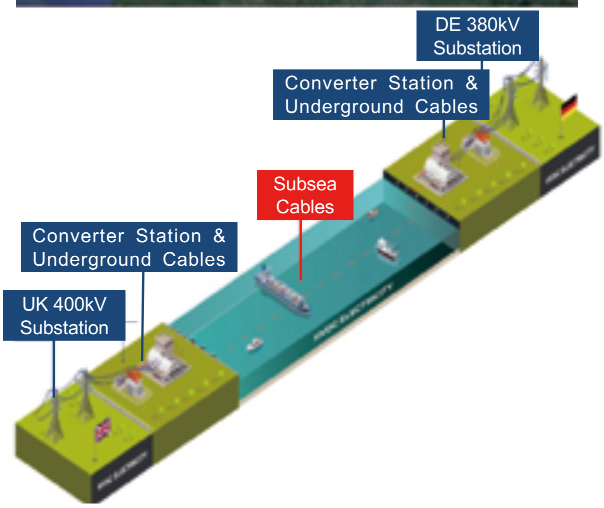
Company Overview

Company	Flotation Energy Limited
Established	2018
Office	・Headquarters: Edinburgh (Scotland) ・Branches: Australia, Taiwan, Japan
Development Projects	United Kingdom ・Morecambe (480MW, fixed) ・White Cross (100MW, floating) ・Green Volt (560MW, floating) ・Cenos (1,350MW, floating) Other areas ・Developing several pipelines in the Europe/Asia Pacific region

Office Location



NeuConnect Interconnector Project (UK-Germany Power Link)



- Project summary
  - NeuConnect will start in 2028 and will enable the UK and Germany to flexibly exchange power from diverse sources with fluctuating output, such as wind and solar, thereby further accelerating the spread of renewable energies.
  - NeuConnect will make a significant contribution to enhancing energy resilience and energy security in both countries, since it will aid the exchange of power in times of emergency.
- Features
  - HVDC Converter Station
(UK side)
DC Voltage 525kV
Bipole - Voltage Source Converter
AC Voltage 400kV
(German side)
DC Voltage 525kV
Bipole - Voltage Source Converter
AC Voltage 380kV
  - Total cable distance: Approx. 706km subsea, Approx. 14km on land

JERA

Canal Thermal Power Station

➢ Purpose

The northeastern United States is densely populated and has a reliably high demand for electricity, but the region is also a challenging location for new large-scale power projects and tends to have tight electricity supply-demand in winter.

For this reason, highly flexible thermal power generation is of great importance, and the Canal Thermal Power Stations contribute to stable supply as significant sources of electricity in the region during emergencies and peak times.

➢ Features

- Capacity : 1,458MW
- Type : Conventional (Unit 1 ~ 2)
  Simple-cycle gas turbine (Unit 3)
- Fuel : Natural gas, petroleum
- Location : Sandwich, Massachusetts, U.S.A.
- COD : 1968 (Unit 1)
  1978 (Unit 2)
  2019(Unit3)

Chubu Electric Power Co.

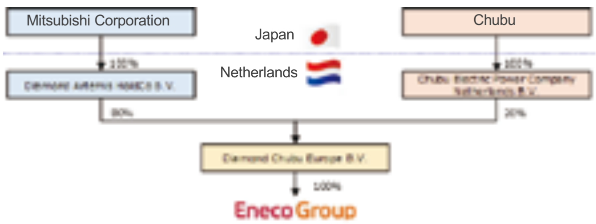
Integrated Energy Company “Eneco” in Netherlands

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 Mar 2023
Total assets	10,389 million EURO
Total revenues	10,779 million EURO
Net result	272 million EURO
ROACE※1	7.2%
Number of employees	3,340 FTE※2

※1 Return on average Capital Employed
※2 Full Time Equivalent



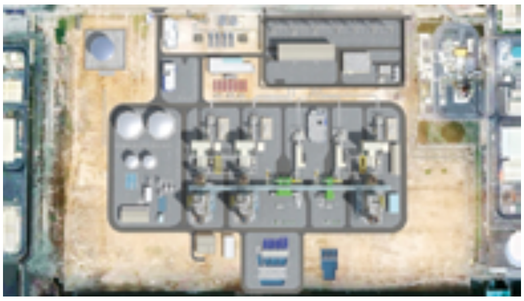
➢ Purpose of investment

- 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.

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
- Offtake : PPA with EWEC

➢ Shareholders of the Project
- 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%

Participation in Power Distribution Business in Cambodia

In 2022, Hokuriku Electric Power Transmission & Distribution Company started collective management of Sun-eee Pte. Ltd. (Sun-eee) with Greenway Grid Global Pte. Ltd. by partially acquiring the shares of Sun-eee.

➢ Purpose
- Contribute to the stable power supply in the area
- Learn power distribution & retail business in Cambodia, aiming at further business expansion overseas

➢ Overview
- HQ : Singapore
- Capital : 1.66M USD
- Business : Power distribution & Retail
- Service area : Part of Prey Veng, Kampong Cham province in Cambodia

Kansai Electric Power Co.

Piiparinmäki Onshore Wind Farm Project

- Location
  - Central Finland
- Features
  - Onshore Wind Power Generation
  - Name : Piiparinmäki
  - Number of Turbines : 41
  - Total Power Output : 211MW
- Partners
  - The Kansai Electric Power CO., Inc. (KPIC Netherlands B.V.) : 15%
  - Glennmont Clean Energy Fund III Wind B.V. : 85%

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: 327MW
    (Diesel: 179MW, Hydro:138MW, Wind:10MW)
  - Equity Share: 44.0%

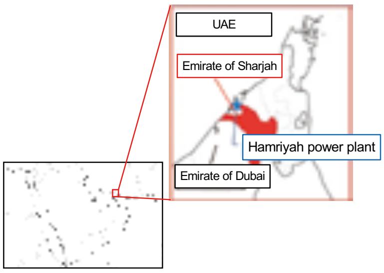
EFL HQ

Nadarivatu Hydro Power Station

Nadarivatu Dam

Shikoku Electric Power Co.

Hamriyah IPP Project in UAE



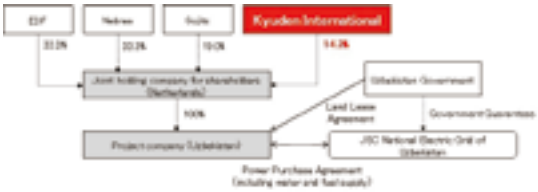
- Purpose
  - Construction of new power plant
  - Plant operation and power wholesale
- Features
  - 1,800 MW CCGT
  - COD: May 2023
  - 23.5 years from COD, under BOOT scheme
  - Shareholders:
    - Sumitomo Corporation
    - GE Energy Financial Services
    - Sharjah Asset Management
    - Shikoku Electric Power Co.

Kyushu Electric Power Co.

Gas-Fired Power Generation Project in Uzbekistan (2022)

Our first power project in Central Asia

Project Scheme



Project Position

- Purpose
  - Replace outdated power generation facilities with high-efficiency gas-fired plants and help Uzbekistan to achieve its target to reduce greenhouse gas emissions.

Features
- Location
  Syrdarya region, Republic of Uzbekistan
- Generation Type
  Combined cycle gas turbine power generation
- Capacity
  approx. 1,600 MW (equity output: approx. 230 MW)
- Fuel
  Natural gas (supplied by JSC National Electric Grid of Uzbekistan)
- Project Company
  "ENERSOK" Foreign Enterprise Limited Liability Company(Tashkent, Uzbekistan)
- Investment Partners
  Kyuden International Corporation (14.3%), EDF (33.3%), Nebras Power (33.3%), Sojitz Corporation (19.0%)

Invested in PetroGreen Energy Corporation in Philippines (2022)

Collaboration with our partner companies

Nabas Wind Power Plant, owned by PetroGreen Energy Corporation

- Purpose
  - Promote the development of renewable energies in Philippines.
  - Contribute to the low-carbon and decarbonization of Philippines by utilizing our technical expertise.

- Company profile

Name	PetroGreen Energy Corporation
Business	Renewable Energy Business
Location	Manila, Philippines
History	Established in 2010 as a renewable energy development and operation company of the Yuchengco Group*1
Paid-in capital	2,137 million Philippine pesos (Approximately 5.1 billion yen)
No. of Employees	Approximately 30

*1 Yuchengco Group
: One of the major corporate groups in the Republic of the Philippines, operating in finance, energy, and other businesses.

Okinawa Electric Power Co.

JICA's 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 2023
- 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

Kidston Stage-3 Wind (K3W) in Australia

Development of an onshore wind farm in Kidston area, Queensland, Australia

Location of the project

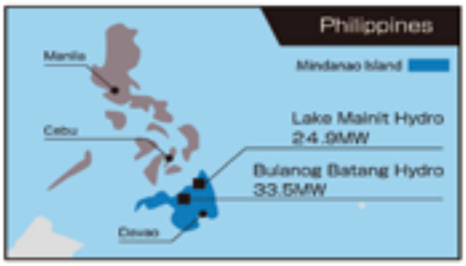
Future image of location

- Features
  - Onshore wind project under joint development by J-POWER and Genex Power Limited ("Genex," an ASX-listed company focused on developing a portfolio of renewable energy generation and storage projects across Australia) in Australia.
  - J-POWER and Genex have been developing the project since 2020 by making full use of J-POWER's experience in wind power generation, including turbine selection and acquiring construction permits and licenses.
  - Located in Renewable Energy Zone in Queensland.
- Overview
  - Capacity：Up to 258 MW
  - Commercial Operation：2026 (planned)
  - Equity Ownership：Genex 50%、J-POWER 50%*1

*1 J-POWER owns 50% stake of the project, and with its 7.7% stake in Genex, J-POWER's overall stake is 53.9%.

Lake Mainit Hydro and Bulanog Batang Hydro in Philippines

Participation in hydroelectric power generation projects in Mindanao, Philippines



Location of the projects

Lake Mainit Hydroelectric Power Plant

- Features
  - J-POWER has participated in hydroelectric power generation project on Mindanao, which has wealth of untapped hydropower potential, since December 2022.
  - Lake Mainit Hydroelectric Power Plant has started commercial operation in March 2023.
  - J-POWER, together with MRC*1, is also developing the Bulanog Batang Hydroelectric Power Project.
- Overview

Lake Mainit：
  - Capacity：24.9 MW
  - Equity Ownership：MRC 60%、J-POWER 40%

Bulanog Batang：
  - Capacity：33.5 MW
  - Commercial Operation：2030 (planned)
  - Equity Ownership：MRC 55%、J-POWER 40% NHPC*2 5%

*1 MRC : Markham Resources Corporation
*2 NHPC :NORMECA Hydro Power

The Japan Atomic Power Co.

Fostering of human resource development

JAPC can offer a comprehensive range of education and training depending on each country's needs.

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, 2023)*

	FY 2022			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	888,874	23,932	1,656	4,649	2,070	–	8,375
Tohoku EPCo	251,441	3,007,204	65,940	2,571	11,871	2,750	193	17,386
TEPCO HD	1,400,975	7,798,696	184,825	9,991	–	8,212	51	18,254
Chubu EPCo	430,777	3,986,681	101,658	5,467	–	3,617	89	9,173
Hokuriku EPCo	117,641	817,601	26,273	1,964	4,565	1,746	–	8,274
Kansai EPCo	489,320	3,951,884	111,565	8,248	13,711	6,578	11	28,548
Chugoku EPCo	197,024	1,694,602	45,328	2,907	7,354	820	6	11,087
Shikoku EPCo	145,551	833,203	23,413	1,153	3,235	890	2	5,280
Kyushu EPCo	237,304	2,221,300	76,546	3,589	8,035	4,140	214	15,978
Okinawa EPCo	7,586	223,517	7,073	–	1,629	–	2	1,631
J-POWER	180,502	1,841,922	0	8,577	8,412	–	555	17,544
JAPC	120,000	92,185	–	–	–	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	100,000	7,945	–	–	54,843	–	–	54,843

Source: Financial statement

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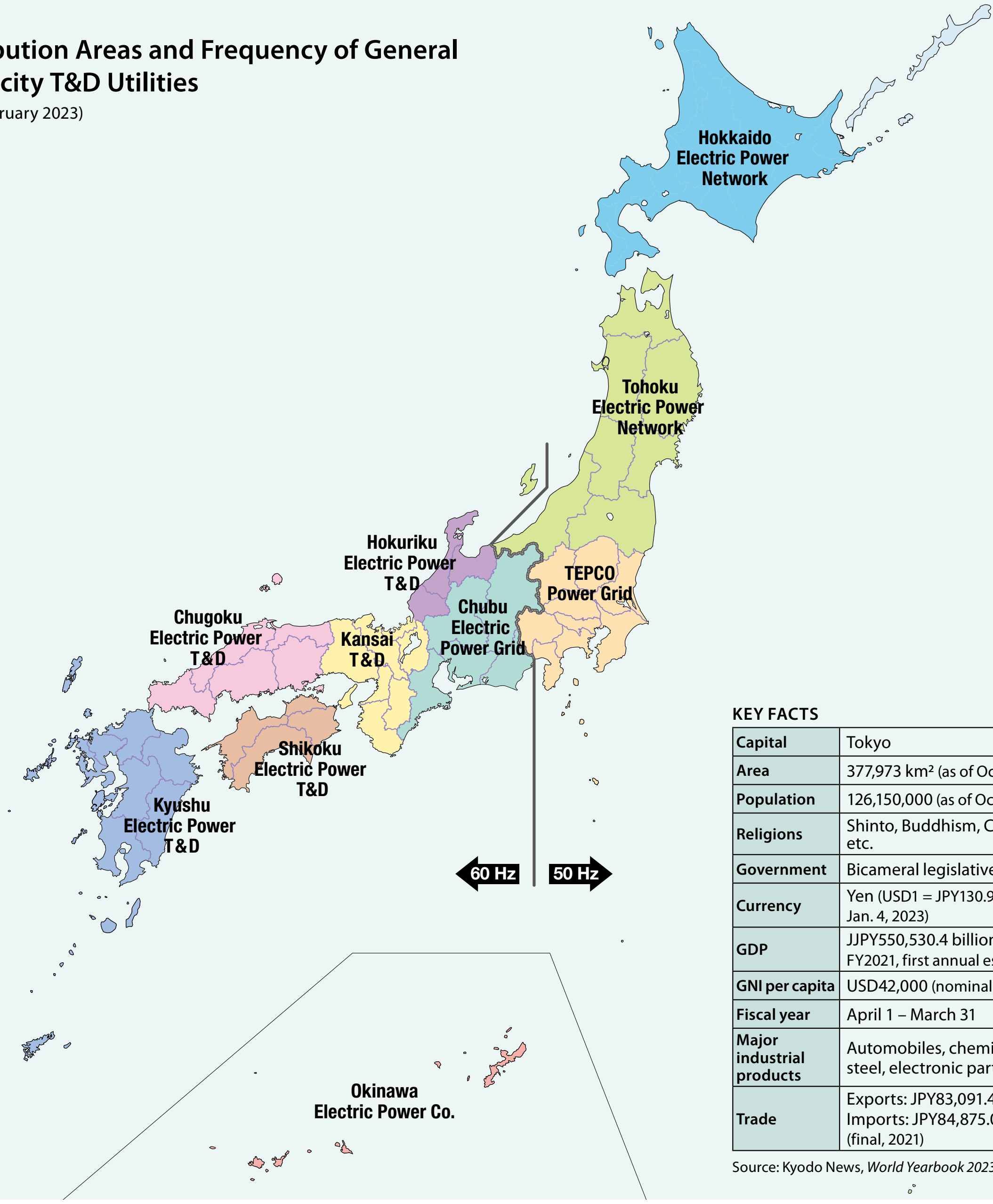
Distribution Areas and Frequency of General Electricity T&D Utilities

(As of February 2023)



KEY FACTS

Capital	Tokyo
Area	377,973 km² (as of Oct. 1, 2022)
Population	126,150,000 (as of Oct. 1, 2020)
Religions	Shinto, Buddhism, Christianity, etc.
Government	Bicameral legislative system
Currency	Yen (USD1 = JPY130.96, as of Jan. 4, 2023)
GDP	JJPY550,530.4 billion (nominal, FY2021, first annual estimate)
GNI per capita	USD42,000 (nominal, 2021)
Fiscal year	April 1 – March 31
Major industrial products	Automobiles, chemicals, food, steel, electronic parts/devices
Trade	Exports: JPY83,091.4 billion / Imports: JPY84,875.0 billion (final, 2021)

Source: Kyodo News, *World Yearbook 2023*

Member Companies (As of February 2023)

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https://www.hepco.co.jp/english/

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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.
1, Higashi-shincho, Higashi-ku, Nagoya, Aichi 461-8680, Japan
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.
5-2-1, Makiminato, Urasoe, Okinawa 901-2602, Japan
http://www.okiden.co.jp/en/

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http://www.jpower.co.jp/english/

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The Electric Power Industry in Japan 2024

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