THE ELECTRIC POWER INDUSTRY IN JAPAN 2023

JEPIC

JAPAN ELECTRIC POWER INFORMATION CENTER, INC.

JEPIC

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

Research and Information Activities

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

International Exchange Activities

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

International Cooperation

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

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

Contents

EXECUTIVE SUMMARY

The information in this document, including the Executive Summary, was current as of September 6, 2022, unless otherwise specified.

Japan's Sixth Strategic Energy Plan, approved by the Cabinet in October 2021, lays out a path for achieving carbon neutrality in 2050 and the earlier goal of reducing greenhouse gas emissions in 2030 by 46% versus 2013. It also sets forth the core principle of "S+3E" for guiding all actions for overcoming the challenges in Japan's energy supply/demand structure. This principle makes safety the fundamental premise for those actions, places top priority on realizing energy security, and calls for a balance between economic efficiency and environmental consciousness.

The Japanese government has also been working on formulating a "Clean Energy Strategy" for linking global warming measures with growth. In May 2022, it released an interim report outlining the key concepts for this endeavor: maximum utilization of pro-growth carbon pricing, and utilization of investment promotion measures based on a combination of regulation and support, including a roadmap for improving investment predictability. While the Strategic Energy Plan had stated that Japan would "reduce the dependence on nuclear power as much as possible," the Basic Policy on Economic and Fiscal Management and Reform 2022, issued in June 2022, calls for efforts to strengthen energy security by thoroughly improving energy efficiency and by making "maximum use" of energy sources such as renewable energy and nuclear power. In July, the GX (Green Transformation) Implementation Council was launched to develop economic, social, and industrial structural reforms for maintaining energy security and achieving decarbonization. Speaking at the inaugural meeting, Prime Minister Fumio Kishida, the Council's chair, noted that Japan faced an extremely tense energy situation that was driven in large part by disruptions and soaring prices in global energy markets, and that risked becoming the country's first energy crisis since the 1973 oil crisis. He also instructed the members to clearly identify matters requiring political decisions to support the stable supply of electricity and gas. The second meeting, convened in August, unveiled a policy to resume operation of 17 nuclear power reactors starting in the summer of 2023, and laid out various issues that need to be resolved, including extension of the operating lives and development and construction of innovative next-generation reactors. The Council also recognized that destabilizing factors for the economy grow with increased dependence on fossil fuels, and put forth a recommendation to study the development of next-generation nuclear power plants as one step for realizing the stable supply of electricity and the 2050 carbon neutrality goal.

I. STRUCTURE OF THE ELECTRIC POWER INDUSTRY

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

- Policy on reform of the electricity system was adopted in April 2013, and liberalization of the electric power retailing and generation sectors was completed in April 2016. The legal separation of transmission and distribution from vertically integrated businesses was implemented in April 2020, resulting in the spin-off of new transmission and distribution companies from the former general electricity utilities. Meanwhile, plans to abolish regulated electricity rates in April 2020 have been deferred.

- Today, Japan's electrical power industry comprises three major sectors: electricity generation, transmission and distribution, and retailing. The number of operators in these sectors was 1,038 (as of April 15, 2022), 35 (February 4), and 738 (July 1), 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.

- 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. Currently, 24 have been selected for decommissioning, and 10 of the remaining 36 (including three under construction) are back in operation.

- 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 has positioned 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, and has accordingly set forth long-term installation targets and actions for attaining them.

- In fiscal 2020, Japan's GHG emissions measured 1,150 million tons (CO_2 equivalent), and emissions of CO_2 accounted for 90.8% of this total, down 20.8% from the fiscal 2013 level.

III. SUPPLY AND DEMAND

- In fiscal 2021, electricity demand[1] in Japan was 881.6 TWh (up 2.2% YoY) and the peak load 3-day average came to 162.3 GW (up 1.9% YoY).

- In fiscal 2021, electric power generated[2] in Japan came to 863.5 TWh (up 2.1% YoY), of which 19.0 TWh was generated by solar power and 7.4 TWh by wind power.

- The lackluster trading prices in the electric power market in recent years have weakened the power generation business. 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.

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

IV. ELECTRIC POWER FACILITIES

- Total generating capacity in Japan came to 314.7 GW at the end of fiscal 2021. This consisted of 49.4% thermal power (15.4% coal, 24.8% LNG, and 9.2% oil), 10.5% nuclear power, 15.6% hydro, and 24.2% renewables (excluding hydro). Development of 20.6 GW of generating capacity is planned to be completed by fiscal 2031. This portion made up by new power plants to be constructed and planned changes in capacity of existing plants, excluding planned decommissioning, consists of 0.2 GW of thermal power, 9.6 GW of renewables (excluding hydro), and 10.3 GW of nuclear power.

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

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

- The Organization for Cross-regional Coordination of Transmission Operators (OCCTO) is working to complete the formulation of the Cross-regional Network Long-term Policy by March 2023 as a master plan for strengthening the domestic grid.

V. RETAIL BUSINESS AND TRADING MARKETS

- The number of registered electricity retailers has continued to rise since the full liberalization of the retail electricity market in April 2016, reaching 738 retailers as of July 2022. As of March 2022, PPSs accounted for a 21.3% share of the total volume of electricity sold.

- The volume of trades on the JEPX spot market in fiscal 2021 was 327.2 TWh (equivalent to more than 30% of all electric power sold nationwide). As of July 2022, the average system price for fiscal 2022 was 19.62 yen/kWh, and is continuing to trend upward.

- In the baseload trading market, a total volume of 748.1 MW was sold for delivery in fiscal 2022, with clearing prices ranging from 9.47 to 15.69 yen/kWh.

- Following a radical change in the capacity market's pricing system, contracts for delivery in 2025 amounted to a total volume of 165.3 GW. As a step for expanding the use of decarbonized power sources, a long-term decarbonized energy auction is scheduled to be held in fiscal 2023.

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

- In November 2021, the non-fossil value trading market launched in 2018 was divided into two markets: a renewable energy value trading market dealing in FIT renewable energy certificates, and a market for achieving the target mandated by the Sophisticated Methods Act, which deals in non-FIT renewable energy certificates and is aimed at achieving the target for non-fossil fuel power source representation in the wholesale electricity market.

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.

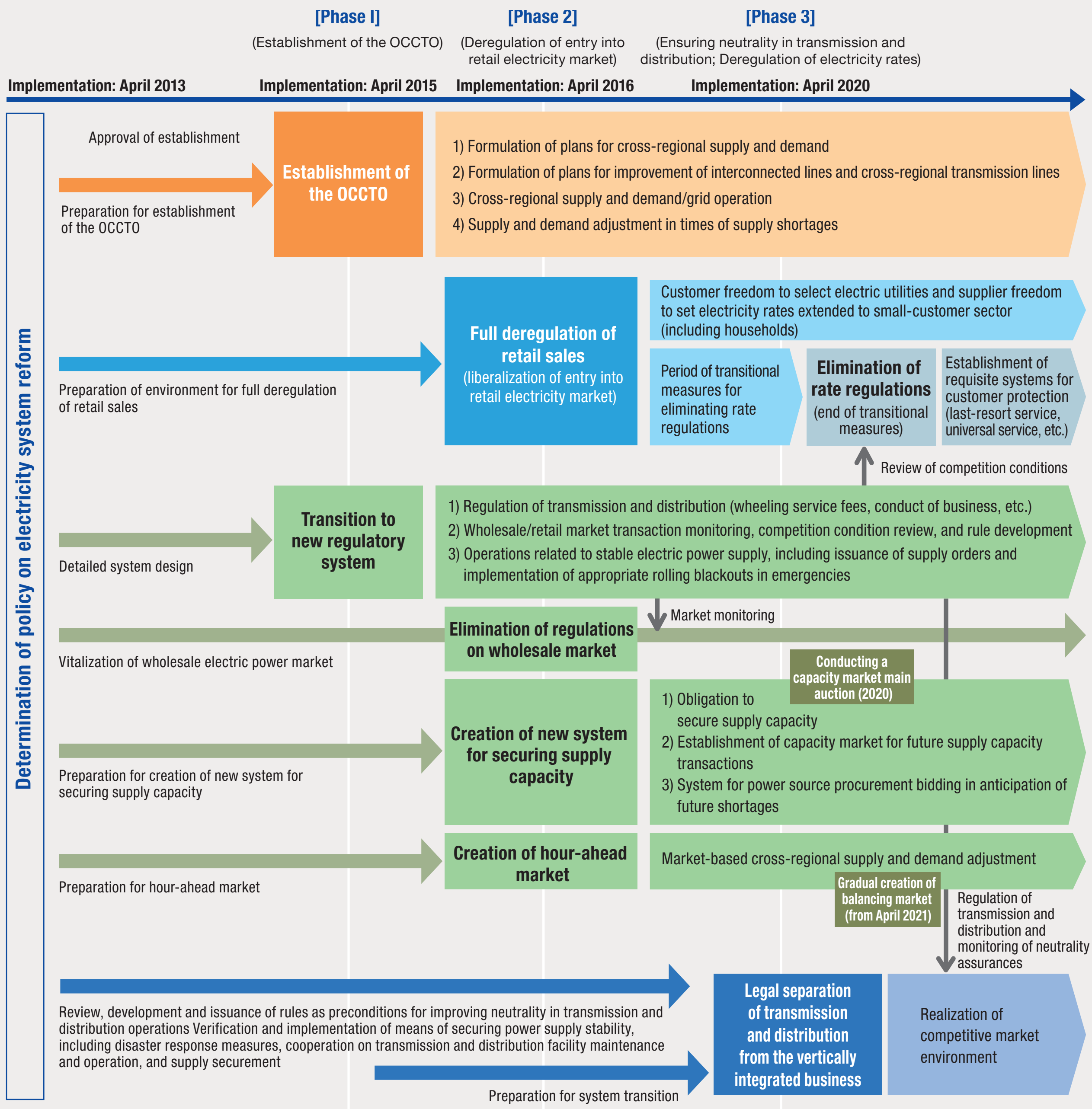
(3) Electricity System Reform

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 (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.

(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 have been considered, including (1) a baseload power market, (2) a capacity market, (3) a balancing market, and (4) a non-fossil value trading market. Trading is underway in markets (1), (2), and (4). 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. A special auction, the long-term decarbonized energy auction, is being considered for adoption in (2) (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 1,038 entities had obtained power generation licenses in the electricity generation sector as of April 15, 2022, and generating capacity was 269 GW[1] as of March 2022. 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 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, 35 corporations (as of February 4, 2022), including Sumitomo Joint Electric Power Co., Ltd., are operating as specified electricity transmission and distribution utilities.

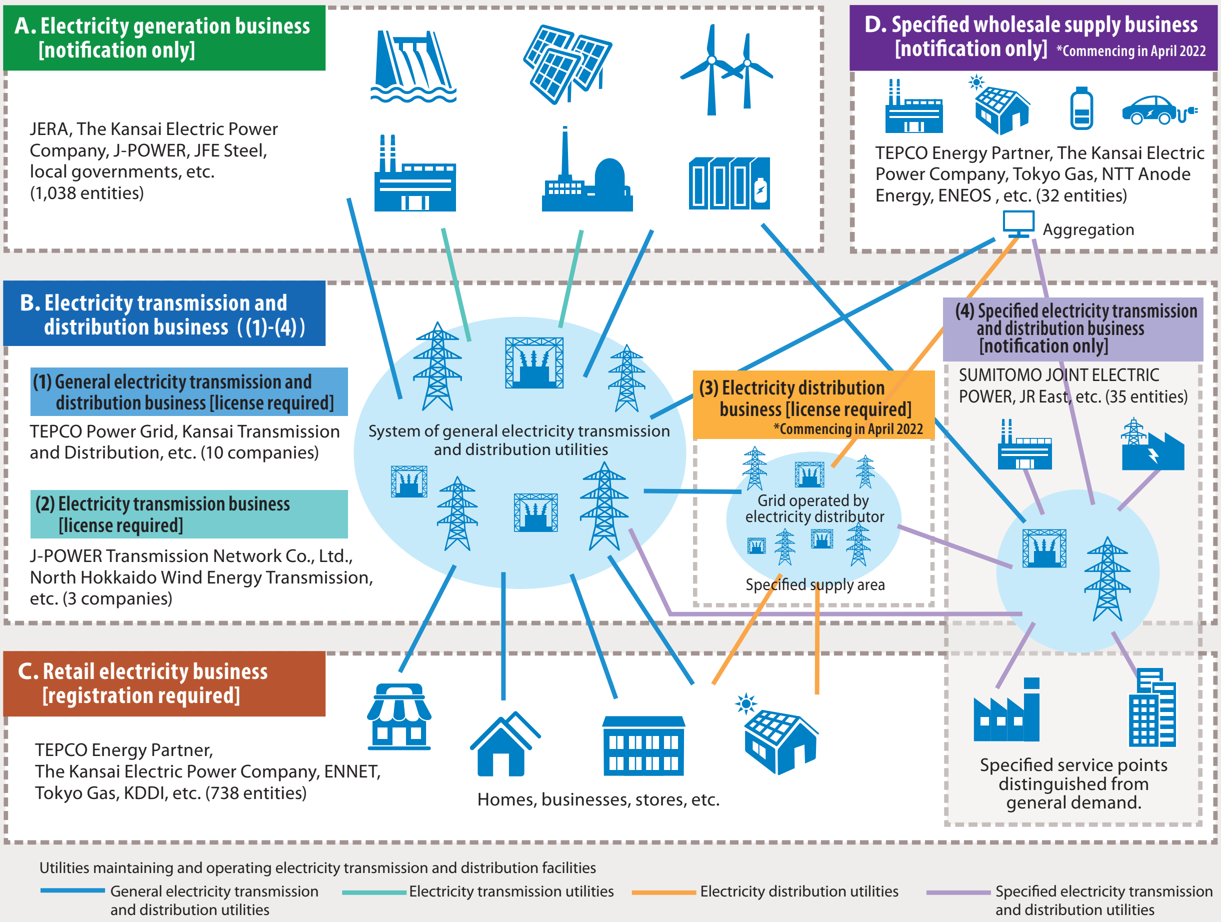
In the electricity retail sector, data released by Agency for Natural Resources and Energy show that a total of 738 entities had obtained retail licenses (as of July 1, 2022). In addition to the former general electricity utilities, electricity retailers include telecommunications carriers, trading companies, gas and petroleum companies, steel manufacturers, and subsidiaries of former general electricity utilities. Net system energy demand in fiscal 2021 came to 881 TWh, of which former general electricity utilities accounted for about 75%.

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

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

Electricity Supply System after Introduction of Licensing

Figure 1.2



Source: Compiled from Agency for Natural Resources and Energy, "(Reference) Electricity Power Supply Structure (from April 2016)"

Agency for Natural Resources and Energy, 32 entities were operating as (1) licensees as of July 8, 2022. (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 July 8, 2022, 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

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.

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 defines challenges and action timetables for 14 promising fields that are expected to grow, and calls for further innovation toward decarbonizing the electric power sector, advancing electrification and the use of hydrogen for heating in the industrial, transport, office, and household sectors, and capturing carbon dioxide.

In April 2021, the government declared that it would seek to reduce greenhouse gas emissions in fiscal 2030 by 46% from the level in fiscal 2013, and thereafter further strive toward 50%. To lay out the path to realizing these goals, the government issued a draft of the Sixth Strategic Energy Plan in July 2021, and the Cabinet approved it in the following October. 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 maps out the challenges and actions for achieving carbon neutrality in 2050, as well as government policy measures to be implemented towards 2030 based on those challenges and actions.

Following the Cabinet's approval of the Plan, the government began formulating a "Clean Energy Strategy" for linking global warming measures with growth. In May 2022, it released an interim report outlining the strategy's key concepts: maximum utilization of pro-growth carbon pricing, and utilization of investment promotion measures based on a combination of regulation and support, including a roadmap for improving investment predictability.

In the following July, the GX (Green Transformation) Implementation Council was launched to create a ten-year roadmap for implementing economic, social, and industrial structural reforms needed to maintain energy security and achieve decarbonization. Speaking at the inaugural meeting, Prime Minister Fumio Kishida, the Council's chair, noted that Japan faced an extremely tense energy situation that was driven in large part by disruptions and soaring prices in global energy markets, and that risked becoming the country's first energy crisis since the 1973 oil crisis. He also instructed the members to clearly identify matters requiring political decisions to support the stable supply of electricity and gas. The second meeting, convened in August, unveiled a policy to resume operation of 17 nuclear power reactors starting in the summer of 2023, and laid out various issues that need to be resolved, including the possible extension of the reactors' legally mandated operating lives, which is currently set at 40 years in principle and up to 60 years maximum. The Council also recognized that destabilizing factors for the economy grow with increased dependence on fossil fuels, and put forth a recommendation to study the development of next-generation nuclear power plants as one step for realizing the stable supply of electricity and the 2050 carbon neutrality goal.

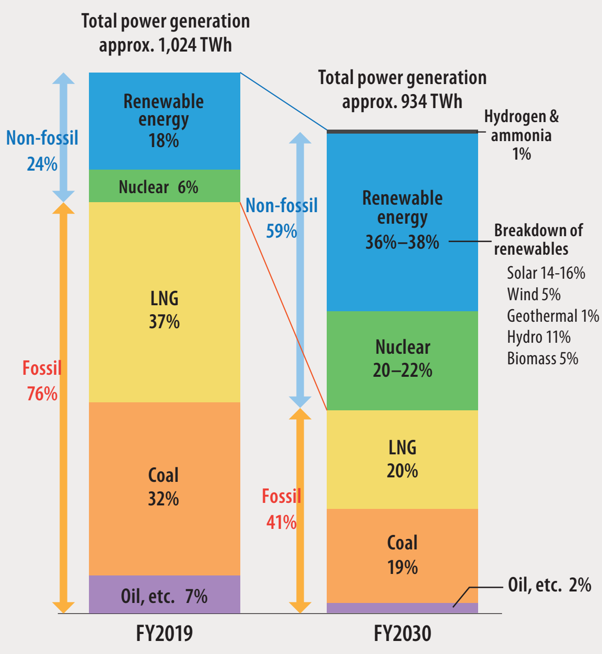
(1) Challenges and Actions for Achieving Carbon Neutrality in 2050

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).

(2) Policy Measures towards 2030

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

Power Generation Mix in Fiscal 2030 Figure 2.1



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

(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. This policy entails, among other actions, 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 Russia 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.

During the Group of Seven summit in June 2022, Japan joined with the United States, Canada, and the European members in voting for a ban on imports of Russian coal and oil. Russia accounted for 11% and 4% of Japan's coal and oil imports, respectively, in 2020. Approximately 9% of Japan's LNG imports are supplied by Russia, mostly the Sakhalin-2 oil and natural gas project in the Russian Far East. The Russian majority state-owned Gazprom owns slightly over 50% of the shares in the new company operating the project, with remainder held by the Russian government. Previously, the UK-based major oil and gas company Shell plc had owned a 27.5% stake in Sakhalin-2, but announced in February 2022 its intention to withdraw from the project. While the Japanese government had decided to ban oil and coal imports from Russia, in August it called on two Japanese trading companies, Mitsui & Co., Ltd. and Mitsubishi Corporation, to maintain their investments in Sakhalin-2 for the sake of energy security. In response, both companies decided to invest in the project's new operating company. Also, of the eight Japanese companies that had been dealing with Sakhalin-2, the following four decided to renew their contracts through the new operator: JERA, Kyushu Electric Power Co., Tokyo Gas, and Hiroshima Gas.

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).
- Setting the period of operation of electricity-generating nuclear reactors at 40 years. Also, limiting the extension of this term to one time only and a length not to exceed 20 years.
- Integration of nuclear power safety regulations with the Nuclear Reactors Regulation Act (separation from the Electricity Business Act).

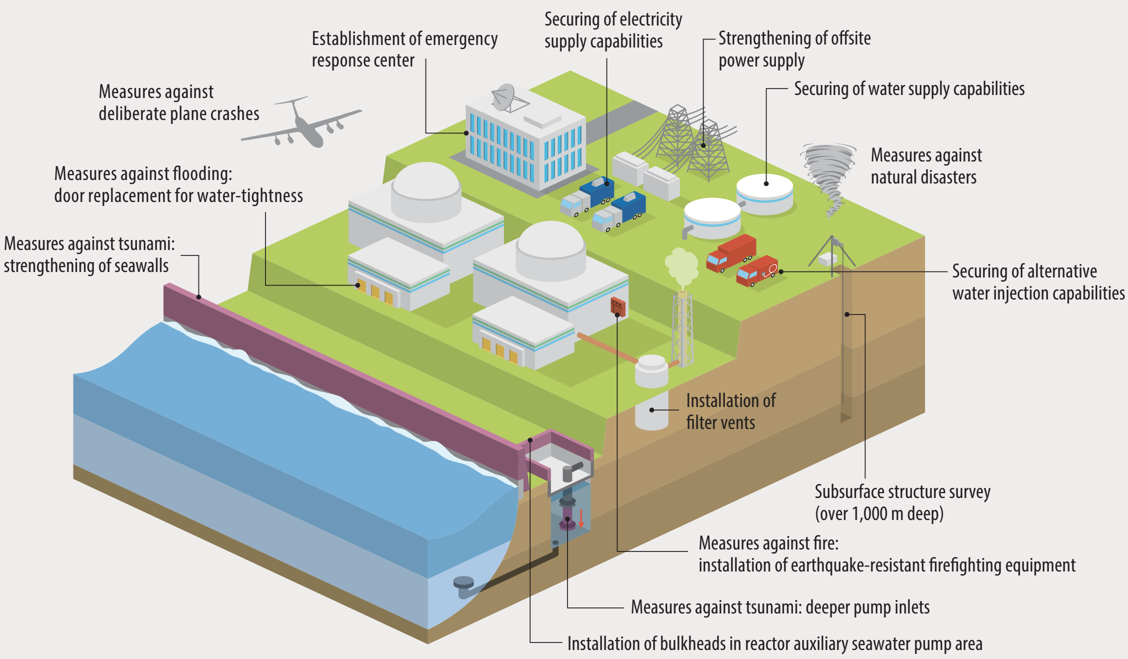
The NRA verifies whether the installation, operation, etc. of electricity-generating nuclear reactors conform to the New Regulatory Requirements through the following 3-tier regulatory review process. Tier 1 grants permission for changes in reactor installation; Tier 2 approves the construction plan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

c. Initiatives by the Private Sector

Alongside the measures being taken by the regulatory

Safety Measures Required by New Regulatory Requirements

Figure 2.2



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

Current State of Nuclear Plant Reviews and Restarts Table 2.1

Tier 1 review completed (change in installation license granted) (17 units)	Restarted	10 units
	Pending completion of Tier 2 and 3 reviews (construction approval, safety regulations, pre-service inspections), and consents of local communities	7 units
Under Tier 1 review (including 2 units under construction)		10 units
Applications not yet filed (including 1 unit under construction)		9 units
Total (including 3 units under construction)		**36 units**
To be decommissioned		**24 units**

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

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

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

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

(2) State of Nuclear Power Generation

Prior to the March 2011 Fukushima Daiichi accident, Japan had 57 nuclear reactors in operation, and nuclear power accounted for roughly 25% of the total electric power generated in fiscal 2010. In 2014, all nuclear reactors were provisionally shut down. After it became possible to determine the economic viability of each plant in light of the New Regulatory Requirements, 24 of the reactors, representing aging small and medium-sized models, were selected for decommissioning. As a result, the number of reactors fell to 36 (including three under construction) as of August 2022. Starting in 2015, some of those reactors were brought back into service, with a total of 10 having restarted by August 2022 (nuclear power provided around 7% of total electricity generated in 2021).

One of the restarted reactors, the No. 3 reactor at Kansai Electric Power Company's Mihama nuclear power station, had exceeded its mandated service life of 40 years but was able to resume operation in July 2021 through an extension approved by the NRA, which was the first such approval to be granted. However, the reactor was stopped again in October 2021 for failure to complete its specialized safety facility[1] on schedule. It went back into operation in September 2022 following the completion of the specialized safety facility.

Of the 36 available reactors, 27 (including two under construction) applied for permission for change in reactor installation under the Tier 1 review. Permission was granted to 17 reactors, and 10 of them were able to resume operation after passing the Tier 2 and 3 reviews and gaining their local governments' consents (see Table 2.1). However,

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

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.

At the August 2022 meeting of the GX Implementation Council, Prime Minister Kishida clearly signaled the government's intent to promote the construction of new reactors, calling on the members to reach "a specific conclusion" on the following measures by the end of the year: a phased restart of the seven reactors that had received permission for change in reactor installation beginning in the summer of 2023 (adding to the ten already back in operation); maximum utilization of existing reactors, including by extending their operating lives; and development and construction of innovative next-generation reactors[2] with new safety mechanisms.

For reference, the capacity factor of nuclear power plants in Japan in 2021 was 22.1%.

(3) Nuclear Fuel Cycle

a. Basic Policy

Japan, a country lacking in energy resources, has adopted a basic policy that seeks to make effective use of resources and reduce the volume and harmfulness of high-level radioactive waste by pursuing a nuclear fuel cycle that reprocesses spent fuel and effectively utilizes the plutonium and 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[3] by fiscal 2030. In February 2022 FEPC released a plan for plutonium use by 11 power companies from fiscal 2022 to 2024.

b. JNFL's Nuclear Fuel Cycle Operations

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

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. Based on the progress in constructing safety facilities mandated by the New Regulatory Requirements, operation is expected to resume in February 2023.

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 preparatory work for adding the required safety features is still underway. Consequently, JNFL has delayed the completion date, originally scheduled for the first half of fiscal 2022, to 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 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.

2 This refers to five types: advanced light-water reactors that add enhanced safety features to existing light-water reactor technology (this approach is already in use overseas, including in the EPR); small modular reactors with a capacity of up to around 300,000 kW that would reduce construction time 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 fusion reactors that would harness the energy released by the nuclear fusion of hydrogen atoms.

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

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

d. Disposal of High-level Radioactive Waste

As for high-level radioactive waste generated from spent fuel, the Nuclear Waste Management Organization of Japan (NUMO) was established in 2000 by mainly electric power companies to implement final disposal of the waste. In October 2020, Suttsu Town and Kamoenai Village in Hokkaido each voted to accept a literature review,[4] 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 2022, the collection of literature and data had been nearly completed for both municipalities, setting the stage for candidate evaluation based on the information gathered.

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

In line with the Japanese government's basic policy for dealing with the country's limited energy resources, the Japan Atomic Energy Agency (JAEA) constructed the Joyo experimental fast-breeder reactor (thermal output: 140,000 kW), and later the Monju prototype fast-breeder reactor (electrical output: 280,000 kW). However, in December 2016, the government finally decided to decommission Monju for several reasons, including poor economic viability. Fast reactor research and development using the Joyo experimental reactor at Oarai Research & Development Institute in Ibaraki Prefecture will continue to be pursued in partnership with other countries following the roadmap developed in accordance with the new policy on fast reactor development adopted by the Inter-Ministerial Council for Nuclear Power in December 2016. In December 2021, the JAEA announced that resumption of the Joyo reactor's operation would be moved back to the end of fiscal 2024, amid delays in the NRA's review of changes for complying with the New Regulatory Requirements.

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

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

3 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.

4 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.

such as extracting high-temperature helium gas (950˚C) and using it to produce hydrogen. The resumption of its operation is expected to lead to implementation of research contracts from the OECD Nuclear Energy Agency and to bilateral collaborations with countries such as Poland, the UK and the USA. In April 2022, the JAEA and Mitsubishi Heavy Industries, Ltd. were contracted by METI's Agency for Natural Resources and Energy to conduct its Hydrogen Production Demonstration Project Utilizing Very High Temperature. The two companies have launched R&D on producing hydrogen using an HTTR, with the project set to run until March 2031. Full-scale hydrogen production testing is scheduled to start in the latter half of this decade.

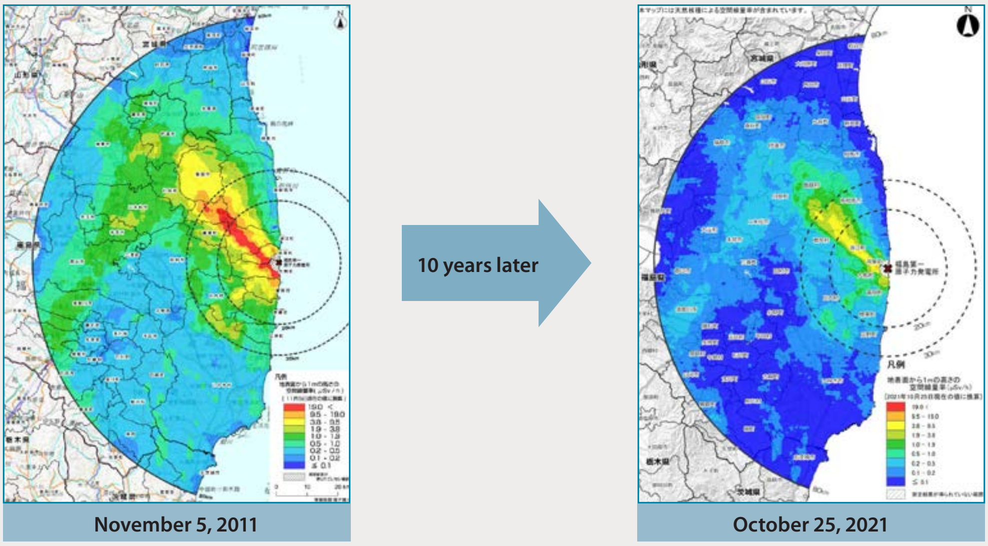
(4) Decommissioning Work at Fukushima Daiichi Nuclear Power Plant

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

a. Decommissioning Roadmap

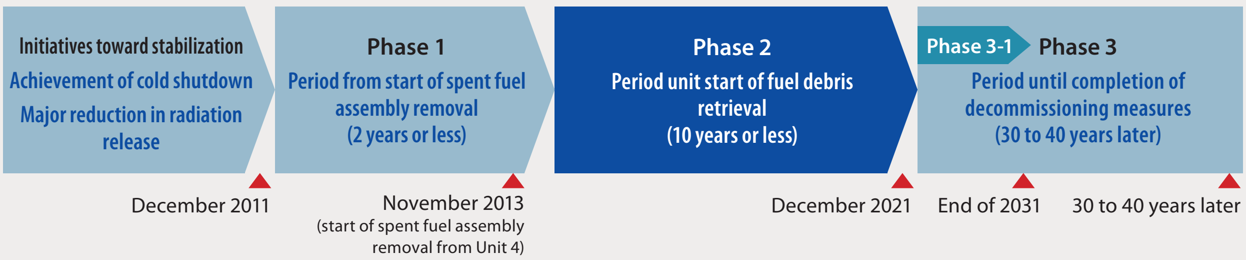
In December 2011, nine months after the Fukushima Daiichi accident, Fukushima Daiichi's reactors were declared to be in cold shutdown and TEPCO released a roadmap for

Changes in Air Dose Rate Figure 2.3



Source: Reconstruction Agency, "Acceleration of Reconstruction Efforts"

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



Source: TEPCO website (https://www.tepco.co.jp/en/hd/decommission/project/roadmap/index-e.html) 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 of the roadmap 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 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. Prior to the scheduled discharge in the spring or summer of 2023, the IAEA will conduct a safety review of the plan, monitor the area of release, and carry out other preparations. In August 2021, the TEPCO announced its intention to dilute the tritium concentration of the water to one seventh of the WHO's drinking water standard by adding large volumes of seawater, and to discharge the diluted water at a point approximately one kilometer off the coast of the power plant, via a tunnel that will be bored in the bedrock.

An IAEA task force visited Fukushima Daiichi Nuclear Power Plant in February 2022 to review the safety of ALPS-treated water, and released a report on its findings in April. The report stated that TEPCO had conducted a "comprehensive and detailed assessment" of radiological impact, and that the assessment indicated that "doses to the assumed representative person are expected to be very low and significantly below the dose constraint set by the regulatory body (NRA)." TEPCO received the NRA's approval for the basic design of the treated water dilution/discharge facility and related facilities in July 2022, and began constructing an undersea discharge tunnel in August 2022.

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 existing 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 65.5 GW between the launch of the FIT scheme and the end of December 2021. Including pre-

Installed Capacity of Renewable Energy (as of end December 2021)

Table 2.2

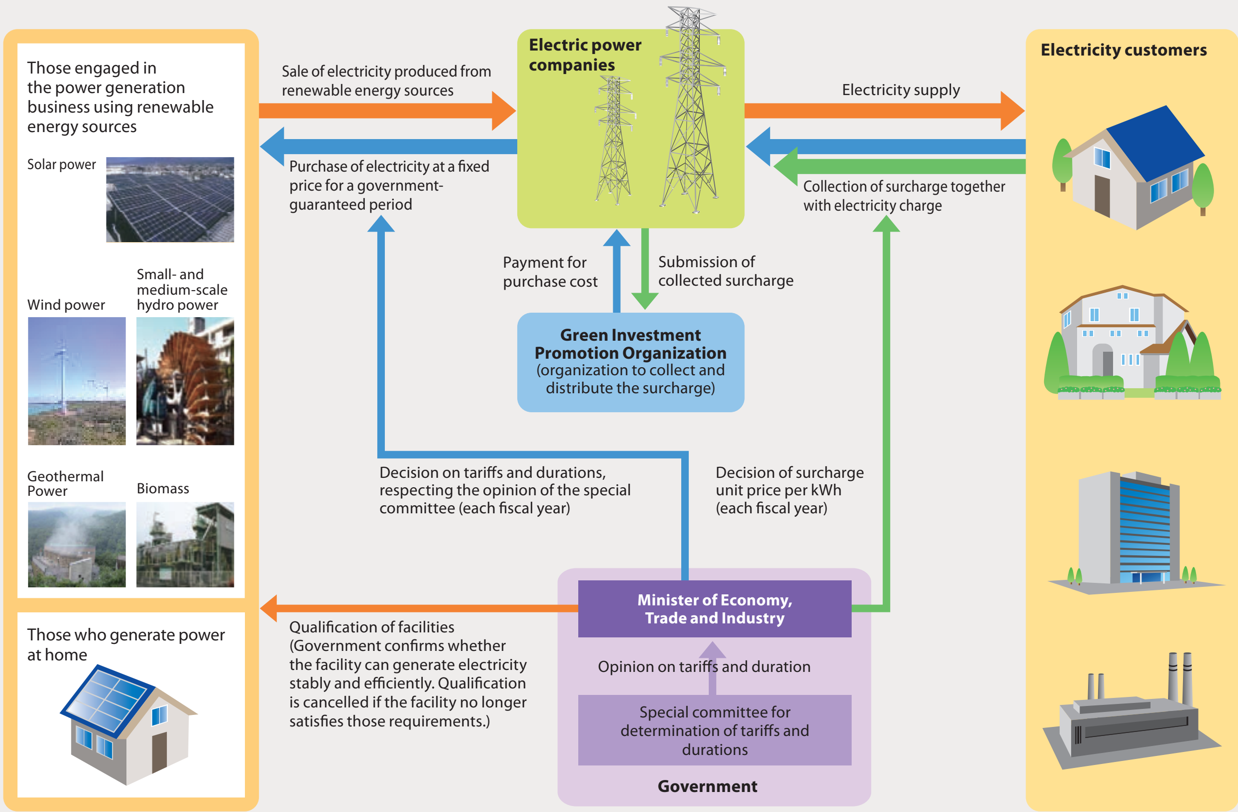
[Unit: MW]

Type	Combined total by end June 2012	Combined capacity installed under FIT	Total
Solar power (residential)	4,700	8,291	12,991
Solar power (non-residential)	900	51,052	51,952
Wind power	2,600	2,202	4,802
Small / medium hydropower	9,600	815	10,415
Biomass	2,300	3,094	5,394
Geothermal power	500	93	593
Total	20,600	65,547	86,147

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

FIT capacity, total installed renewables capacity reached approximately 86 GW. In April 2022, the government launched a feed-in premium (FIP) scheme for large-scale commercial solar power, among other power sources.

(2) FIT Scheme and Issues

The government passed the Act on Special Measures Concerning Procurement of Electricity from Renewable Energy Sources by Electricity Utilities in August 2011, which requires the 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.

Purchase Prices and Durations under the FIT Scheme Table 2.3

Purchase category			Purchase price [yen/kWh]				Duration
			FY2021	FY2022	FY2023	FY2024	[years]
Solar (household)	Less than 10 kW		19	17	16	–	10
Solar (commercial)	10 kW–50 kW		12	11	10	–	
	50 kW or above		11	10	9.5	–	
Onshore wind power	Less than 50 kW		17	16	15	14	20
	50 kW or above		Bidding system				
	Replacement capacity		15	14	–	–	
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)	Bottom-fixed offshore wind power		32	29	Bidding system	–	
	Floating offshore wind power		36	36			
Geothermal	Less than 15,000 kW		40	40			15
	15,000 kW or above		26	26			
Geothermal (with all facilities upgraded)	Less than 15,000 kW		30	30			
	15,000 kW or above		20	20			
Geothermal (with original underground facilities in use)	Less than 15,000 kW		19	19			
	15,000 kW or above		12	12			
Small & medium-sized hydro	Less than 200 kW		34	34			20
	200 kW–1,000 kW		29	29			
	1,000 kW–5,000 kW		27	27		–	
	5,000 kW–30,000 kW		20	20	16	–	
Small & medium-sized hydro using existing conduits*	Less than 200 kW		25	25			
	200 kW–1,000 kW		21	21			
	1,000 kW–5,000 kW		15	15		–	
	5,000 kW–30,000 kW		12	12	9	–	
Biomas	General wood, etc.	Less than 10,000 kW	24	24		–	20
	Unused materials	2,000 kW or above	32	32		–	
	Construction material waste	All capacities	13	13		–	
	General waste/other	All capacities	17	17		–	
	Biogas from methane fermentation	All capacities	39	39	35	–	

* Upgrades to electrical facilities and penstocks utilizing existing conduits.

Source: Compiled from Agency for Natural Resources and Energy website

Results of FIT Tenders in Fiscal 2021 & 2022

Table 2.4

Technology	Timing	Eligible facilities	Successful bids
Solar power	June 2021	250 kW or above	Total output: 208,000.0 kW (135 bids) Successful bid prices: 10.00–10.98 yen/kWh
	August 2021	250 kW or above	Total output: 233,817.7 kW (208 bids) Successful bid prices: 10.28–10.75 yen/kWh
	November 2021	250 kW or above	Total output: 242,807.5 kW (82 bids) Successful bid prices: 10.23–10.40 yen/kWh
	March 2022	250 kW or above	Total output: 268,709.9 kW (273 bids) Successful bid prices: 8.99–10.25 yen/kWh
	June 2022	250 kW–1,000 kW	Total output: 24,764.7 kW (39 bids) Successful bid prices: 9.80–10.00 yen/kWh
Onshore wind power	November 2021	–	Total output: 936,408.9 kW (32 bids) Successful bid prices: 14.98–16.16 yen/kWh
Biomass power	November 2021	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: 74,950.0 kW (1 bid) Successful bid prices: 18.50 yen/kWh

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

The electricity supply sources, purchase prices and purchase periods covered by the FIT scheme for each fiscal year are to be determined by METI. The purchase prices and periods for fiscal 2021 onward are as 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 2022 is 3.45 yen per kWh (2.7424 trillion yen for Japan as a whole), or 10,764 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 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 to bring down purchase prices. The results of FIT tenders made in fiscal 2021 are shown in Table 2.4.

(3) Complete Overhaul of the FIT Scheme and Launch of the FIP Scheme

As adoption of renewables has spread, a number of problems with FIT have emerged, including rising renewable surcharges on electricity rates and difficulties with receiving power generated by renewables on the grid side. 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 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

Results of FIP Tenders

Table 2.5

Technology	Timing	Eligible facilities	Successful bids
Solar power	June 2022	1,000 kW or above	Total output: 128,940.0 kW (5 bids) Successful bid prices: 9.85–9.90 yen/kWh

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

Sakai Solar Power Station (Kansai Electric Power Co.)

Hibiki-nada Offshore Wind Project (Kyusyu Electic Power Co.)
Project launch: scheduled in FY2025 / Operator: Hibiki Wind Energy Co., Ltd.

Setana Osato Windfarm(Electric Power Development Co., Ltd. (J-POWER))
COD: 2020 / Owner: J-POWER / Capacity: 50,000 kW

Wasabizawa Geothermal Power Plant (Electric Power Development Co., Ltd. (J-POWER))
COD: 2019 / Owner: Yuzawa Geothermal Power Corporation / Equity: J-POWER (50%), Mitsubishi Materials Corporation (30%) and Mitsubishi Gas Chemical Company (20%) / Capacity: 46,199 kW

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

Table 2.6

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

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 of other power sources, among other benefits. The FIP tender results published in June of fiscal 2022 are shown in Table 2.5.

(4) Development of Legal Framework for Advancing Offshore Wind Farm Projects, 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, and has set long-term installation targets as part of its policy for advancing this form of energy. Many Japanese companies are seeking to enter this field by collaborating with partners, particularly European electric power enterprises experienced in offshore wind power. 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 2.6).

Following the December 2021 auction, there emerged calls for a cap on the number of successful bids made by each bidder as a way to provide market entry opportunities to a larger number of enterprises, and for accelerated launch of projects. In response, the government proposed changes to bidding rules and gathered stakeholder feedback on the proposal. Discussions are now underway toward holding the next auction in 2022 under two revisions: providing an incentive for speeding up project launches by giving higher weight to bids with earlier start dates, and awarding higher scores to bids that offer benefits such as greater supply chain resilience by contributing to stable supply of electric power (i.e., early service recovery following outages).

Electricity utilities and other concerned parties have recognized the need for a transmission system that can

Government Action on GHG Reduction Targets

Table 2.7

Date	Trend
December 1997	Kyoto Protocol adopted at COP3. Japan's GHG reduction target set at 6% below 1990 levels.
October 1998	Act on Promotion of Global Warming Countermeasures instituted in response to adoption of the Kyoto Protocol.
April 2005	Kyoto Protocol Target Achievement Plan outlining the measures necessary to attain Japan's 6% GHG reduction target approved at a meeting of the Cabinet.
July 2015	The Japanese government submits to the UNFCCC Secretariat its INDC target of reducing emissions by 26% below fiscal 2013 levels by fiscal 2030.
December 2015	Paris Agreement adopted.
June 2019	The Long-term Strategy under the Paris Agreement approved by the Cabinet (decision to reduce emissions in 2050 by 80%).
October 2020	Prime Minister Suga declares goal to make Japan carbon neutral by 2050.
December 2020	Green Growth Strategy announced as plan for achieving carbon neutrality by 2050.
April 2021	Japan announces that its GHG emission reduction target for 2030 will be raised to 46% at US-hosted Leaders Summit on Climate.

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

efficiently transmit power to service areas from the regions where many offshore wind power projects are planned (Hokkaido, Tohoku, etc.). The government, general electricity transmission and distribution utilities, and the Organization for Cross-regional Coordination of Transmission Operators are exploring options such as strengthening the grid networks and building a submarine DC power transmission system.

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.

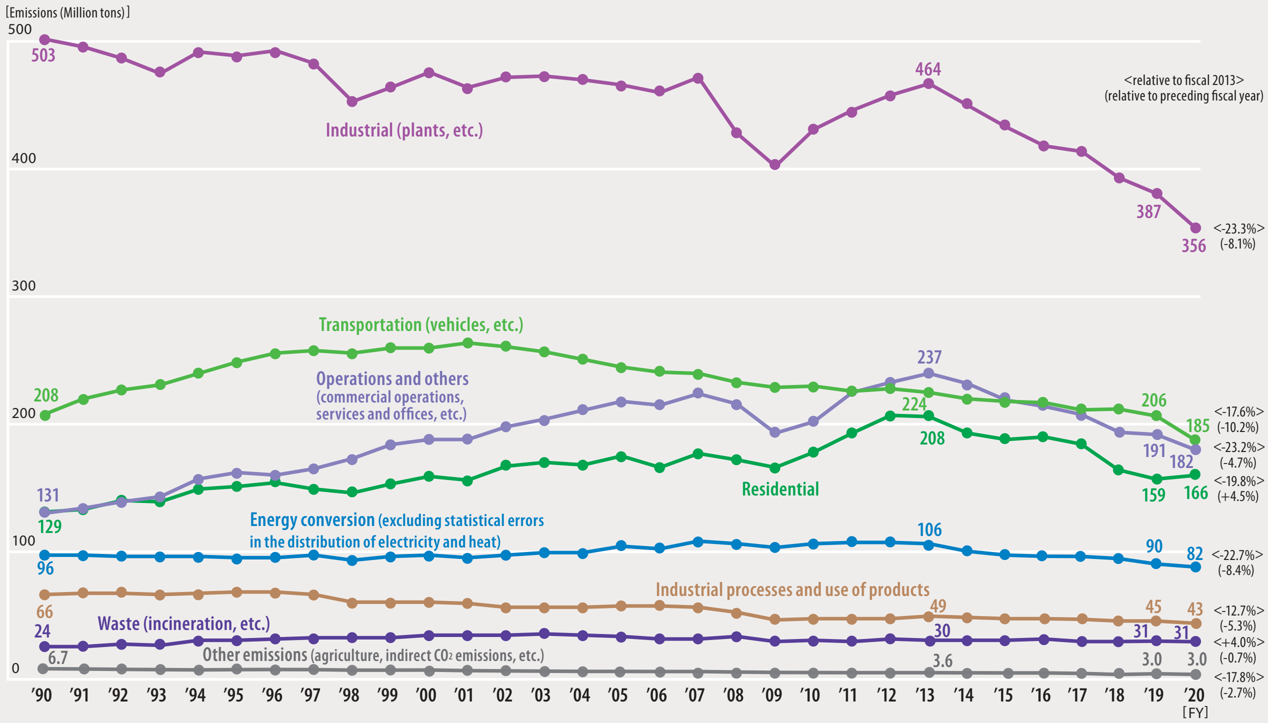
The Japanese government set in 2015 the goal of reducing emissions in fiscal 2030 by 26.0% from fiscal 2013, and established in June 2019 a reduction target of 80% for fiscal 2050. Both goals were reported to the UN Secretariat.

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 fiscal year 2030 from its fiscal year 2013 levels, setting an ambitious target which is aligned with the long-term goal of achieving net-zero by 2050" and "will continue strenuous efforts in its challenge to meet the lofty goal of cutting its emission by 50 percent."

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)

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

a. GHG Emissions in Japan

In fiscal 2020, Japan's GHG emissions measured 1,150 million tons (CO_2 equivalent), and emissions of CO_2 accounted for 90.8% (1,044 million tons) of this total. CO_2 emissions decreased by 20.8% versus fiscal 2013 (see Figure 2.6).

CO_2 emissions in individual sectors have been decreasing since 2013, and declining by 17.0%, 18.8%, and 23.3% respectively in the industrial sector, the commercial sector, and the residential sector between fiscal 2013 and fiscal 2019. This was due largely to lower energy consumption resulting from energy conservation in all sectors and to improvements in the CO_2 emission intensity for electricity.

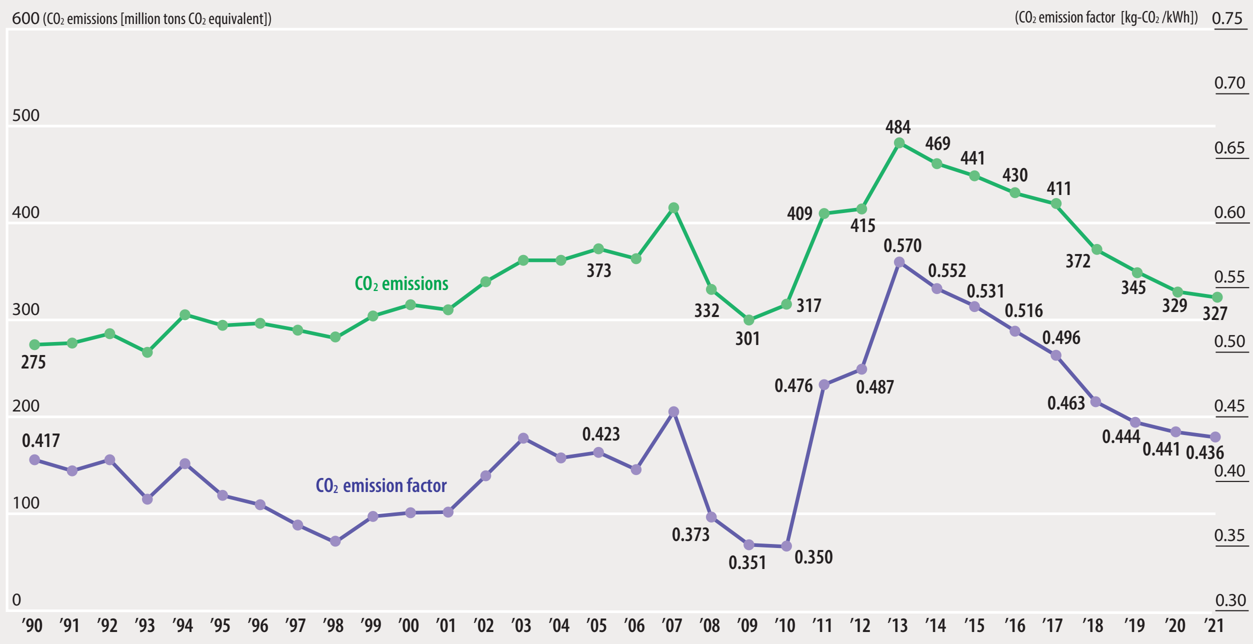
b. CO_2 Emission and Global Warming Countermeasures Implemented by the Electric Power Industry

The Federation of Electric Power Companies of Japan (FEPC) (consisting of former general electricity utilities) is participating in the Commitment to a Low Carbon Society that was announced by Japan Business Federation in 2013, and has been promoting measures on both the supply and demand sides of the electricity. In July 2015, the 10 FEPC members, J-POWER, the Japan Atomic Power Co. and 23 PPSs announced their own Commitment to a Low-Carbon Society in the Electricity Industry, which commits them to achieving a CO_2 emission factor in the electricity in fiscal 2030 of approximately 0.37 kg-CO_2/kWh (equivalent to a reduction of 35% from the fiscal 2013 level). The Electric Power Council for a Low Carbon Society (ELCS) was established in February 2016 with the aim of moving forward with the attainment of these targets for all electricity utilities as a whole. According to data released by ELCS, CO_2 emissions in fiscal 2021 (final figures) came to 327 million tons-CO_2 and the CO_2 emission factor was 0.436 kg-CO_2/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

CO_2 Emissions in the Electric Power Industry

Figure 2.7



Note: Reflected adjustments made for Kyoto Mechanism credits

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

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 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-CO_2/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 CO_2 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 CO_2 emission trends in the electric power industry.

III. SUPPLY AND DEMAND

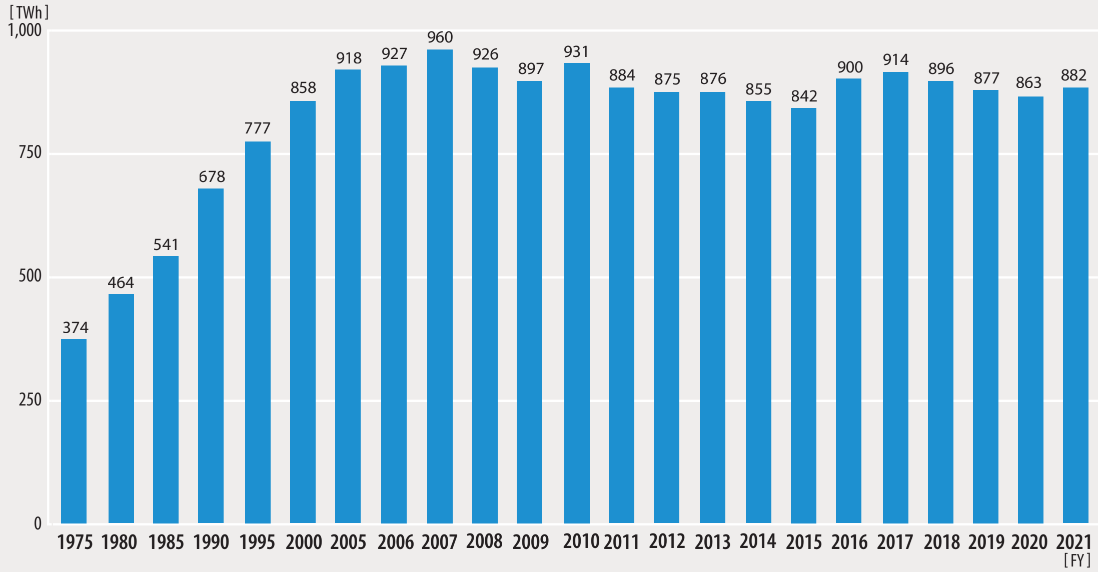
1. Electricity Demand and Peak Load

Japan's electricity demand increased for the most part until the early 2000s. The real GDP growth rate in fiscal 2021, a year in which the COVID-19 pandemic's constraints on economic activity began to loosen, was 2.2% compared to fiscal 2020, when it stood at -4.5% versus the preceding year. Annual electricity demand[1] has either declined or remained unchanged since reaching 959.7 TWh in fiscal 2007, and in fiscal 2021 came to 881.6 TWh (2.1% increase from previous fiscal year) (see Figure 3.1). This trend is attributable to several factors, including (1) the slowing of economic growth, (2) improved energy conservation, and (3) demographic decline. More recently, however, growing solar power generation in the residential sector, which is not included in these statistics, also appears to have played a part. Peak national demand has also remained largely unchanged since fiscal 2011 and the average of the three highest daily loads in fiscal 2021 came to 162.3 GW (1.9% increase from previous fiscal year).

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

Power consumption in fiscal 2020 breaks down by use as follows: 29% residential demand, 33% 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 non-industrial sectors, namely the residential and commercial sectors. Growth in consumption in the commercial sector has been propelled by growth in offices and commercial facilities triggered by development of a service economy and the accompanying use of air conditioners and other appliances. In the residential sector, the rapid spread of heating and cooling appliances, such as air conditioners and electric carpets and other household appliances, driven by rising living standards, ensured that power consumption continued to grow until fiscal 2005. Growth then leveled off as the population continued to decline, appliance ownership reached a saturation point, and energy-saving

Changes in Electricity Demand, 1975–2021 Figure 3.1

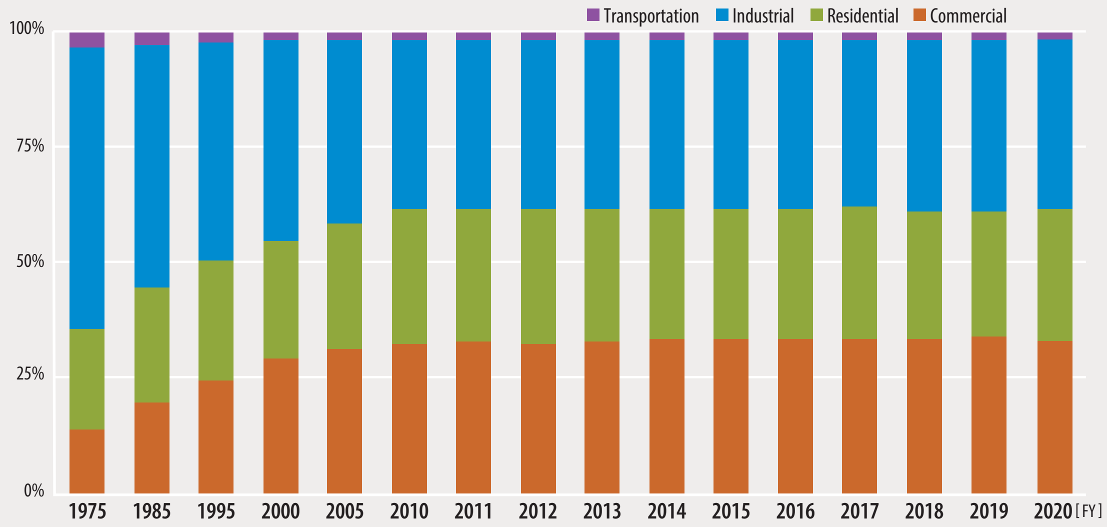


Source: Compiled from Agency for Natural Resources and Energy, "Handbook of Electric Power Industry" (2021) and "Surveys and Statistics of Electricity" (2022)

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

Breakdown of Power Consumption by Sector, 1975–2020

Figure 3.2



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

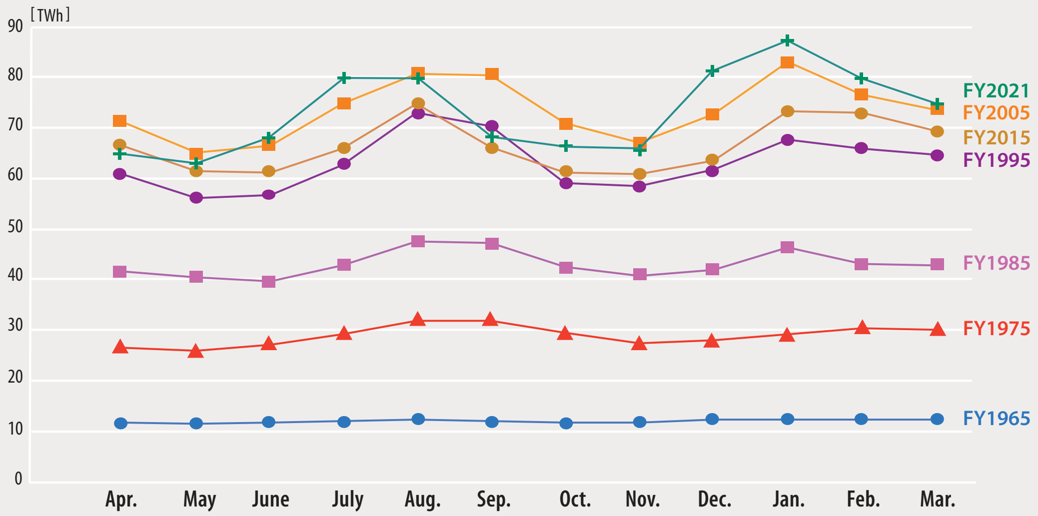
Source: Agency for Natural Resources and Energy, "Energy Balance in Japan" (2022)

devices began to capture a growing share of the market. In fiscal 2011, increased awareness of the importance of saving electricity in the aftermath of the Fukushima Daiichi accident caused consumption to go into decline. In fiscal 2019, non-industrial consumption accounted for 62% of final power consumption.

In the years preceding the March 2011 Great East Japan Earthquake, the rise in the non-industrial share of demand widened the gap between summer/winter demand and spring/fall demand (see Figure 3.3), and between daytime and nighttime hours (see Figure 3.4) due to the use of electricity for heating and cooling. Since the disaster, however, power

Electric Power Consumption over the Course of a Year

Figure 3.3

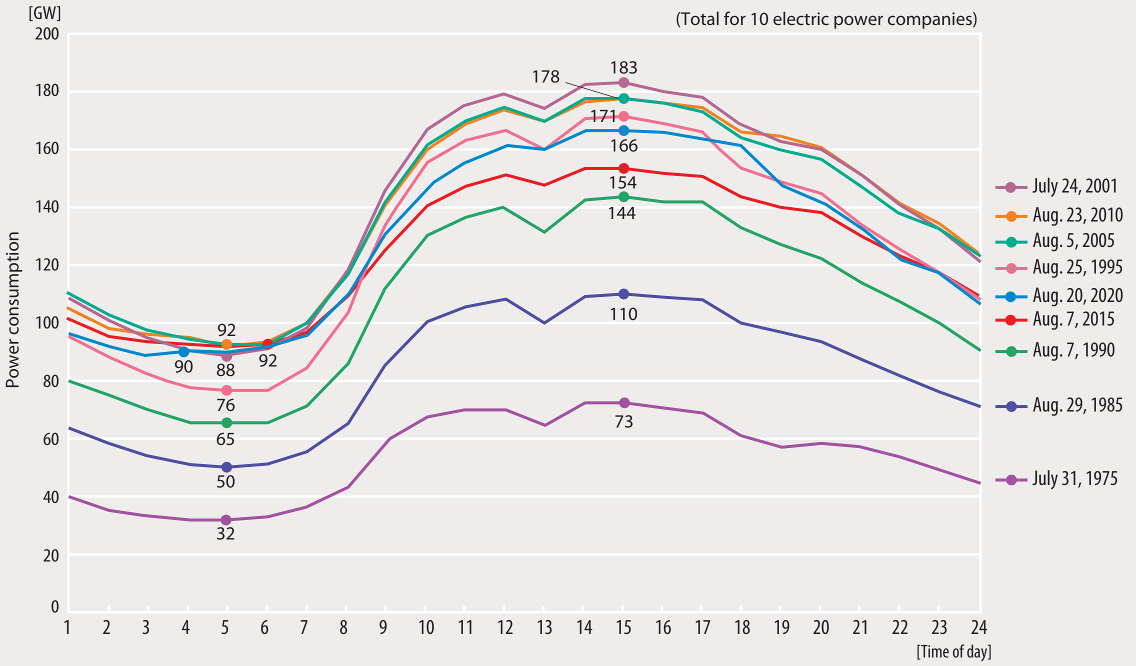


Note 1: Figures for fiscal 1975 and 1985 exclude Okinawa Electric Power Co.
Note 2: Figures are totals for 10 electric power companies through fiscal 2015, and for 10 areas in fiscal 2016.

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

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

Figure 3.4

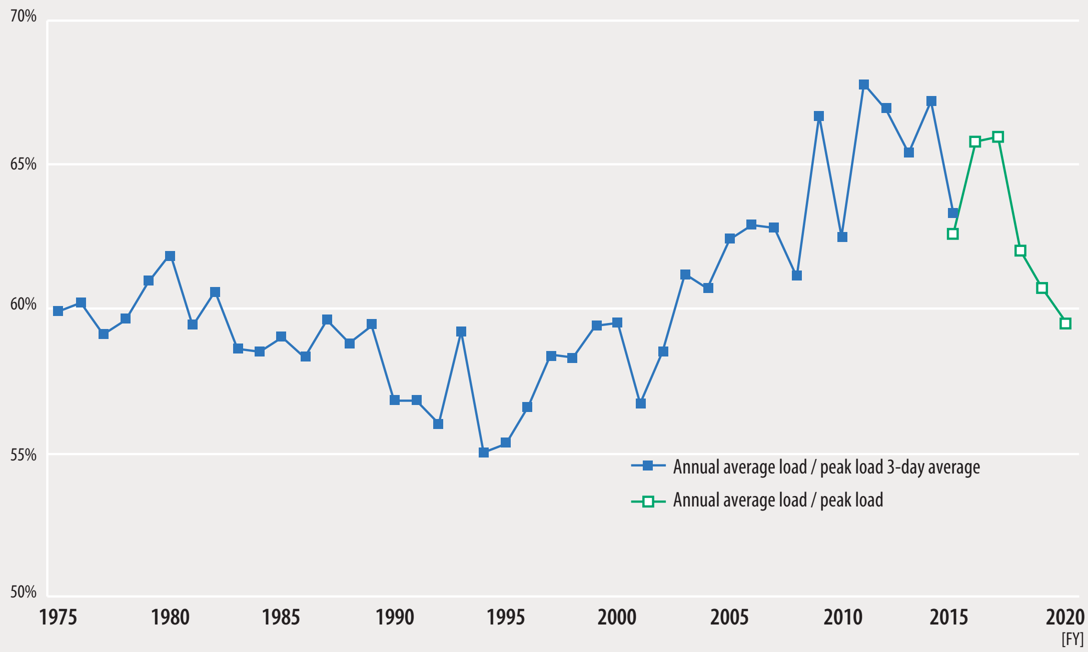


Note: Figures for fiscal 1975 exclude Okinawa Electric Power Co.

Source: Compiled from Japan Atomic Energy Relations Organization, "Graphical Flip-chart of Nuclear & Energy Related Topics" (2022), and OCCTO, Cross-regional Organization System, "Supply/demand-related Information"

Annual Load Factor, FY1975–FY2020

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) conservation, wider adoption of solar power generation, and other measures have curbed daytime grid power demand during the summer, thus shrinking the disparities between the summer and other seasons, and between daytime and nighttime hours during the summer.

Efficiency in the use of generation facilities declines with growing variation in demand, pushing up power supply costs. Nevertheless, while the annual load factor (i.e., the ratio of annual average load to annual peak load, an indicator of the efficiency of use of generation facilities) followed a downward trend up to the mid-1990s, it actually improved to 60%–70% from the mid-2000s. This is thanks in large part to the introduction of electricity rates designed to level loads and nighttime electricity use (see Figure 3.5).

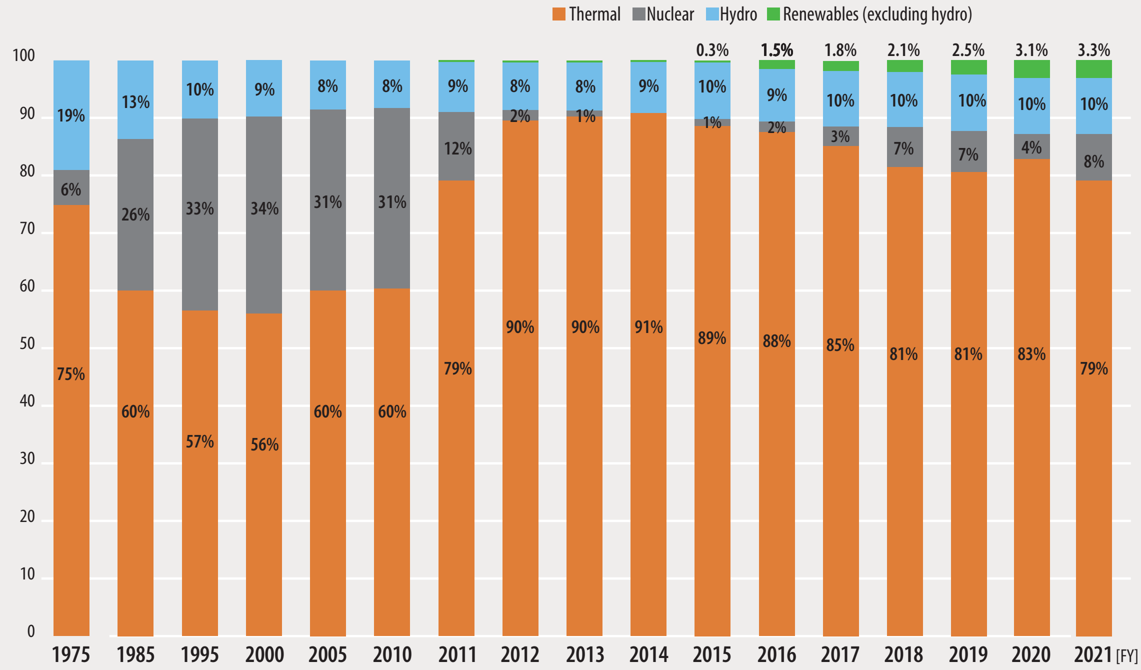
2. Electric Power Generated

Electric power generated[2] came to 863.5 TWh in fiscal 2021 (2.1% increase 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 back online. As a result, nuclear's share of power generated in fiscal 2021 rose to 7.8%.

On the other hand, the construction of renewable energy installations such as wind and solar power plants has increased. In fiscal 2021, 7.4 TWh of electric power was generated by wind power, and 19.0 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.

Power Generation Mix, FY1975–FY2021

Figure 3.6



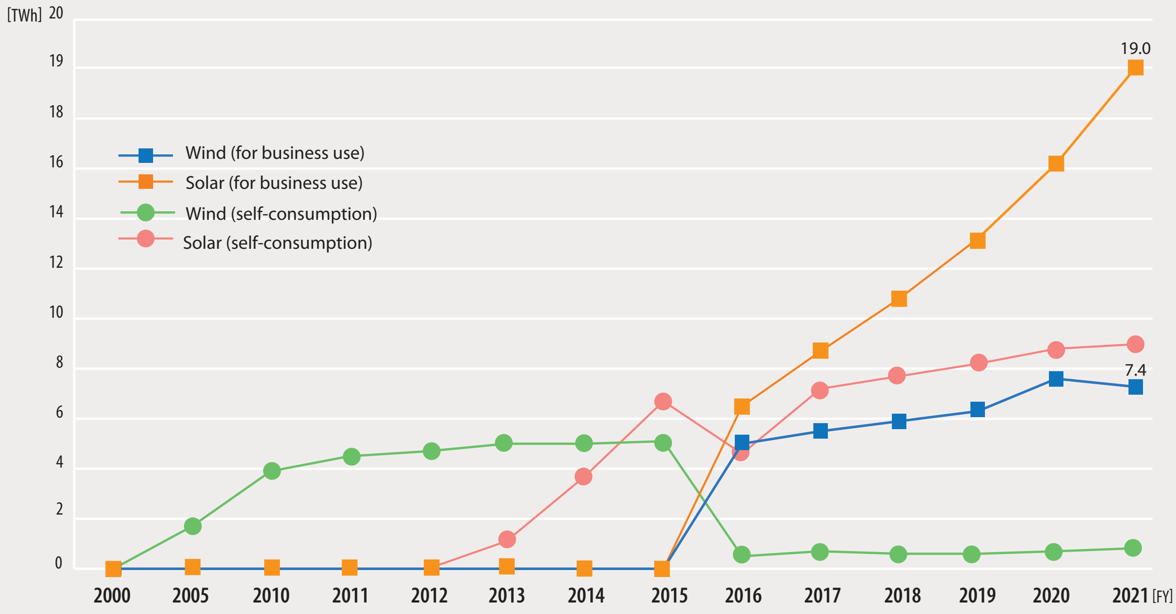
Note: Figures on electric power generated for electric utilities are generation-end figures through fiscal 2015, and transmission-end figures from fiscal 2016.

Source: Compiled from Agency for Natural Resources and Energy, "Handbook of Electric Power Industry" (2021) and "Surveys and Statistics of Electricity" (2022)

2 Electric power generated by electricity utilities.

Trends in Electric Power Generated by Wind and Solar Energy

Figure 3.7



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

Source: Compiled from Agency for Natural Resources and Energy, "Handbook of Electric Power Industry" 2021) and "Surveys and Statistics of Electricity" (2022)

3. Electricity Supply and Demand Balance

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

a. Recent Developments

Eleven years 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 timing planned outages of generation facilities to take place outside periods of peak demand, and ensuring supply capacity by leveraging markets, demand response, and interregional electric power sharing. Notably, demand-side measures include expanding the deployment of demand response and encouraging customers to conserve electricity during shortages 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 in March and an advisory in June.[3] One factor behind the issuance of the warning in March was that electric power facilities had been damaged by an earthquake that occurred off the coast of Fukushima Prefecture earlier that month.

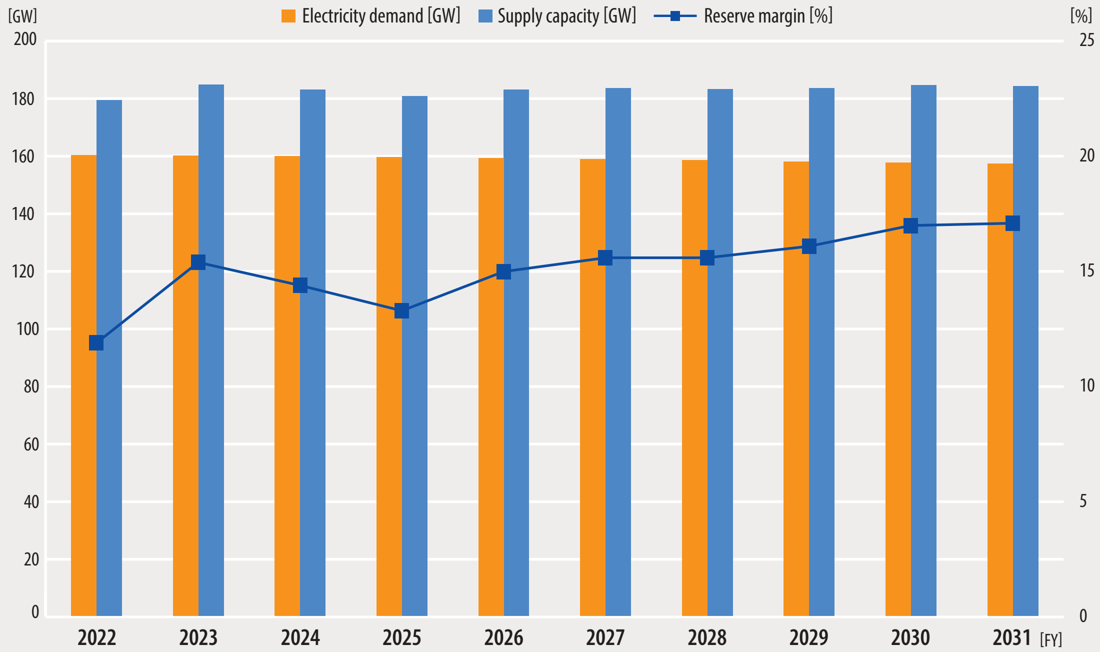
b. Supply and Demand Projections

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

3 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 FY2021[4]" (2022)

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 2021 to fiscal 2030 will be almost 0%, and electricity demand and supply capacity are expected to remain at current levels (see Figure 3.8). However, the Russian invasion of Ukraine has led to growing uncertainty about Japan's access to fuel imports, which, along with other factors, is prompting concern about the potential for supply shortages.

(2) Securing Balancing Capacity

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

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

In fiscal 2021, 10,970 MW of power source I and 129,140 MW of power source II were procured. In addition, 3,640 MW of power source I' was procured, of which 2,300 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.

4 This refers to the supply plans prescribed by Article 29 of the Electricity Business Act. 0

IV. ELECTRIC POWER FACILITIES

1. Power Generation Facilities[1]

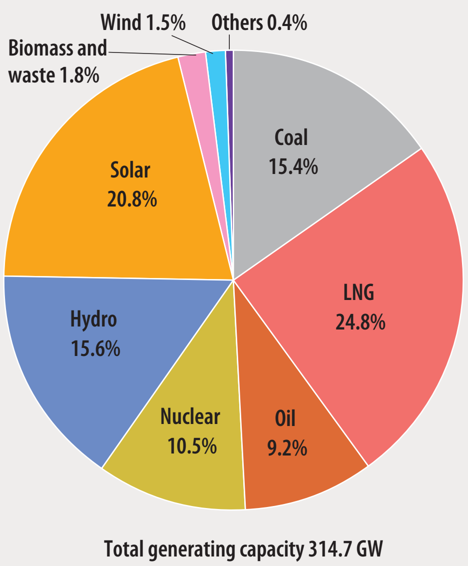
Total generating capacity in Japan was 314.7 GW at the end of fiscal 2021. This consisted of 49.4% thermal power (15.4% coal, 24.8% LNG, and 9.2% oil), 10.5% nuclear power, 15.6% hydro, and 24.2% renewables (excluding hydro). Figure 4.1 shows the breakdown of total generating capacity by power source at the end of fiscal 2021.

(1) Power Generation Facilities for Electric Utilities

a. Thermal Power

The total installed capacity of thermal power plants was 155.3 GW as of the end of fiscal 2021. This accounts for 49.4% 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).

Breakdown of Commercial Power Generation Facilities by Power Source (FY2021) Figure 4.1



Source: OCCTO, "Aggregation of Electricity Supply Plans for FY2022"

Coal-fired generating capacity came to 48.4 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 78.0 GW. LNG-fired power plants produce lower SOx, NOx, and CO_2 emissions than oil- and coal-fired plants. Construction of large LNG-fired power plants employing high-efficiency combined-cycle technologies is underway to further reduce emissions of these substances. A new plant[2] added to the grid in 2018 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 28.9 GW. Oil plays a measurable role in power supply during peak demand and balancing but accounted for just 2.4% of all power generated in fiscal 2021, representing a considerably smaller contribution versus other thermal power generation methods (coal, 32.7%; LNG, 37.0%).

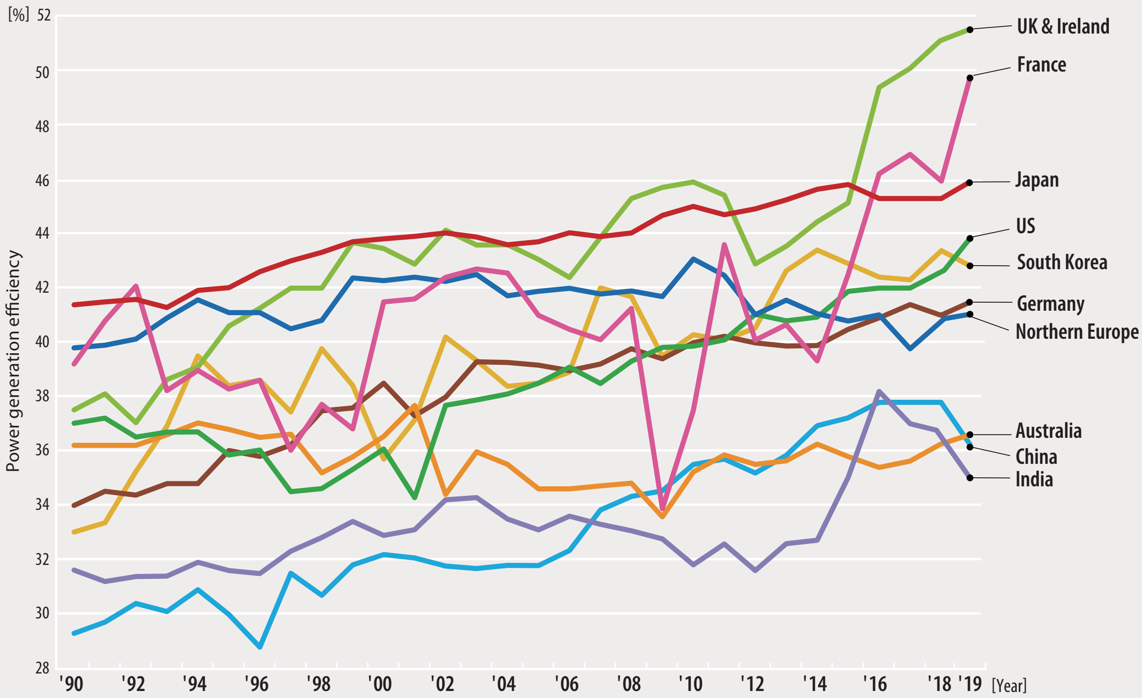
b. Hydro Power

Hydro power generating capacity stood at 49.2 GW at the end of fiscal 2021. 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 27.5 GW. Variable speed pumped storage systems

1 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).

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

Figure 4.2

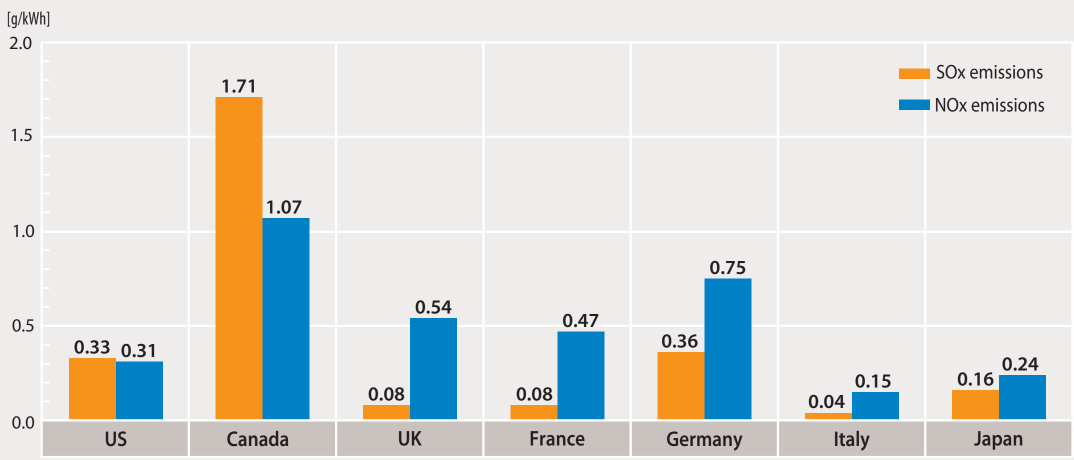


Note: 1. Power generation efficiency is generation-end weighted average of power generation efficiencies of coal, oil, and gas (low heating value basis).
2. Covers facilities of electricity generation utilities whose main business is selling electricity to third parties.
3. Figures for Japan are for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

Source: FEPC, "INFOBASE 2021" (2021)

Comparison of SOx and NOx Emissions per Unit of Power Generated at Thermal Power Plants of Major Countries (2019)

Figure 4.3



Source: FEPC, "INFOBASE 2021" (2021)

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

A large-scale storage battery (a redox flow battery) (Hokkaido Electic 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

Joetsu Thermal Power Station (Joetsu City, Niigata) (Tohoku Electric Power Co.)

Abekawa Hydroelectric Power Station (Chubu Electric Power Co.)
Official name: Abekawa Hydroelectric Power Station / COD: December 2024 (scheduled) / Owner: Chubu Electric Power Company

Taketoyo Thermal Power Station (JERA Co., Inc.)
COD: August 2022* unit5 / Owner: JERA
Taketoyo Thermal Power Station Unit 5 is a high-efficiency coal-fired power station that uses an ultra-supercritical (USC) power generation system, and it contributes to the stability of the electricity supply. By co-firing woody biomass fuel, it reduces CO_2 emissions as much as possible to mitigate environmental impact.

have also been adopted for a portion of pumped storage power generation. These systems provide a means of addressing fluctuations in output from variable renewable energy as they are able to control their input power flexibly during pump operation.

c. Renewable Energy

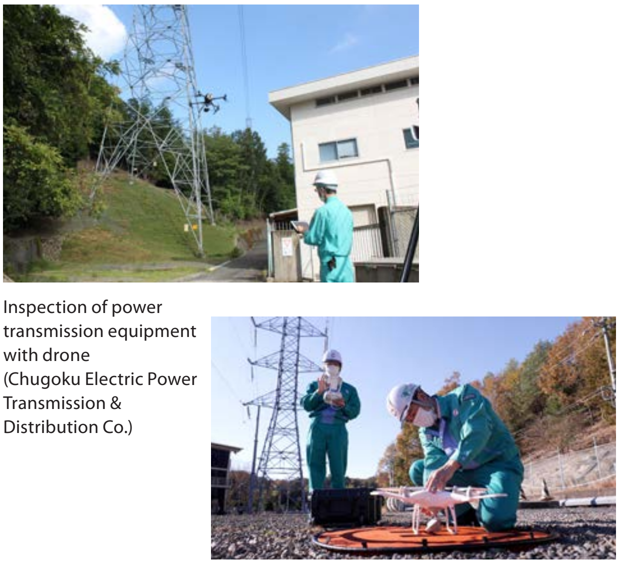
• Solar

Installed solar power generating capacity at the end of fiscal 2021 was 65.4 GW. The deployment of renewable energies, mainly solar power, has been progressing in Japan. Solar power makes up approximately 86.0% of total FIT-certified renewable power generating capacity. As a result, decrease in net demand[3] 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 has been curtailed in Tohoku, Chugoku, Shikoku, and Kyushu (including its remote islands) since 2018. Resolution of this fluctuating output challenge is a critical task for advancing the further deployment of solar power.

• Wind

Wind power generating capacity was 4.7 GW as of the end of fiscal 2021. 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

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



Inspection of power transmission equipment with drone
(Chugoku Electric Power Transmission & Distribution Co.)

Sakuma Frequency Converter Station (Electric Power Development Co., Ltd. (J-POWER))
COD: 1965 / Owner: J-POWER Transmission Network Co.,Ltd. / Transmission Network / Capacity: 300MW

Thyristor Valve in the New East-West HVDC interconnection at the Shin-Shinano substation (2021)
(Tokyo Electric Power Company Holdings, Inc.)

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

impacts and constraints on grid capacity. The majority of installed wind power generation facilities are onshore, and only around 50 MW of capacity is offshore. However, the FIT-certified capacity of offshore wind installations has trended upward, reaching 668 MW at the end of fiscal 2021.

• Biomass and waste

Biomass and waste generating capacity at the end of fiscal 2021 came to 4.8 GW. In Japan, this form of power generation has centered upon municipal waste incineration and the direct combustion of black liquor from papermaking and wood waste from lumber production. Biomass and waste power, low environmental load type thermal power is a renewable that, unlike variable renewable energy (solar and wind), can stably generate power with minimal fluctuation. This means that it can be used to reliably generate electricity in the wake of disasters, and thus is being increasingly introduced as a power source that can help to strengthen disaster resilience, even when compared with other renewables.

d. Nuclear Power Generation

Total nuclear power generating capacity at the end of fiscal 2021 was 33.1 GW (33 units, excluding 3 under construction and 24 scheduled for decommissioning). Ten nuclear reactors (all PWRs) have resumed operation as of September 2022 (see "Nuclear Power Generation" in Section 2, Chapter II).

(2) Future Plans

a. Transition of Power Generating Capacity and Power Development Plans

In March 2022, OCCTO published the "Aggregation of Electricity Supply Plans for FY2022."[4] Figure 4.4 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 2031 (new installation, uprating/derating, and retirement plans).[5]

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. While renewable generating capacity will increase driven by construction of new solar power plants and wind farms, hydro power generating capacity will increase only marginally.

b. Actions toward Achieving Carbon Neutrality in 2050

The Sixth Strategic Energy Plan (see "1. Strategic Energy Plan" in Chapter II) 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 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. 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 a "Strategic Roadmap for Hydrogen and Fuel Cells" in March 2019. Among other goals, this plan aims to commercialize hydrogen power generation by around 2030, and calls for efforts to establish the technologies needed and to reduce the production cost of hydrogen. It also seeks to make hydrogen power generation as cost competitive as existing LNG-fired power generation, including with regard to environmental value.[6]

• 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.

• Storage Batteries

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

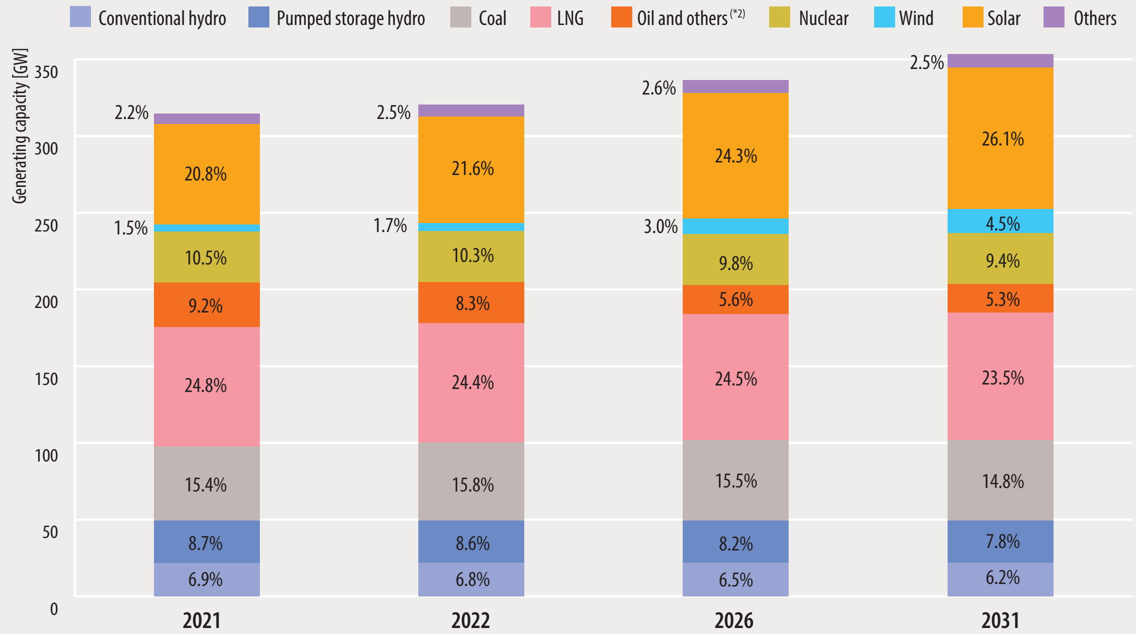
The use of battery storage systems is rising. A cumulative total of over 620,000 stationary lithium-ion battery storage systems with a capacity in excess of 4.4 GWh were in use in fiscal 2021 (see Figure 4.5). Meanwhile, METI is conducting experimental projects using battery storage systems. Themes selected 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

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

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

Trends in Generating Capacity by Power Source, 2021–2031 (*1)

Figure 4.4



*1 Generating capacity is the sum of the values submitted by electricity utilities.
*2 "Oil and others" includes the total installed capacities from oil, LPG, and other gas and bituminous mixture fired capacities.

Source: OCCTO, "Aggregation of Electricity Supply Plans for FY2022"

Power Development Plans up to FY 2031 by Stages

Table 4.1

[Output: MW]

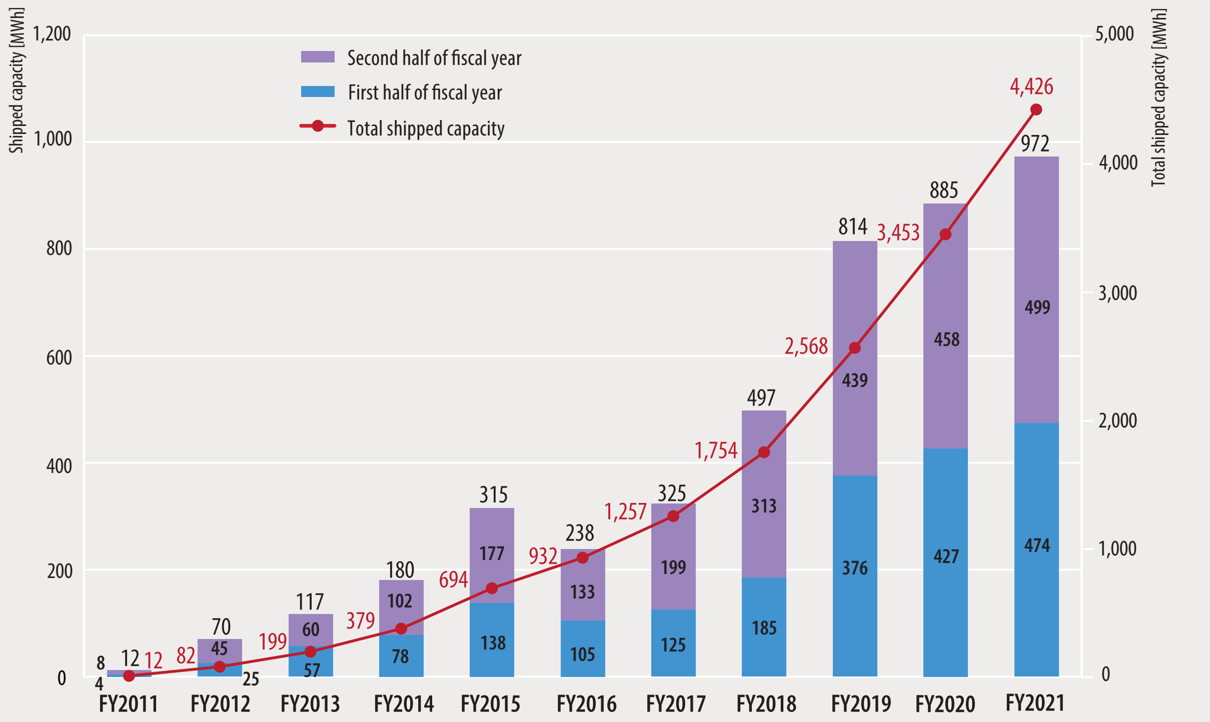
Power source		New installation plan		Updating/derating plan		Retirement plan		Total
		Output	Sites	Output	Sites	Output	Sites	Output
Hydro		**446**	**68**	**60**	**43**	**-193**	**35**	**313**
	Conventional	446	68	60	43	-193	35	313
	Pumped storage	–	–	–	–	–	–	–
Thermal		**11,995**	**28**	**7**	**1**	**-11,729**	**37**	**273**
	Coal	4,820	7	–	–	-288	2	4,532
	LNG	7,149	15	7	1	-2,168	6	4,988
	Oil	26	6	–	–	-9,273	29	-9,247
Nuclear		**10,180**	**7**	**152**	**1**	**0**	**0**	**10,332**
Renewables		**10,458**	**376**	**-6**	**2**	**-810**	**64**	**9,642**
	Wind	3,636	89	–	–	-650	52	2,986
	Solar	5,102	241	–	–	-2	1	5,100
	Geothermal	75	5	–	–	-50	1	25
	Biomass	1,583	37	–	–	-48	3	1,535
	Waste	62	4	-6	2	-63	7	-7
Total		**33,078**	**479**	**213**	**47**	**-12,734**	**136**	**20,561**

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, FY2022"

6 The plan aims to reduce the cost of hydrogen delivered from plants to 30 yen/Nm³ in around 2030 and to 20 yen/Nm³ thereafter.
7 The Sixth Strategic Energy Plan sets a target of 36%–38% for renewables' contribution to the power generation mix in 2030.

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



Source: Compiled from the Japan Electrical Manufacturers' Association, "Self-reported Statistics on Stationary Lithium-Ion Storage Battery Systems" (FY2021).

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.

(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 Okinawa Electric Power Co. (132 kV). As of the end of March 2022, these transmission lines had a circuit length of 179,922 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

Transmission and Distribution Facilities

Table 4.2

	1975	1985	1995	2005	2015	2017	2018	2019	2020	2021
Circuit length of transmission lines [km]										
220kV or above	14,167	23,486	29,107	35,209	36,949	36,865	36,986	37,021	37,216	37,205
110kV Under 220kV	28,913	35,106	36,952	35,962	35,588	35,459	35,390	35,441	35,457	35,431
Under 110kV	69,361	78,660	88,648	95,176	106,167	106,341	106,494	106,784	107,058	107,286
Total	112,441	137,252	154,707	166,347	178,704	178,665	178,870	179,246	179,731	179,922
Transformation facility capacities										
Substation output capacity (MVA)	234,748	447,866	657,536	778,740	833,112	843,886	846,638	850,313	868,556	872,552
Total Number of substations	3,466	5,152	5,814	6,570	6,718	6,774	6,783	6,786	7,137	7,125
Circuit length of distribution lines [km]										
Overhead	2,623,787	3,179,970	3,661,963	3,918,743	4,005,974	4,023,882	4,031,278	4,038,426	4,046,028	4,052,015
Underground	14,358	25,348	50,371	65,287	70,733	72,096	72,735	73,420	73,995	74,494
Total	2,638,145	3,205,318	3,712,334	3,984,030	4,076,707	4,095,978	4,104,013	4,111,846	4,120,023	4,126,509

Source: FEPC, "Electricity Statistics Information"

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 2022, Japan's ten general electricity transmission and distribution utilities had 7,125 substations with a total installed capacity of 872,552 MVA (Table 4.2). Almost all substations are now unmanned, with remote monitoring and control.

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

(3) Distribution Facilities

Distribution lines are classified into extra-high voltage lines (33/22 kV), high voltage lines (6kV), and low voltage lines (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 2022, the total length of distribution lines in Japan was 4,126,509 km. Of this, 74,494 km (approximately 1.8%) consisted of underground lines (Table 4.2).

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

Smart meters for 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.

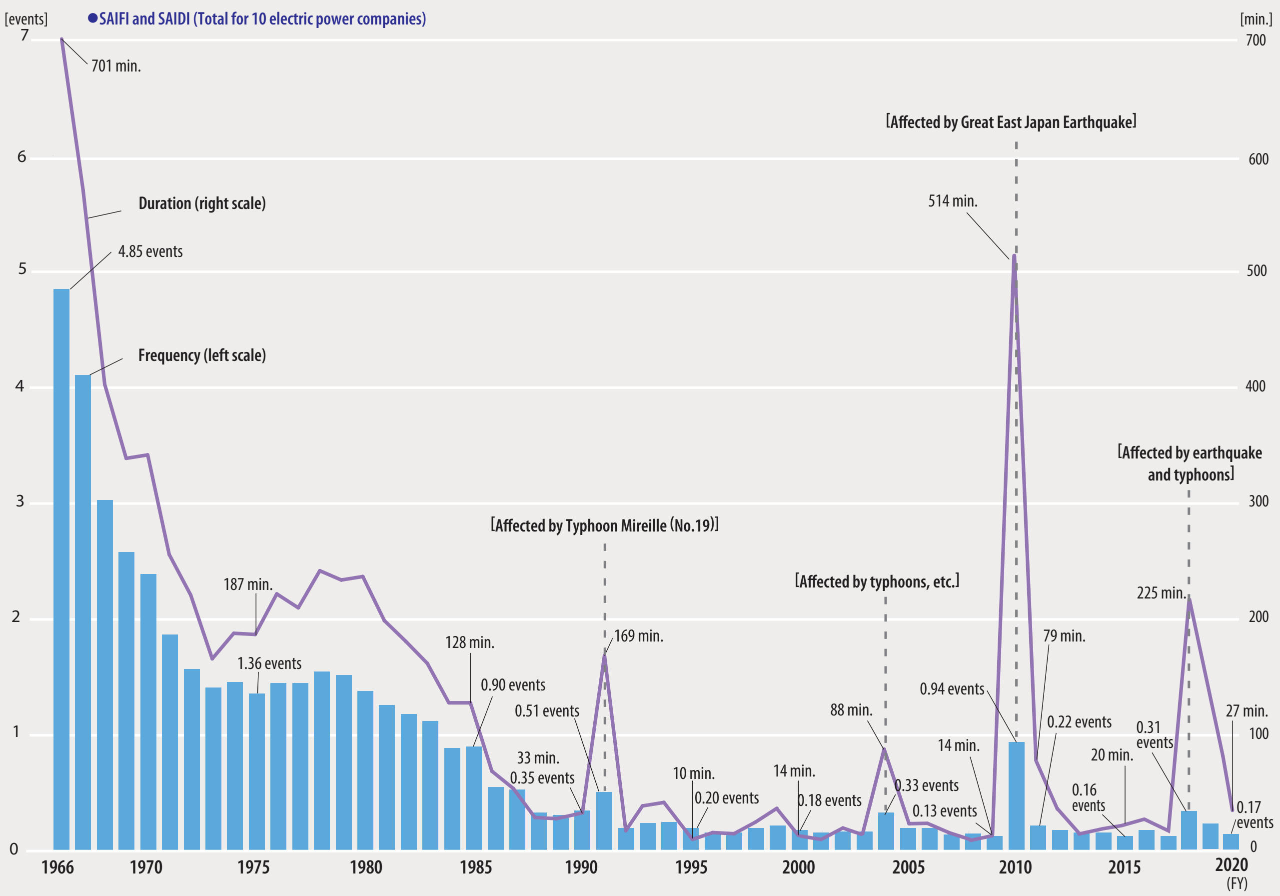
(4) Supply Reliability (SAIDI, SAIFI)

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 4.6).

In fiscal 2020, the System Average Interruption Frequency Index (SAIFI) was 0.17 interruptions and the System Average Interruption Duration Index (SAIDI) was 27 minutes (see Figure 4.6). The national averages were lower than in fiscal 2019 despite power outages that occurred in Kyushu, Chugoku, and Shikoku due to Typhoon Haishen (No. 10) in September 2020 (approx. 530,000 households were without power at the peak, and service was completely restored 60 hours after the peak).

SAIFI and SAIDI Trends

Figure 4.6



Note: 9 electric power companies up to FY1988

Source: FEPC, "INFOBASE 2021" (2021)

Removing snow from power lines (Hokkaido Electric Power Network)

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

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

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

3. Cross-Regional Operation and Interregional Interconnections

(1) Cross-Regional Operation

The Japanese power grid is divided into two frequency systems: a 50 Hz system in eastern Japan and a 60 Hz system in western Japan[8]. The neighboring grids of nine of the general electricity transmission and distribution utilities' service areas are connected to one another (Okinawa area is the exception). Japan has no international interconnections.

The former general electricity utilities have worked with each other interregionally in order to improve economic efficiency and ensure a stable power supply by developing optimal power sources, conducting capital investment, and exchanging power so as to benefit from differences in their regional characteristics and demand structures. Today, OCCTO nationally monitors conditions such as the supply/demand situation and grid operational status, and instructs the utilities to interregionally exchange electricity when the supply/demand situation deteriorates. It is also reviewing the ways that the interconnections are used.

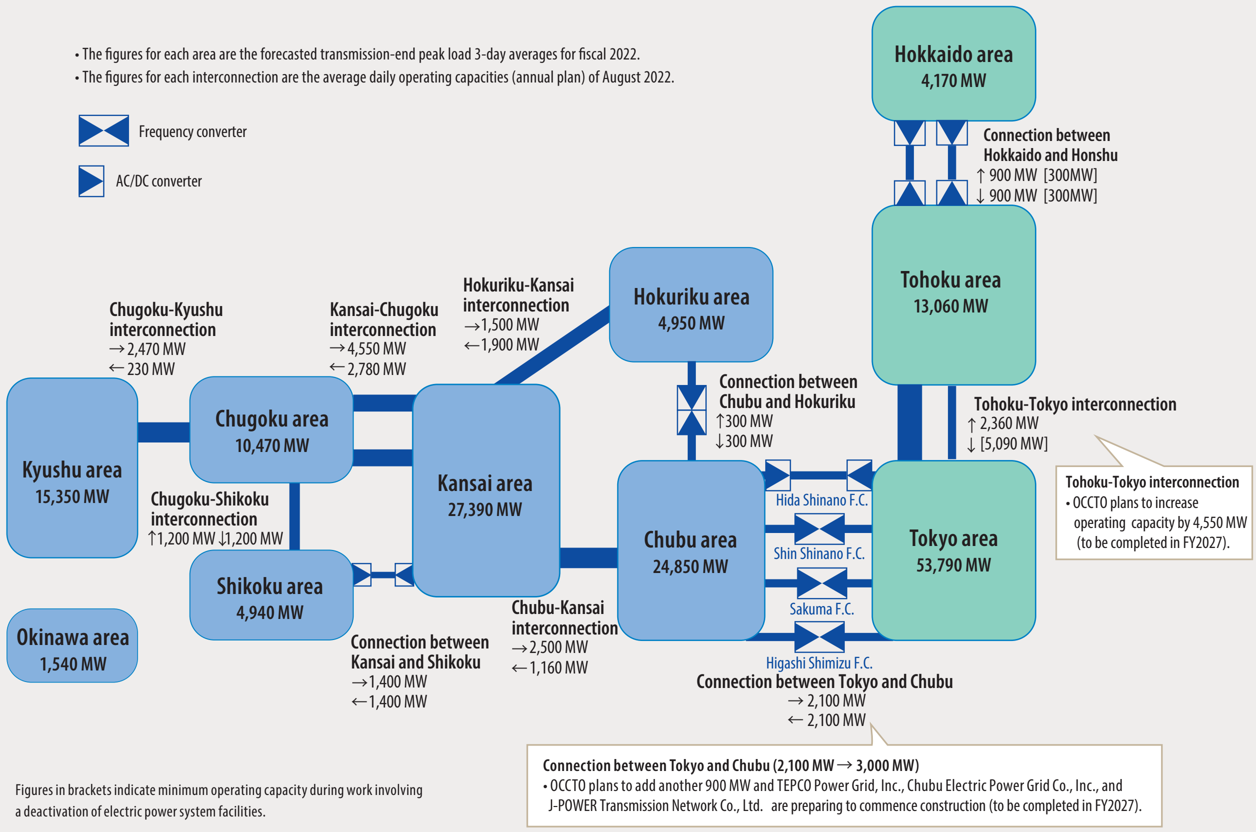
Traditionally, electricity generation utilities have been allowed to use these interconnections on a first-come, first-served basis. However, this model was abandoned in October 2018, and an implicit-auction approach was introduced under which, in principle, use of the interconnections will be assigned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

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.

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

National Grid Connections

Figure 4.7



Source: Compiled by the authors from Agency for Natural Resources and Energy, "Detailed Design for Constructing a Sustainable Electric Power System" (2020), and OCCTO, "Grid Operating Capacity in FY2021–2030 (Annual & Long-term)" (2022)

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 2022, 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 4.7).

Along with the increasing large-scale adoption of distributed energy sources in recent years, OCCTO has been considering plans to enhance these interconnections, taking into account the individual utilities' views. As part of those plans, the Sakuma and Higashi-Shimizu frequency converters' capacity will be expanded by a total of 900 MW by the end of fiscal 2027 (from 2.1 GW to 3.0 GW in total). Responding to calls from IPPs and others, OCCTO plans to increase the capacity of the Tokyo-Tohoku interconnection by 4.6 GW by fiscal 2027.

(3) Medium- and Long-range Grid Improvements

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

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

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

In the area of grid strengthening, OCCTO is working out a master plan to be issued in March 2023 as a cross-regional network development framework for systematic implementation of facility expansions to interregional interconnections and main grids. Under the master plan, the transition to systematic development of the power transmission network will involve a shift from a "pull" approach, where planning is done in response to requests from the power sources as they are made, to a "push" approach in which systematic development is carried out based on the master plan, with consideration given to the potential of each power source.

Premised on this, OCCTO has developed an approach to transmission and distribution facility development that tailors the "connect and manage"[9] model already used in the United Kingdom and elsewhere to Japanese conditions. It employs the following three mechanisms.

a. 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.

b. 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.[10] 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.

c. Non-firm access

This is a method of allowing fresh access on condition that output is limited while other power sources are in operation.[11] This has already been put into practice since January 2021 for main grids without available capacity, and for local grids and distribution grids connecting to the main grid. In April 2022, it started being applied, regardless of capacity availability on the other end of the interconnection, to power sources with main grid-class receiving voltage that have undergone an interconnection study.

9 This is a model for answering the interconnection needs of new power sources, while improving the efficiency of transmission and distribution facilities through maximum utilization of existing facilities.
10 A single fault affecting one transmission or distribution line, one transformer, one generator, or one other item of electrical equipment.
11 Since this approach does not require expansion of main grid facilities, 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 2022, 46.99 million low voltage customers (68% of the total) paid regulated rates.

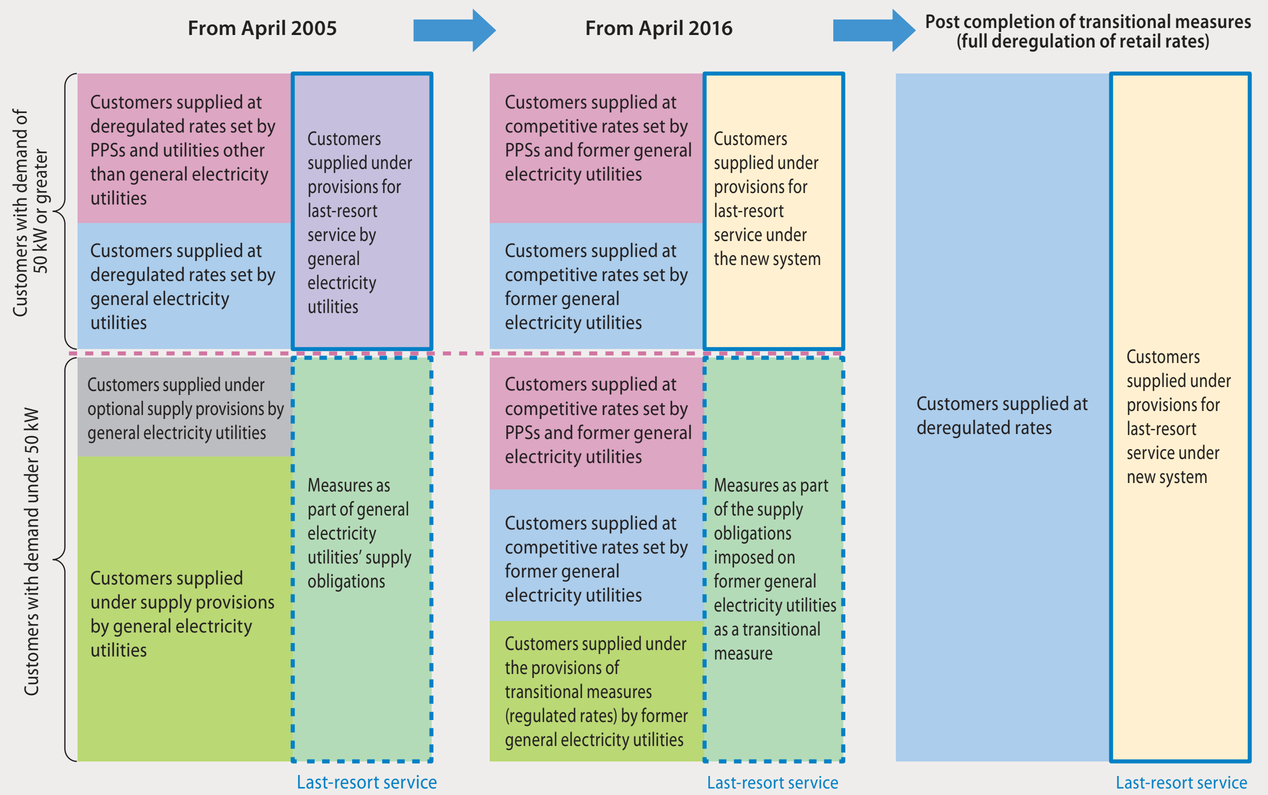
Regulated rates were originally to be discontinued at the end of March 2020. However, as competition had not developed sufficiently, METI decided in July 2019 to maintain regulated rates from April 2020 onwards. Discontinuation of regulated rates will continue to be considered, while paying close attention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

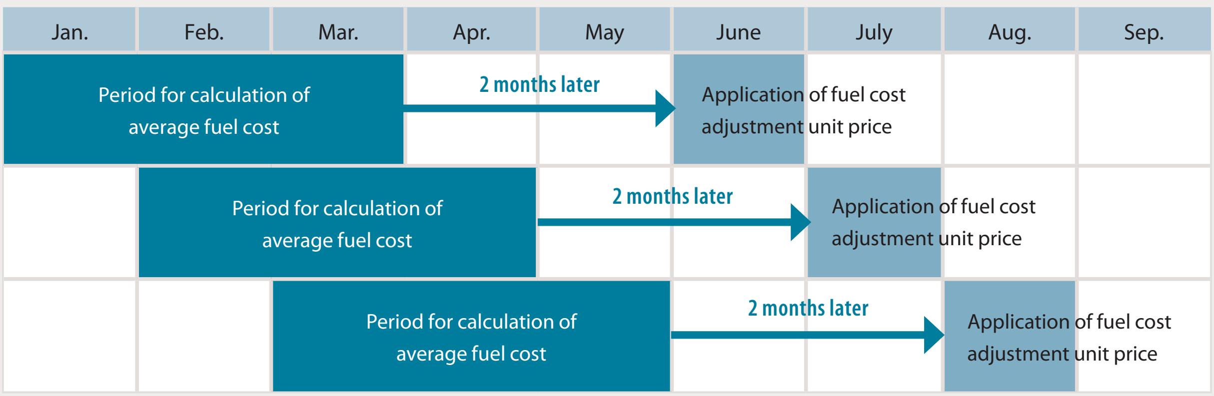
At present, the period (time gap) before fuel price fluctuations is reflected in electricity prices is set to two months in order to level rate fluctuations, and fuel price three-month averages are reflected in the electricity rates charged each month (see Figure 5.2). Also, as a measure for reducing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

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

Figure 5.2



Source: Compiled from FEPC materials

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.

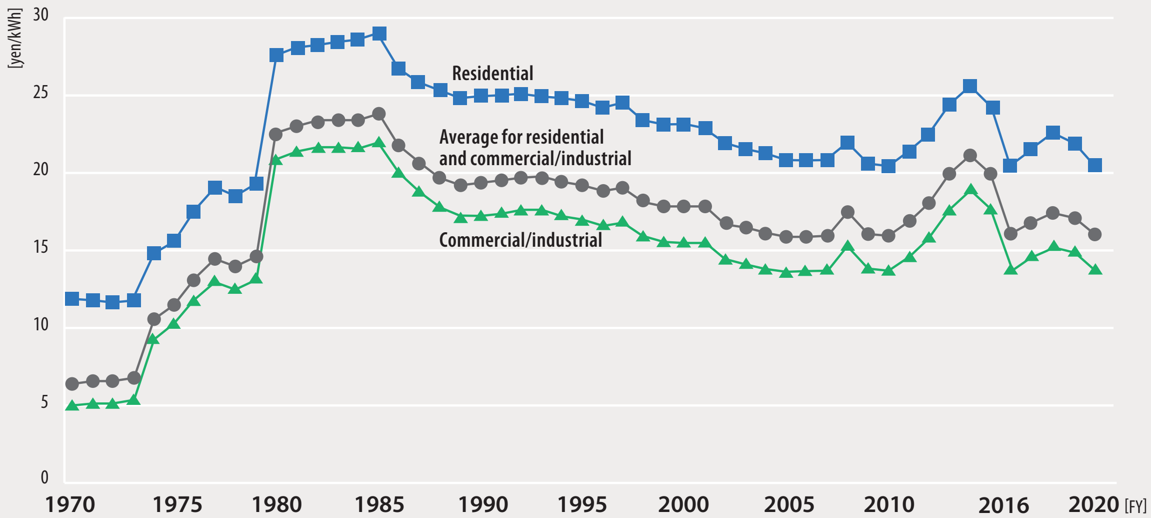
(4) Wheeling Charges

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. The wheeling charges are deliberated by a review meeting of specialists on electricity pricing under the auspices of the Electricity and Gas Market Surveillance Commission, taking into account both the appropriate recovery of requisite costs and fairness for network users. They are then opened to public comment prior to final adoption.

Since April 2016, general electricity transmission and distribution utilities have been required to provide electricity

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

Currently, revisions to the wheeling charge system are being developed for implementation around fiscal 2023. The discussions include detailed design of a new scheme that would set revenue caps at certain intervals on general electricity transmission and distribution utilities based on their investment plans and other considerations, with the aim of encouraging them to make the operational efficiency improvements needed to keep their business sustainable under the revenue caps. The purpose of the scheme is to help general electricity transmission and distribution utilities make the necessary investments while also achieving cost efficiencies, and in doing so advance the growth of renewables into the main energy source and strengthen resilience.

(5) Fee on the Power Generation Side

Under the current system, the expenses associated with 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. Fourteen PPSs filed for bankruptcy in fiscal 2021, the largest number to date for a single year. Of the roughly 700 PPSs operating as of April 2021, 31 (approx. 4%) became insolvent, closed down, or left the market during the past year. 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 13,000 as of May 20. Also, Chubu Electric Power Company appears headed toward a rate hike for household service in October 2022, and it is likely that the rates of all former general electricity utilities will reach the cap set by the fuel-cost adjustment scheme.

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 have become cheaper than unregulated rate plans as utilities have sought to counter the sharp rise in fuel prices by reflecting power procurement costs in the unregulated rates. As a result, customers have been shifting to the lower final guaranteed supply rates. In response, METI has 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 will be put into effect by the general electricity transmission and distribution utilities in September 2022.

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 738 retailers as of July 2022.

As of March 2022, PPSs accounted for a roughly 21.3% share of the total volume of electricity sold. Of that share, approximately 23.4% 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 2.6% 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.

a. Rate Plans Tailored to Lifestyles

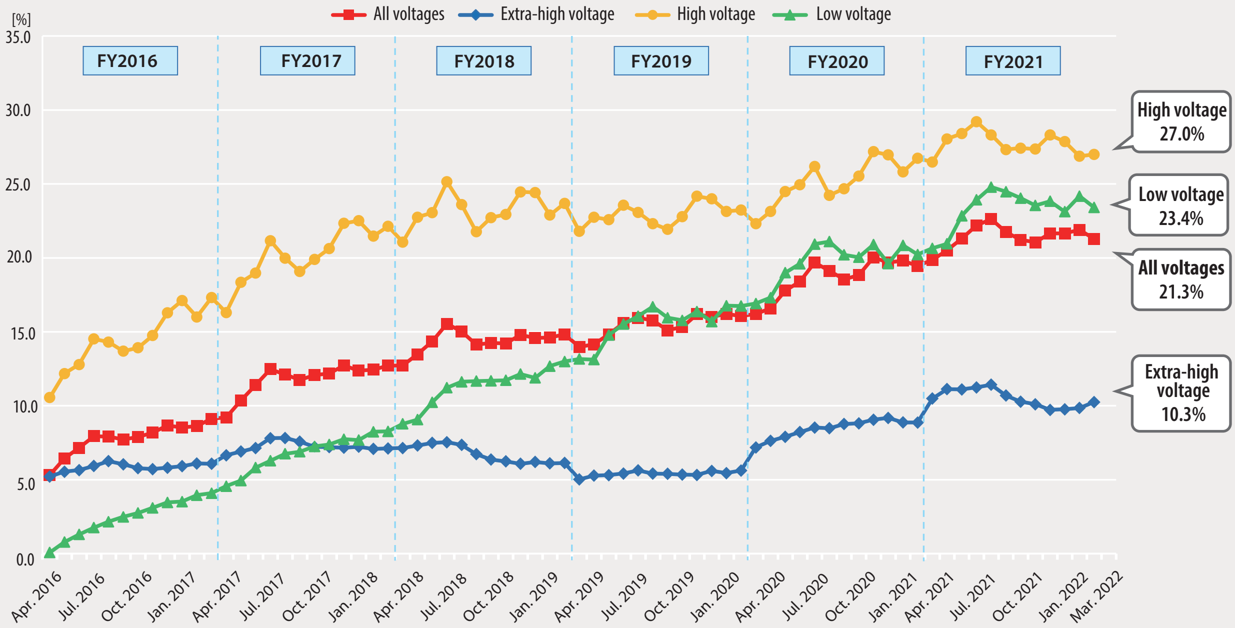
Electricity retailers are offering time-of-use rate plans for customers who tend to be out during the day and consume most of their electricity at night, as well as for customers who use storage heaters and/or water heaters overnight and during off-peak hours. Such plans offer lower unit rates for nighttime 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,

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" 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, 2022, there were 259 trading members.

JEPX currently provides a marketplace for the following electricity transactions:

- Spot market: Trading in 30-minute increments of electricity for next-day delivery.
- Forward market: Trading in electricity for delivery over the course of a specified future period. Products are created by packaging together specific periods and times, such as monthly 24-hour products or weekly daytime products.
- Intra-day market: A market for correcting unexpected misalignments between supply and demand occurring between a spot market transaction and delivery (a minimum of one hour later).
- Bulletin board trading market: JEPX mediates the trading of electricity for prospective buyers and sellers.

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

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

The volume of trades on the spot market has been on the rise since 2016, reaching approximately 327.2 TWh in fiscal 2021. This means that more than 30% of all electricity sold in Japan is sold through the spot market. PPSs procure more than 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 an earthquake that occurred off the shore of Fukushima Prefecture. As of July 9, 2022, it stood at 19.62 yen/kWh, and is continuing to trend upward (see Figure 5.5).

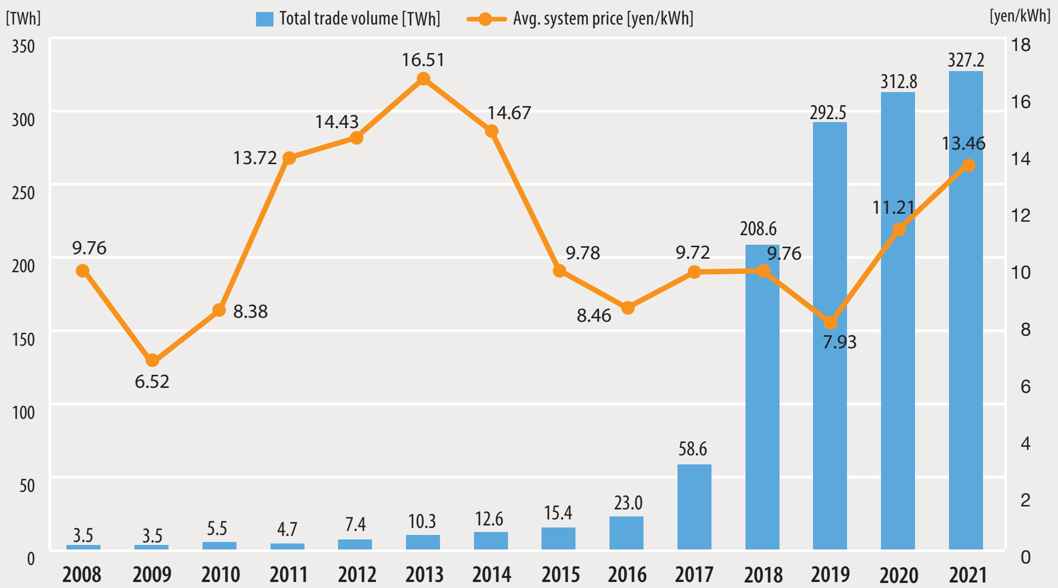
Amid the steep rise in prices, some electric power companies and other operators have started to cut back on add-on purchases from the spot market by leveraging demand response to make efficient use of electricity. Due to fuel procurement risks, supply shortages are expected to occur throughout fiscal 2022. 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) New Markets

New markets have been developed to secure stable power supply, achieve the sustainable, efficient, and equitable supply of electricity, and actualize environmental value, among other goals. The intention is that the creation of these unconventional new markets will serve to actualize and render tradable new forms of value to accompany the lowered entry/exit barriers in existing markets. The new markets are mainly the following: (a) a baseload power market, (b) a capacity market, (c) a balancing market, and (d) a non-fossil value trading market. In addition, trading has begun in the electricity futures market.

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” (2021), and JEPX data

a. Baseload Power Market

New market entrants find it difficult to own or enter contracts to buy electricity from baseload power sources such as coal, large hydropower, and nuclear power plants, due to the tendency for the scale of development to grow, and the large number of bilateral contracts between large-scale 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. Trading in this market is done at an annually fixed price. Four auctions for delivery in fiscal 2022 were conducted, for a total volume of 748.1 MW, with clearing prices ranging from 9.47 to 15.69 yen/kWh. The amount of buy bids has been trending upward versus previous fiscal years. Meanwhile, due to fragmentation of the market, gaps have occurred in some areas between the clearing price and the settlement price of the electricity contracted, and the authorities are now considering making changes to the system to counter this.

b. Capacity Market

The predictability of the payback on investment in power generation business is likely to decline, depending on the increasing competition and changes in environmental trends. If the adoption of renewables expands simultaneously, it is expected that the power generation operating rate will decline, the selling price of electricity will fall, and revenues from selling electricity from all sources will come down. Conversely, regulatory organizations have been concerned that if investments in power generation capacity are not made at the appropriate time, there could be more situations in which the supply and demand balance becomes too tight, and electricity balancing capacity cannot be secured. Therefore, a capacity market was established in 2020 for the purpose of (1) ensuring a greater degree of investment predictability, (2) the replacement of old power plants with new ones and (3) the securing of supply capacity (installed capacity) through market mechanisms.

The capacity market is operated by OCCTO. Auctions are conducted for securing capacity four years in advance. Capacity traded in 2020 for delivery in fiscal 2024 amounted to 167.6 GW in volume, and had a clearing price of 14,137 yen/kW, which exceeded the index price. This prompted a drastic overhaul of the pricing method for capacity auctioned in 2021 for delivery in 2025, with the auction resulting in a total volume of 165.3 GW traded and market fragmentation of the clearing price: 5,242 yen/kW in the Hokkaido area and the Kyushu area, and 3,495 yen/kW in other areas, with all prices falling from the preceding fiscal year. The 2022 auction will be held in November, and the results will be announced in January 2023.

Special auctions are sometimes held in the capacity market as a means of implementing policy measures, among other purposes. A special auction in the form of a long-term decarbonization auction will be held in 2023 so that power generation utilities can secure multiyear capacity revenues that make it easier for them to visualize long-term returns on initial investments in new facilities that contribute to achievement of both the 2050 carbon neutrality goal and stable supply.

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 for procuring and operating balancing supply and demand more efficiently on a cross-regional basis was studied. Market trading began in April 2021 for Replacement Reserve for FIT (balancing capacity with a response time under 45 minutes that balances errors in renewable energy predictions and operates continuously for three hours), and in April 2022 for Replacement Reserve (balancing capacity with a response time under 15 minutes that corrects supply/demand imbalances resulting from errors in renewable energy predictions or unexpected losses of power sources, and operates continuously for three hours). Trading is scheduled to begin in fiscal 2024 for Frequency Restoration Reserve (balancing capacity with a response time under 5 minutes that balances normal-time prediction errors and operates continuously for at least 30 minutes), Synchronized

Frequency Restoration Reserve (balancing capacity with a response time under 5 minutes that responds to normal-time fluctuations within the time period or losses of power sources, and operates continuously for at least 30 minutes), and Frequency Containment Reserve (balancing capacity with a response time under 10 seconds that responds to normal-time fluctuations within the time period or losses of power sources, and operates continuously for at least 5 minutes).

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. 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), and a market for achieving the target[1] mandated by the Sophisticated Methods Act regarding the non-fossil share of the power generation mix (dealing in non-FIT renewable energy certificates). 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 most recent round (May 2022), the clearing price (weighted average price) was 0.3 yen/kWh in the renewable energy value trading market and 0.6 yen/kWh in the market for achieving the Act-mandated target.

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 2022, the market's trading volume is small in comparison with JEPX, and improvements are being studied, including with regard to future challenges.

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

TOPICS:
Electric Power Company Projects for Promoting Hydrogen

Hydrogen is expected to become an indispensable energy source for the realization of a carbon-neutral society. As part of the Sixth Strategic Energy Plan, approved by the Cabinet in October 2021, the Japanese government is calling on the electric power sector to utilize hydrogen and ammonia, both of which do not emit carbon dioxide when combusted. Electric power companies are stepping up their efforts in this area by pursuing the use of hydrogen as a fuel and building up a hydrogen supply chain, with an eye on achieving full-scale real-world deployment in the future.

1. Utilization of Hydrogen as Fuel

(1) Tohoku Electric Power Company

Tohoku Electric Power Co. Inc. (Tohoku EPCo) is taking part in a project in Fukushima Prefecture for developing technologies for practical hydrogen-based energy storage and use. Other project members include Tohoku Electric Power Network Co., Inc., Toshiba Energy Systems & Solutions Corporation, Iwatani Corporation, and Asahi Kasei Corporation.

The project is currently in the demonstration phase, which will run until the end of February 2023. Work is underway to establish technologies enabling practical hydrogen-based power-to-gas (P2G) energy storage and use. Specifically, the project aims to further evolve control systems (hydrogen energy management, power grid control, and hydrogen supply/demand forecasting systems) and water electrolysis technology.

The site is Fukushima Hydrogen Energy Research Field (FH2R), opened by Tohoku EPCo in March 2020. Here, a hydrogen production unit in the 10-MW-class (the world's largest class) is being used to establish green, low-cost hydrogen production technology that balances grid supply and demand to make maximum use of highly fluctuating output from renewable energy without using storage batteries.

The project is largely driven by the need for a way to minimize output control while the use of renewable energy is expanded. P2G, as a technology that realizes the large-scale, long-term storage, can serve this need. However, in order to efficiently promote hydrogen-based energy storage and use, technologies must be established for not only a grid supply/demand balancing function that fully utilizes the highly fluctuating output from renewable energy (demand response), but also a function for optimal system control through hydrogen supply/demand forecasting.

In their R&D for evolving the various control systems, the project members are seeking to improve functionality for realizing the use of hydrogen energy systems as a supply/demand balancing resource. This includes adding a reverse-power-flow function for solar power.

Meanwhile, the R&D for advancing water electrolysis technology is aimed at reducing the cost of water electrolysis facilities through diverse approaches, such as optimization of part/equipment replacement cycles based on aging analysis, and review of the structure/materials of electrolysis cell frames for potential improvements.

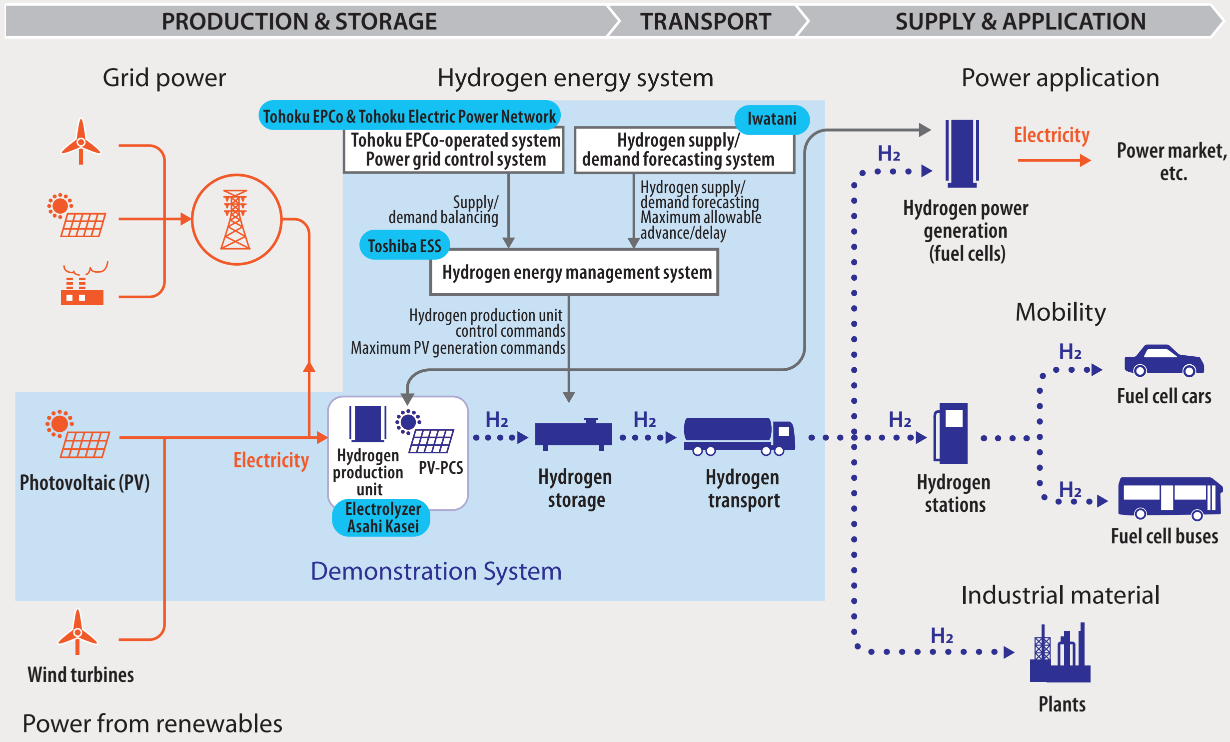
(2) Tokyo Electric Power Company

TEPCO Energy Partner, Inc. is pursuing a joint project for newly developing a small packaged P2G system as a decarbonization solution for industrial sectors where it is difficult to electrify operations. The other collaborators are Yamanashi Prefecture, Tomoe Shokai Co., Ltd., UCC Ueshima Coffee Co., Ltd., and Toray Industries, Inc.

Taking place over the five years from fiscal 2021 through fiscal 2025, the project is carrying out four tasks: development of a 500-kW PEM (polymer electrolyte membrane) P2G system as a single package, and deployment of the system at several sites in Japan; development of a next-generation hydrogen tube trailers needed as a means of large-capacity transport to support the wide use of hydrogen energy in the future; development of a model for "grand master" decarbonized plants that make full use of existing facilities and hydrogen energy; and promoting decarbonization of food processing operations through technology that addresses challenging applications of hydrogen energy, such as coffee bean roasting. Since June 2021, the project has been conducting real-world testing in Yamanashi Prefecture, producing green hydrogen with the P2G system for use at plants, supermarkets, and other sites.

Project Overview

Figure 1



This project is part of NEDO's Development of Technologies for Realizing a Hydrogen Society program, which comprises: development of hydrogen energy system technology; development of large-scale hydrogen-energy utilization technology; and comprehensive investigative research.

Related authorities: Agency for Natural Resources and Energy; Ministry of Economy, Trade and Industry; Reconstruction Agency; Cabinet of Japan; Fukushima Prefecture; Namie City

Project implementers: Toshiba Energy Systems & Solutions Corporation; Tohoku Electric Power Co., Ltd.; Tohoku Electric Power Network Co., Inc.; Iwatani Corporation; Asahi Kasei Corporation

The outcomes of the project's development work will be further evolved as part of the Yamanashi Model, a decarbonized energy network that will use hydrogen as a fuel for heating.

(3) JERA

JERA Co., Inc., which is seeking to achieve net-zero carbon emissions across its domestic and overseas operations by 2050, is carrying out a demonstration project with IHI Corporation to establish technology for large-scale ammonia co-firing. Launched in fiscal 2021, the project is taking place at Hekinan Thermal Power Station. In May 2022, the two companies, recognizing that the project's progress made it possible to accelerate the schedule for installing burners, tanks, pipes, and other essential equipment, decided to move up the start of the main demonstration by one year to fiscal 2023. This will involve large-scale co-firing using ammonia (20% in terms of heat value) at the plant's Unit 4.

2. Construction of Hydrogen/ Ammonia Supply Chain

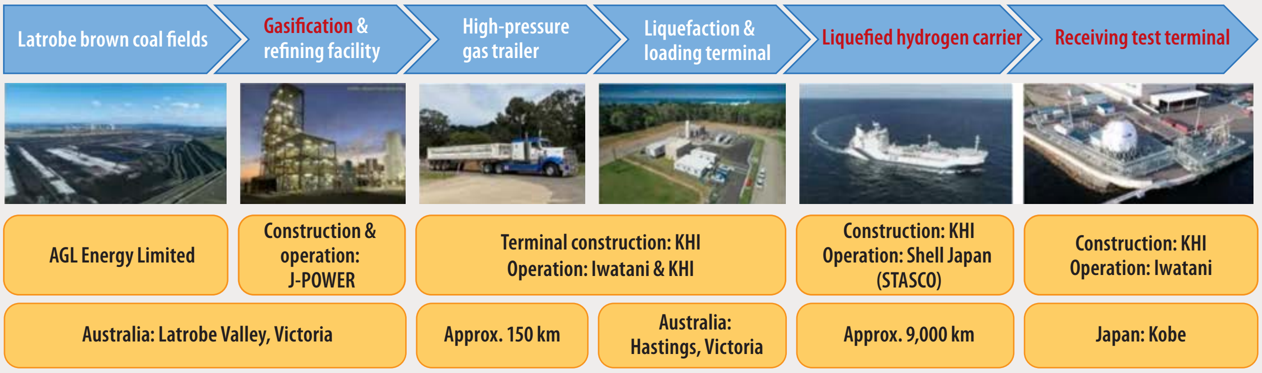
(1) J-POWER

Since 2016, Electric Power Development Co., Ltd. (J-POWER) has been jointly running the HySTRA project for demonstrating maritime transport and loading/unloading of hydrogen made from brown coal using a liquefied hydrogen carrier, together with Iwatani Corporation, Kawasaki Heavy Industries, Ltd., Shell Japan Ltd., Marubeni Corporation, ENEOS Corporation, and Kawasaki Kisen Kaisha, Ltd.

HySTRA, which is being conducted between Japan and Australia, is aimed at developing technologies for manufacturing and transporting large quantities of hydrogen, and at identifying challenges in building the supply chain. Suiso Frontier, the world's first liquefied

Japan-Australia Supply Chain Demonstration

Figure 2



- Stages in red: Elements for which HySTRA received assistance from NEDO.
- Stages in white: Elements for which the Australian consortium received assistance from the Australian and Victorian governments.

hydrogen carrier (carrying capacity: approx. 1,250 m^3) departed Japan in December 2021 and arrived in Australia in January 2022. After taking on hydrogen produced from brown coal, it returned to Japan in February. The hydrogen was then unloaded to an on-land liquefied hydrogen storage tank. Analysis of data from each operational stage found that this demonstration was completed successfully. As part of this project, J-POWER constructed and operated coal gasification and gas refining plants that used brown coal mined in Latrobe Valley.

According to a report on the project, the equipment and facilities that were demonstrated to be safely operable represent not only game-changing technologies for clean energy businesses of the future, but also a step forward toward the advent of a society where hydrogen will become an everyday source of energy like natural gas.

(2) Chubu Electric Power Company

The Chubu region served by Chubu Electric Power Co., Inc. is home to a wide variety of businesses. For this reason, the company sees the region as having strong potential for reducing CO_2 emissions and expanding demand for hydrogen, envisioning it as an ideal model area for transforming the shape of industry and energy use, and for reforming supply chains. In March 2022, the company entered into the Comprehensive Cooperation Agreement for the Realization of a Large-scale Hydrogen Society in Chubu with the prefectures of Gifu, Aichi, and Mie, Nagoya City, the Nagoya Chamber of Commerce & Industry, the Central Japan Economic Federation, and the Chubu Association of Corporate Executives. The purpose of the agreement is to develop the supply chain needed for large-scale deployment and stable use of hydrogen. In addition, a Committee for Promoting Social Implementation of a Large-scale Hydrogen Supply Chain in Chubu was formed to advance concrete actions in this regard. Going forward, the partners will engage in infrastructural development and planning for promoting hydrogen import, storage, supply, and use.

(3) Hokuriku Electric Power Company

Hokuriku Electric Power Company joined the Japan Hydrogen Association, which promotes hydrogen-related global cooperation and supply chain development, in July 2021. An open, cross-industry organization that takes a comprehensive perspective of the entire hydrogen supply chain, the JHA seeks to create an early path to a hydrogen-powered society by carrying out real-world projects. The JHA is committed to proposing and coordinating such projects, establishing funds for them, studying basic processes of management/operation, creating demand, issuing policy recommendations on deregulation and other matters, engaging in international activities, and collecting, analyzing, and sharing information from domestic and international sources.

(4) Kansai Electric Power Group

The Kansai Electric Power Co., Inc. (KEPCO) signed an MoU in September 2021 on jointly implementing a feasibility study for the Central Queensland Hydrogen Project, which proposes to develop a facility in Gladstone, Queensland, Australia for large-scale production and liquefaction of hydrogen derived from renewable energy, and to export the hydrogen to Japan. The agreement was signed with Iwatani Corporation, Kawasaki Heavy Industries, Ltd., Marubeni Corporation, and two Australia-based energy infrastructure companies, Stanwell Corporation Limited and APT Management Services Pty Ltd.

The Japan-Australia project aims to create a large-scale green liquefied hydrogen supply chain for stably achieving low-cost hydrogen production and supply over the long term. Its target is to realize hydrogen production of at least 100 t/day by around 2026, and at least 800 t/day by 2031. In addition to exports to Japan, the developers will also consider supplying the green hydrogen to customers in Australia.

The feasibility study will mainly examine green hydrogen production technology, construction of a hydrogen liquefaction plant and a carrier, associated finance and environmental assessments, and a commercialization model. KEPCO's role in the study is to provide information on potential utilization of hydrogen, such as a fuel for thermal power generation and supply of heat.

3. Hydrogen Applications Other Than Power Generation

(1) Kansai Electric Power Company

The Kansai Electric Power Co., Inc. (KEPCO) launched a project in July 2021 with Tokyo University of Marine Science and Technology, Iwatani Corporation, and Namura Shipbuilding Co., Ltd. to conduct R&D on hydrogen fuel cell ships. Compared with conventional vessels, ships powered with hydrogen fuel cells are expected to offer strong environmental performance by lowering emissions of CO_2 and environmentally hazardous substances during travel. They also promise greater comfort for crews and passengers, as they will be free of the noise, vibrations, and odors associated with conventional ships. The project will seek to create a hydrogen fuel cell ship suitable for commercial operation by carrying tasks such as building the infrastructure for supply of marine hydrogen fuel, developing energy management processes, designing the hull structure, and conducting sea trials. The members plan to showcase the potential of hydrogen energy to domestic and international audiences at Expo 2025 in Osaka as part of their drive to contribute to zero-emissions maritime transport of the future. The project also includes demonstration testing of a marine hydrogen station.

(2) Chugoku Electric Power Company

The Chugoku Electric Power Co., Inc. (Chugoku EPCo) has teamed up with drone manufacturer Luce Search Inc. to develop a hydrogen fuel cell drone. In June 2021, the project was approved for a grant under a METI public program for subsidizing the costs of projects with potential to help advance industrial safety.

Drones are already being used in industry for tasks such as ascertaining the physical effects of disasters and inspecting power facilities. However, the challenge of extending flight duration needs to be tackled in order to expand the role of drones and achieve greater labor savings.

The two companies are now working together to advance the project. Luce Search is using its long flight time-related expertise and sophisticated fuselage design technologies to develop a prototype, while Chugoku EPCo is formulating specifications for drone handling of tasks for commercial use and providing support for demonstration testing.

STATISTICAL DATA

Electric Power Generation*

[TWh]

FY	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Hydroelectric	**83.6**	**84.9**	**86.9**	**91.4**	**84.6**	**90.1**	**87.4**	**86.3**	**86.3**	**87.6**
Electric Utilities	67.4	68.6	70.3	74.9	81.9	87.9	85.0	84.3	84.5	85.8
Industry-owned	16.3	16.3	16.7	16.5	2.7	2.3	2.4	2.0	1.8	1.8
Thermal**	**986.8**	**987.3**	**955.4**	**908.8**	**877.0**	**861.4**	**823.6**	**792.9**	**790.0**	**776.0**
Electric Utilities	735.9	743.1	717.8	675.7	794.4	777.5	726.2	696.2	697.9	681.4
Industry-owned	250.8	244.2	237.6	233.1	82.6	83.9	97.4	96.7	92.1	94.6
Nuclear	**15.9**	**9.3**	**–**	**9.4**	**17.3**	**31.3**	**62.1**	**61.0**	**37.0**	**67.8**
Electric Utilities	15.9	9.3	–	9.4	17.3	31.3	62.1	61.0	37.0	67.8
Industry-owned	–	–	–	–	–	–	–	–	–	–
Wind Power	**4.8**	**5.2**	**5.0**	**5.2**	**5.5**	**6.1**	**6.5**	**6.9**	**8.3**	**8.2**
Electric Utilities	0.2	0.2	0.0	0.1	5.0	5.5	5.9	6.3	7.6	7.4
Industry-owned	4.7	5.0	5.0	5.1	0.5	0.7	0.6	0.6	0.7	0.8
Solar	**0.2**	**1.2**	**3.8**	**6.8**	**11.1**	**15.9**	**18.5**	**21.4**	**25.0**	**27.9**
Electric Utilities	0.1	0.1	0.1	0.1	6.5	8.7	10.8	13.2	16.2	19.0
Industry-owned	0.1	1.1	3.7	6.7	4.6	7.2	7.7	8.2	8.8	8.9
Geothermal	**2.6**	**2.6**	**2.6**	**2.6**	**2.2**	**2.1**	**2.1**	**2.1**	**2.1**	**2.0**
Electric Utilities	2.5	2.4	2.4	2.4	2.2	2.1	2.1	2.0	2.0	2.0
Industry-owned	0.1	0.2	0.2	0.2	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**
Electric Utilities	–	–	–	–	0.3	0.3	0.2	0.2	0.2	0.2
Industry-owned	–	–	–	–	–	–	–	–	–	–
Total	**1,094.0**	**1,090.5**	**1,053.7**	**1,024.2**	**997.9**	**1,007.3**	**1,000.4**	**970.8**	**949.0**	**970.0**
Electric Utilities	822.0	823.7	790.6	762.6	907.6	913.2	892.2	863.2	845.4	863.5
Industry-owned	272.0	266.8	263.2	261.6	90.4	94.1	108.2	107.6	103.6	106.5

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

Source : METI (2011-2020)

Electric Power Consumption

[TWh]

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

FY		2016	2017	2018	2019	2020	2021
Low Voltage	Residential	272.9	280.4	271.4	267.7	278.0	278.1
	Commercial and Industrial	37.9	38.4	37.1	35.7	35.4	34.8
Specified-Scale Demand*	High Voltage	308.3	310.6	307.8	302.8	290.3	296.5
	Extra-High Voltage	231.4	233.8	236.3	229.9	214.9	225.5
Specified Supply**		6.0	6.1	6.3	6.2	5.5	6.1
Self-Consumption		43.2	45.1	37.4	34.9	36.8	38.1
Supplied by Electric Utilities		**899.8**	**914.4**	**896.2**	**877.1**	**863.2**	**881.6**
Power Generated and Consumed by Privately-owend Power Facilities		70.8	70.0	77.2	75.6	66.3	68.4
Total Consumption		**970.6**	**984.3**	**973.4**	**952.7**	**929.5**	**950.0**
Others (Last Resort Supply and Isolated Area Supply)		2.3	2.3	2.3	2.2	2.4	2.4

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

Source: METI

Installed Generating Capacity*

[MW]

FY	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Hydroelectric	**48,934**	**48,932**	**49,597**	**50,035**	**50,058**	**50,014**	**50,037**	**50,033**	**50,033**	**49,924**
Electric Utilities	44,651	44,676	45,403	45,786	49,521	49,562	49,582	49,635	49,635	49,528
Industry-owned	4,282	4,256	4,194	4,248	536	452	455	398	398	396
Thermal**	**188,903**	**191,258**	**193,356**	**190,805**	**193,910**	**193,462**	**193,026**	**189,784**	**191,758**	**188,247**
Electric Utilities	139,794	141,901	143,777	143,040	174,392	173,261	171,469	168,760	170,260	167,474
Industry-owned	49,109	49,357	49,579	47,765	19,517	20,201	21,557	21,024	21,498	20,773
Nuclear	**46,148**	**44,264**	**44,264**	**42,048**	**41,482**	**39,132**	**38,042**	**33,083**	**33,083**	**33,083**
Electric Utilities	46,148	44,264	44,264	42,048	41,482	39,132	38,042	33,083	33,083	33,083
Industry-owned	–	–	–	–	–	–	–	–	–	–
Wind Power	**2,562**	**2,646**	**2,750**	**2,808**	**3,203**	**3,483**	**3,498**	**3,951**	**4,119**	**4,254**
Electric Utilities	83	82	30	50	2,893	3,091	3,165	3,580	3,750	3,862
Industry-owned	2,479	2,563	2,720	2,758	310	391	332	371	369	392
Solar	**267**	**1,559**	**4,085**	**5,624**	**9,110**	**12,592**	**14,974**	**16,522**	**19,028**	**21,034**
Electric Utilities	65	67	81	87	5,655	7,318	8,922	10,549	12,408	14,124
Industry-owned	202	1,492	4,005	5,536	3,455	5,274	6,052	5,973	6,620	6,910
Geothermal	**512**	**512**	**508**	**517**	**526**	**471**	**473**	**481**	**487**	**487**
Electric Utilities	477	477	473	473	511	466	463	463	469	469
Industry-owned	35	35	35	43	15	5	11	18	18	18
Others	–	–	–	–	**64**	**54**	**43**	**43**	**43**	**60**
Electric Utilities	–	–	–	–	64	54	43	43	43	60
Industry-owned	–	–	–	–	0	0	0	0	0	0
Total	**287,327**	**289,171**	**294,560**	**291,836**	**298,352**	**299,209**	**300,093**	**293,897**	**298,550**	**297,088**
Electric Utilities	231,219	231,468	234,028	231,484	274,519	272,885	271,685	266,112	269,648	268,599
Industry-owned	56,107	57,703	60,532	60,352	23,834	26,324	28,407	27,785	28,903	28,489

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

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

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

Voltage [kV]	Transmission Lines [km]				Substations	
	Route length		Circuit length		Number	Output Capacity [MVA]
	Overhead	Underground	Overhead	Underground		
500	8,044	113	15,602	201	85	230,450
275	7,438	612	14,705	1,533	162	176,815
220	2,618	61	5,030	134	71	44,330
187	2,686	15	5,228	35	48	18,985
110–154	15,503	1,064	28,194	1,974	758	162,331
66–77	38,367	7,481	68,615	13,483	4,660	229,287
≦55	13,786	6,171	15,015	10,173	1,325	10,354
Total	**88,442**	**15,517**	**152,389**	**27,533**	**7,109**	**872,552**

Distribution Lines [km]				Transformers	
Route length		Circuit length		Output Capacity [MVA]	
Overhead	Underground	Overhead	Underground	Overhead	Underground
956,715	44,450	4,052,017	74,493	352,462	36,648

Source : FEPC

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	869.3
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	60.3

* 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 (2015-2020)

Summarized Comparative Table Classified by Country for the Year 2019

	USA	UK	France	Germany	Russia	China	India*	Japan
Total Installed Capacity [MW]	**1,212,584**	**77,898**	**135,328**	**226,396**	**275,800**	**2,010,060**	**411,773**	**293,897**
Hydroelectric	100,816	4,365	25,557	14,662	51,800	358,040	45,447	50,033
Thermal	829,875	43,910	18,589	78,529	191,900	1,189,570	282,350	189,784
Nuclear	106,351	9,261	63,130	9,516	30,300	48,740	6,780	33,083
Renewables and others	175,542	20,362	28,051	123,688	1,700	413,710	77,916	20,997
Total Energy Production [GWh]	**4,131,152**	**323,801**	**537,700**	**609,406**	**1,121,000**	**7,326,900**	**1,521,785**	**970,771**
Hydroelectric	287,949	7,602	60,000	19,730	196,000	1,302,100	134,991	86,314
Thermal	2,569,164	146,319	42,600	266,223	714,000	5,046,500	1,244,959	792,810
Nuclear	809,057	56,184	379,500	75,071	209,000	348,700	37,813	61,035
Renewables and others	464,981	113,694	55,600	248,382	2,100	629,600	104,022	30,612
Capacity Factor [%]	–	42.4	45.4	30.7	–	43.7	56.0	35.0
Total Energy Production per Capita [kWh]	12,586	4,847	8,295	7,340	7,638	5,233	1,172	7,688
Domestic Energy Supplies [GWh]	4,150,188	328,198	473,410	–	1,110,100	6,283,500	–	–
Energy Sales [GWh]	3,811,151	273,493	–	439,830	–	5,911,100	1,209,972	836,038
Number of Customers [At year-end; thousand]	154,898	31,275	–	–	–	603,454	298,878	88,329
Maximum Demand [MW]	786,214	48,230	88,500	–	151,700	–	183,804	164,610
Annual Load Factor [%]	59.9	70.5	61.1	–	79.7	–	–	60.7
Thermal Efficiency [%]	–	32.2	–	43.7	40.5	40.1	–	–
Loss Factor (Transmission and Distribution) [%]	5.1	8.0	7.7	–	–	5.9	20.7	–
Total Consumption per capita [kWh]	–	4,431	6,739	6,107	6,888	5,186	932	7,545

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

Source: JEPIC, METI

OVERSEAS ACTIVITIES OF MEMBER COMPANIES

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

Recent Overseas Activities of Member Companies*

North and South America

Company	Project	Location	Type	Capacity [MW]	Equity [%]	COD
Hokkaido	PV project in Mexico	Mexico	PV	290	12.0	2018
JERA	El Sauz Onshore Wind IPP	USA	Onshore Wind	302	100	2022
Kansai	Aviator	USA	Onshore Wind	525	48.5	2020
Chugoku	South Field Energy	USA	CCGT	1,182	10.0	2021
Shikoku					8.9	
Kyushu					18.1	
Shikoku	Huatacondo	Chile	PV	98	30	2019
Kyushu	Enernet Global Inc.	USA	Microgrid	–	(Private)	–
J-POWER	Jackson**	USA	CCGT	1,200	100	2022

Europe

Company	Project	Location	Type	Capacity [MW]	Equity [%]	COD
Tokyo	Zenobe	UK	Battery Storage	235	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
Chubu	BorWin1, BorWin2, DolWin2, HelWin2	Germany	Offshore Transmission	2,810	12	2017
Chubu	Eneco Group	Netherlands	Integrated Energy Business	–	20	2020
JERA	Hydrogenious LOHC Technologies Hydrogen Related Project	Germany	Liquid Organic Hydrogen Carrier	–	–	2023
Kansai	Piiparinmaki	Finland	Onshore Wind	211	15	2022
Kansai	NeuConnect	UK-Germany	Interconnector	–	17.5	2028
Kansai	Triton Knoll	UK	Offshore Wind	857	16	2022
J-POWER					25	

*Not an exhaustive list

**J-POWER has made a decision to sell its 49% interest in Jackson to another company, and as of December 31, 2022, the transfer is in the process of being approved by the relevant authorities in the USA.

Asia

Company	Project	Location	Type	Capacity [MW]	Equity [%]	COD
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
Tokyo	Corporate Solar PPA Project in Thailand	Thailand	Rooftop solar	3.8	49	2022
Chubu	New Clark City	Philippines	Distribution and Retail	–	9	2019
Kansai					9	
JERA	Formosa 2 Offshore Wind IPP	Taiwan	Offshore Wind	376	49	2022
JERA	Meghnaghat Gas Thermal IPP	Bangladesh	Gas	718	49	2022
JERA	Aboitiz Power Corporation	Philippines	Coal/Oil/Renewable	4,573	27	–
Hokuriku	Acquisition of 25.01% shares of Sun-eee	Cambodia	Distribution and Retail	–	25.01	2022
Kansai	Nam Ngiep 1	Laos	Hydro	290	45	2019
Chugoku	Feng Ping Xi	Taiwan	Hydro	37.1	25.0	2024
Chugoku	Yunlin	Taiwan	Offshore Wind	640	3.375	–
Shikoku					4.4	
Kyushu	Sarulla/Geothermal IPP	Indonesia	Geothermal	330	25	2017
J-POWER	Rooftop Solar (7 projects)	Thailand	Rooftop Solar	9.6	60	2023

Others

Company	Project	Location	Type	Capacity [MW]	Equity [%]	COD
Chubu	Project for Improvement of Energy Loss Reduction on Distribution Network	Mozambique	Consulting	–	–	2020-2024
Hokuriku	Fujairah F3 IPP	United Arab Emirates	CCGT	2,400	19.6	2023
Chugoku	Energy Fiji Limited	Fiji	Electric Company	329	44	–
Shikoku	Hamriyah	United Arab Emirates	CCGT	1,800	15	–
Kyushu	Al Dur 1IWPP	Bahrain	CCGT & Water Plant	1,234	19.8	2021
Okinawa	Project for Introduction of Hybrid Power Generation System in Pacific Island Countries	Pacific Islands	Consulting	–	–	2017-2023
J-POWER	Kidston Stage-3 Wind	Australia	Onshore Wind	258	53.9	2025

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

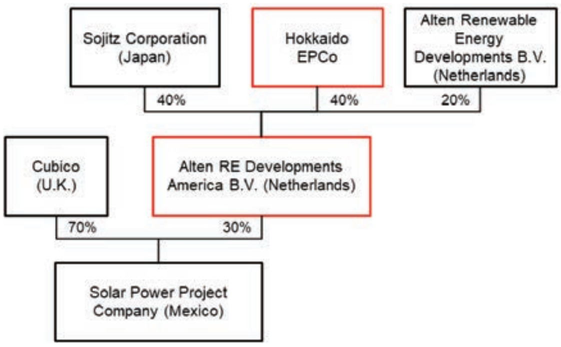
Hokkaido Electric Power Co., Inc. (HEPCO) is participating in the operation of a solar power plant in Mexico through an equity stake in Alten RE Developments America B.V., which invests in solar power generation businesses.

➢ 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

Note) Plan to cover the coal yard with shades entirely

Conceptional Drawing

➢ Purpose

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

➢ Facilities

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

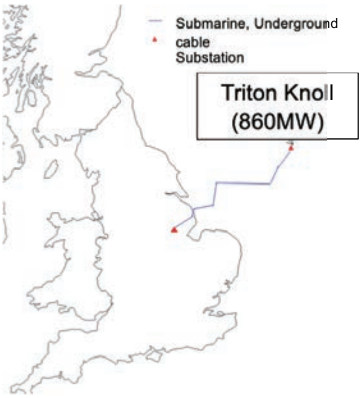
➢ Special Notes

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

Tokyo Electric Power Company Holdings

TEPCO PG's first investment in a power transmission project outside of Japan

Electricity Transmission Business in the UK for a 23-year



- Purpose
  - As our first investment project to the international transmission business, TEPCO Power Grid will start the operation and maintenance of the new offshore electricity transmission asset that connect with the Triton Knoll Offshore Windfarm, utilizing the knowledge and know-how of asset management and operation in Japan, with the partner (Equitix limited) from 2022 after the asset acquisition.
- Facilities
  - Two 220 kV/66 kV offshore substations
  - One 400 kV/220 kV onshore substation
  - Total cable length: 107 km

  (Submarine 50km, Underground 57km)

JERA

Formosa 2 Offshore Wind IPP Project

Photo credit to Formorsa 2 Wind Power Co., Ltd.

➢Purpose

JERA will gain knowledge and experience in construction and operation of the offshore wind power generation and leverage this to move forward with projects in Japan and abroad. Through this renewable energy project, JERA will contribute to reducing the environmental load of power generation .

➢Features

•Location : Approx. 4 to 10km off the coast of Miaoli County
•Type : Offshore Wind Power Generation
•Capacity : 376MW
•Number of Generators : 47 Units
•COD : 2022 (Scheduled)

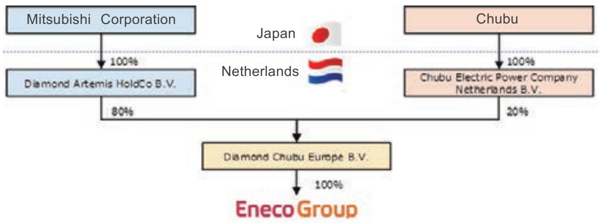
➢Notes

The project has secured the support of Taiwan Power Company under a 20-year Power Purchase Agreement based on the FIT (Feed in Tariff) scheme.

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 2021

Total assets	9,878 million EURO
Total revenues	5,211 million EURO
Net result	209 million EURO
ROCE	4.7%
Number of employees	2,970 FTE※

※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.

JICA Technical Cooperation Project in Republic of Mozambique

JICA Project for Improvement of Energy Loss Reduction on Distribution Network

Technical Transfer on EDM’s power distribution sites

➢ Counterparts
- Electricidade de Moçambique (EDM)

➢ Purpose
- Capacity building for EDM staff regarding distribution planning, design and O&M for energy loss reduction

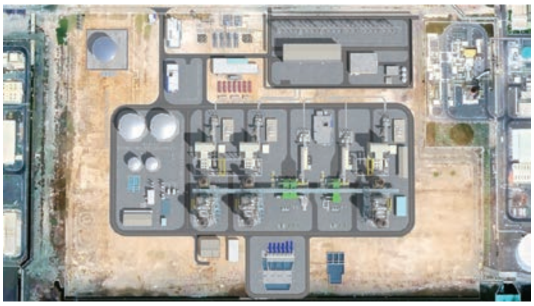
➢ Activities on this Project
- Training related to distribution loss reduction and O&M works
- Technical transfer through loss reduction pilot project
- Preparation of guidelines / manuals

➢ Implementation Period
- From March 2020 (4 years)

Hokuriku Electric Power Co.

Fujairah F3 IPP Project in UAE

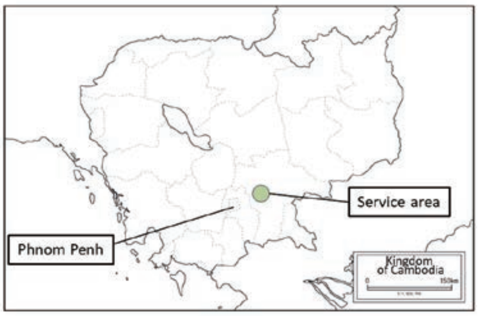
Hokuriku Electric Power Company acquired 19.6% interest in the project and 34% shares of the company, that will undertake operation and maintenance, in March 2021.



- Purpose
  - Overseas business expansion by utilizing the knowledge and experience of power plant operation.
- Features
  - Type : CCGT
  - Capacity : 2,400MW
  - COD : 2023
  - 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
- Basic data of Sun-eee
  - 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.

Aviator Onshore Wind Farm Project

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

Nam Ngiep 1 Hydropower Project

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

Chugoku Electric Power Co.

Participation in Energy Fiji Limited in Fiji (2021)

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

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

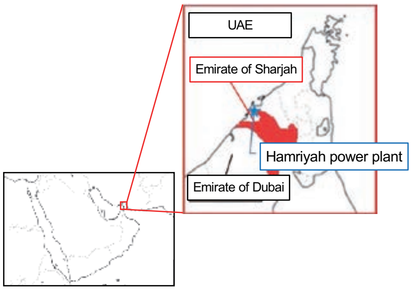
EFL HQ

Nadarivatu Hydro Power Station

Nadarivatu Dam

Shikoku Electric Power Co.

Gas-fired Power Plant in Hamriyah, UAE



Project	• Construction of new power plant in Hamriyah, United Arab Emirates (UAE) Capacity: 1,800 MW (GTCC) • Plant operation and power wholesale
Business term	• 23.5 years from launch of commercial operation, under BOOT scheme
Our equity	• 15%
Co-sponsors	• Sumitomo Corporation • GE Energy Financial Services (GE EFS) • Sharjah Asset Management
Power purchaser	• Sharjah Electricity & Water Authority
Construction, operation & maintenance	• EPC: US-based electric equipment manufacturer • O&M: Sponsors and O&M service provider founded by us
Schedule	• June 2022: Block 1 launch • July 2022: Block 2 launch • May 2023: Full operation (tentative)

- **Our first IPP project in UAE**
- **Emirate of Sharjah's first IPP project**
- **Will supply approx. 40% of Sharjah's power after start of full operation**
- **Our first time to invest and take part in an O&M company. We will assign senior managers to the company.**

Kyushu Electric Power Co.

Abu Dhabi HVDC subsea transmission

Kyuden Group's first participation in an overseas power transmission business.

- Purpose
  - Construct two HVDC subsea transmission facilities to power ADNOC's offshore oil and gas production facilities with cleaner energy sources from the mainland delivered through the TAQA grid.
- Features
  - Project sites
    the United Arab Emirates
  - Agreement Date
    2021/12/21
  - Shareholders
    ADNOC、TAQA、
    Kyuden Group、KEPCO、EDF
- SCOD
  - 2025

JICA Technical Consulting Project in Kenya

JICA Project for Strengthening Operation and Maintenance Capacity of Olkaria Geothermal Power Station Using IoT Technology.

*Carried out by Kyuden Group - Kyuden International Corporation and West Japan Engineering Consultants Inc..

- Purpose
  - Enable the local staff to perform a long-term stable operation and maintenance as well as improve performance of the power stations.
- Activities on this project
  - Share technical knowledge to improve the availability of the stations' operation and the condition monitoring of the geothermal reservoirs.
  - Provide technical supports for station data management skills.
- Period
  - From April 2020 (3 years)

Okinawa Electric Power Co.

JICA's Technical Cooperation in Pacific Island Countries

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

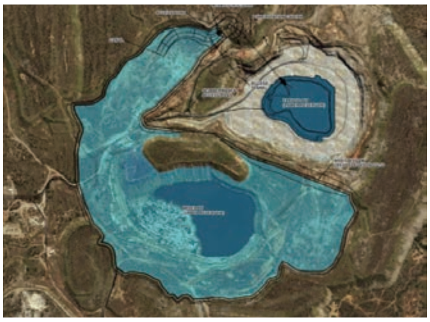
- Objectives
  - To promote introduction of hybrid power generation system
- Period
  - From 2017 to 2023
- Countries
  - Fiji, Tuvalu, Kiribati, Federated States of Micronesia (FSM), Republic of the Marshall Islands (RMI), Samoa, Tonga, Cook Islands, Nauru, Papua New Guinea, Solomon Islands and Palau
- 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

K2-Hydro Project (K2H) in Australia

Development of a pumped storage hydro in Kidston area, Queensland, Australia

Location of the project



Future image of location

- Features
  - First pumped storage hydro project in Australia in 40 years.
  - Genex Power Limited ("Genex," the renewable energy company, Australia), which J-POWER has invested since May 2021, has been developing the project.
  - Based on a Technical Services Agreement entered into with Genex, J-POWER supports Genex in constructing and operating the pumped storage hydro power plant, applying its knowledge and technical capabilities.
  - Located in Renewable Energy Zone, Queensland.
- Overview
  - Capacity: 250 MW (125MW x 2 units)
  - Construction Start: 2021
  - Commercial Operation: 2024 (planned)

Triton Knoll Offshore Wind Farm Project in UK

Large scale offshore wind farm of North Sea, east of England

Location of the project

Triton Knoll Offshore Wind Farm

- Features
  - First overseas offshore wind project among Japanese Power Utilities
  - Participated in August 2018
  - Located in the North Sea region east of England, known as area with optimum wind conditions for wind power generation
  - Qualified for CfD (Contracts for Difference) scheme of UK, which guarantees 15 years of stable revenue after its application date
- Overview
  - Capacity: 857 MW (approx.9.5 MW x 90 units)
  - Owned Capacity: 214 MW
  - Equity Ownership: J-POWER 25%
  - Construction Start: 2018
  - Commercial operation: 2022

The Japan Atomic Power Co.

Fostering of human resources

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

Tokai Training Center

Preparation of master plan for introduction of nuclear power

Nuclear power plant simulator

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

Member Companies Data (As of March 31, 2022)*

	FY 2021			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	663,414	22,165	1,631	4,469	2,070	–	8,170
Tohoku EPCo	251,441	2,104,448	67,346	2,558	12,073	2,750	243	17,625
TEPCO HD	1,400,975	5,309,924	186,494	9,879	–	8,212	51	18,142
Chubu EPCo	430,777	2,705,162	108,932	5,466	–	3,617	88	9,171
Hokuriku EPCo	117,641	613,756	28,085	1,964	4,565	1,746	–	8,274
Kansai EPCo	489,320	2,851,894	100,657	8,248	14,566	6,578	11	29,403
Chugoku EPCo	197,024	1,136,646	47,107	2,905	7,054	820	6	10,785
Shikoku EPCo	145,551	641,948	22,565	1,153	3,239	890	2	5,284
Kyushu EPCo	237,304	1,743,310	79,445	3,580	8,035	4,140	213	15,969
Okinawa EPCo	7,586	176,232	7,033	–	2,163	–	2	2,166
J-POWER	180,502	1,084,621	0	8,560	8,666	–	545	17,771
JAPC	120,000	92,981	–	–	–	2,260	–	2,260

*Some consolidated data contains non-consolidated data.
**Calculated based on figures contained in the "key facilities" sections of financial statements.

Source: Compiled based on companies' financial statements (Japan Atomic Power Company data are from summary statement of business)

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

JERA	5,000	4,435,275	–	–	59,243	–	–	59,243

Source: Financial statement

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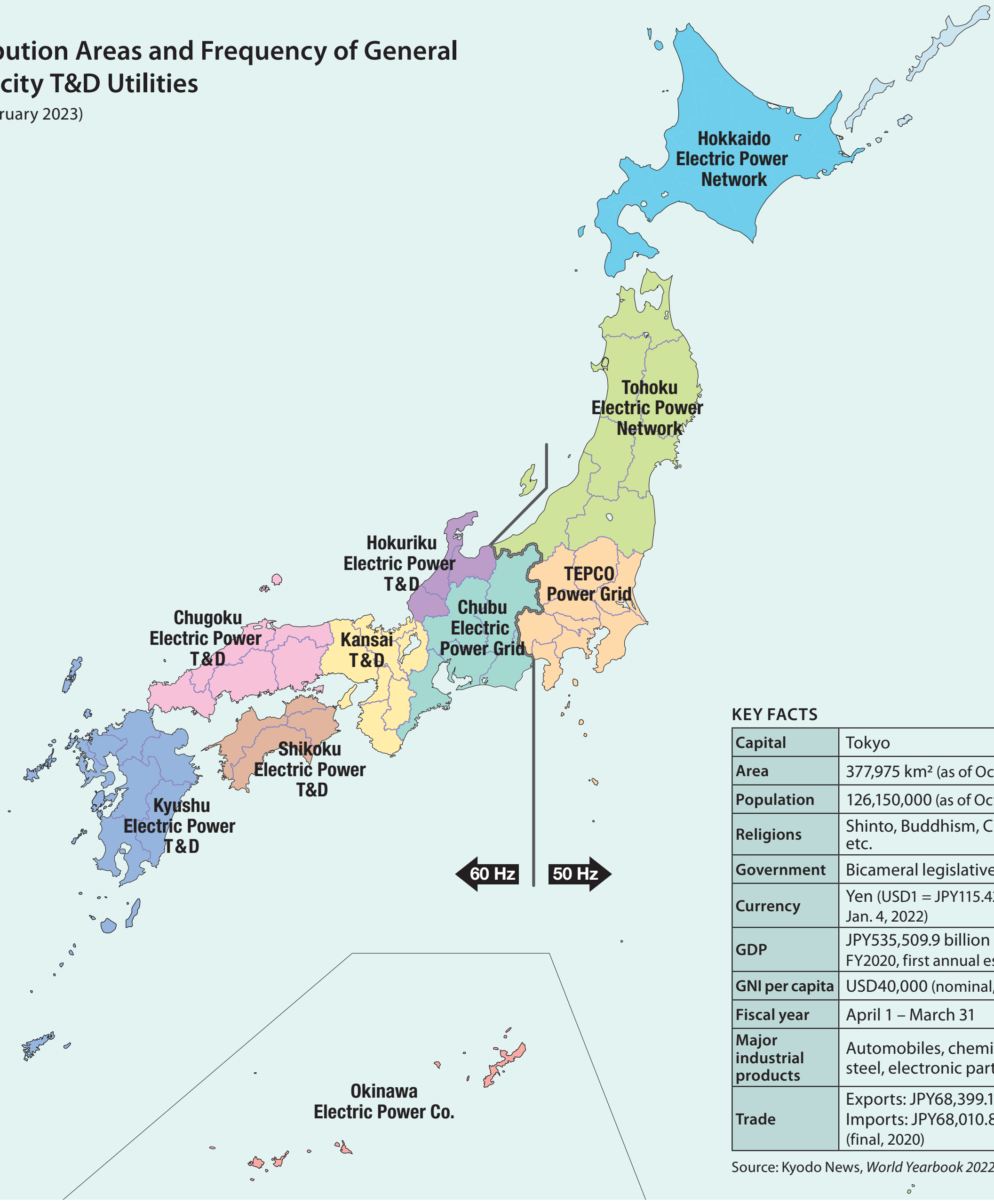
Distribution Areas and Frequency of General Electricity T&D Utilities

(As of February 2023)



KEY FACTS

Capital	Tokyo
Area	377,975 km² (as of Oct. 1, 2021)
Population	126,150,000 (as of Oct. 1, 2020)
Religions	Shinto, Buddhism, Christianity, etc.
Government	Bicameral legislative system
Currency	Yen (USD1 = JPY115.42, as of Jan. 4, 2022)
GDP	JPY535,509.9 billion (nominal, FY2020, first annual estimate)
GNI per capita	USD40,000 (nominal, 2020)
Fiscal year	April 1 – March 31
Major industrial products	Automobiles, chemicals, food, steel, electronic parts/devices
Trade	Exports: JPY68,399.1 billion / Imports: JPY68,010.8 billion (final, 2020)

Source: Kyodo News, *World Yearbook 2022*

Member Companies (As of February 2023)

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

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

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THE ELECTRIC POWER INDUSTRY IN JAPAN 2023

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