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Business Risks of New Coal-fired Power Plant Projects in Japan

The Decline in Capacity Factor and Its Effect on the Business Feasibility

September 2017

Acknowledgments
This report was produced by reference to interviews with a wide range of energy-related businesses, consultants, research organizations, and other parties concerned, and owes a lot to energy experts of external research institutions. Here we express our appreciation.

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Renewable Energy Institute is a non-profit think tank which aims to build a sustainable, rich society based on renewable energy. It was established in August 2011, in the aftermath of the Fukushima Daiichi Nuclear Power Plant accident, by its founder Mr. Son Masayoshi, Chairman & CEO of SoftBank Corp., with his own resources.

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- Electricity demand in Japan decreased by around 10% in just five years from 931.1 TWh in fiscal year (FY) 2010 to 841.5 TWh in FY 2015, mainly due to improvement in energy efficiency and the rise in electricity charges after the Great East Japan Earthquake.
- The first change observed on the supply side was the rapid deployment of renewable electricity facilities, mainly solar PVs, resulting from the enforcement of the Feed-in Tariff in July 2012. The ratio of renewable energy in total electricity generated and purchased rose by six percentage points in six years since FY 2010 from 8.9% to 15.0%.
- The second change was the drastic decrease of electricity supplied by nuclear power plants. While a few plants have been restarted, the share of nuclear power plants in total electricity generated in FY 2016 remained less than 2%.
- While the capacity factor of thermal power plants rose to 62% in FY 2012 to make up for the reduced supply capability of nuclear power plants, it has turned to a declining trend since FY 2013 with improvements in energy savings and efficiency and the increase in renewable energy. The figure had dropped to 53% by FY 2016.
- We analyzed thermal power plants' hours of operation based on the actual data on electricity supplied by power companies in FY 2016. Results indicate that all nine power companies whose electric power systems are connected face difficulties in maintaining the capacity factor at a high level for their coal-fired power plants, coke oven gas plants, and combined cycle gas fired power plants.

2 Outlook for the future electricity supply and demand

- According to projections by the Japanese Government and the Organization for Cross-regional Coordination of Transmission Operators (OCCTO), no major increase is expected either in annual electricity demand or peak demand. The actual electricity demand may even fall below the figure projected by the government.
- According to the "Aggregation of Electricity Supply Plans FY2017" (hereinafter referred to as the "Electricity Supply Plan"), published by the OCCTO in March 2017, supply capability will exceed electricity demand consistently, and the reserve margin rate will exceed the optimal level of 8% up to FY 2026.
- The Electricity Supply Plan assumes that the capacity factor of coal-fired power plants will decline from 80% in FY 2015 to 69% in FY 2026.

3 The decline in capacity factor of coal-fired power plants and its effect on the business feasibility

- Assumptions made in the Electricity Supply Plan are based on a conservative assumption, such as there will be no electricity supply from nuclear power plants that have not yet obtained decisions to restart. This is based on the objective of the Electricity Supply Plan to ensure a stable supply of electricity. On the other hand, to consider the business risks of new coal-fired power plant projects, it would be more appropriate to assume that all the planned coal-fired units will be built, and that nuclear and renewables will increase to certain levels, as suggested by their respective current upward trends. Hence, we made a provisional calculation of the capacity factor of coal-fired plants for FY 2026 based on the following assumptions:
  - (i) All plans for new constructions and extensions of coal-fired power plants that have been publicly announced will be implemented, and operation will start.
  - (ii) Electricity demand will remain at the same level as that in FY 2016.
  - (iii) While nuclear power plants will restart to a certain degree, their share in the electricity mix will remain at 10%, or about half of the figure estimated for 2030 by the government in the Long-Term Energy Supply and Demand Outlook, which is 20-22%.
  - (iv) Deployment of solar PV is assumed to be at 81.92 GW, which is a figure estimated by RTS, a leading consulting firm in Japan on solar PV, as a growth scenario based on current conditions.

- The results indicate that the capacity factor of coal-fired power plants may decline to 56% — significantly below 69%—the figure estimated in the Electricity Supply Plan.
- If nuclear power plants will not restart at the level of the assumption above and remained at 5% of electricity supply, the capacity factor of coal-fired plants will be 62%. However, if electricity demand declines by about 5% due to energy efficiency improvements, the capacity factor of coal-fired plants may become 49%—below 50%.
- It is considered that business plans of coal-fired power plants are based on the assumptions of a 70% capacity factor and a 40 year operational lifetime. These assumptions are not feasible and it will thus be difficult to realize the profit expected.

4 Corporate trends and policy developments that affect future investment in coal-fired power plants

- Since the Paris Agreement entered into force, corporate activities toward de-carbonization, such as efforts toward 100% renewable energy, have been growing in Japan. Demand for coal-fired power plants, which are by far the largest greenhouse gas emitter among fossil fuels, will certainly decline.
- The national Long-term Low-carbon Vision, prepared in March 2017, envisions that 90% or more energy will be supplied from low carbon energy sources by 2050. The use of coal-fired power plants is hardly assumed. The progress of the government's efforts aiming at introducing carbon pricing, combined with various initiatives at the corporate level toward de-carbonization, will bring down the demand for coal-fired power plants.

Conclusion

Plans of four new coal-fired power plants were cancelled in 2017 for the first time since its steady increase from the Great East Japan Earthquake. For the operators planning for the remaining 42 plants and financial institutions involved in coal businesses, it should be in their interest to make appropriate investments and financing decisions by forming a clear view of the situation of Japan and the global trend toward a de-carbonized society, which have been described in this report.

Introduction

In October 2016, the Renewable Energy Institute published a report, "Coal Business and Policy Trends ―What Japanese investors should know after the Paris Agreement," to explain why the world is leaving behind types of business that deal with fossil fuels, especially coal, showing the present state of things and factors behind it. Specifically, the report revealed decreasing coal consumption around the globe, falling profitability of, and increasing bankruptcies in, the coal mining industries in the United States and China, and enhanced climate change initiatives and accelerated energy transition to renewable energy in Europe and the United States. In China, India, and the United States, coal-fired power plants have been operating at a much lower capacity factor than before. In China, the average capacity factor fell below 50%. That means that any amount of capital invested in a coal-fired power plant, whose construction costs higher, would become difficult to recover as the income it could earn by selling the power it generates would be reduced, therefore making its business less feasible.

Nevertheless, as of the end of May 2017, Japan has plans to build 42 new coal-fired generation units (approx. 18.6 GW)[1]. Behind the move lies the current "Basic Energy Plan," a revised version formulated in April 2014, after the disaster at TEPCO's Fukushima Daiichi Nuclear Power Plant in March 2011 (hereinafter the "Fukushima Nuclear Disaster"). The Plan ranks coal-fired power generation as "an important base-load power source superior in terms of stable supply and economic efficiency." The Plan served as an "imperial charter" for a growing number of new coal-fired power units that were planned for construction as a substitute for nuclear power plants and in response to the expected growth of demand for electricity in the future, as well as for the purpose of securing inexpensive power sources needed amid the liberalization of the electricity market by the new and existing power utilities to advance into other service areas.

However, amid the global shrinkage of coal business, Japan, an economy that has been promoting coal-fired power generation, also seems quite likely to experience rapid declines in the capacity factor of coal power plants, as a result of excessive investment in capacity, improved energy efficiency, and growth of renewable energy. The first sign of change has already been seen: the current conditions in the electricity market have changed, at least in part, from those which power companies and others probably assumed when they made a plan to construct new coal-fired power units.

Over the past five years, the Japanese economy has been growing with a 10% decline in the demand for electricity. Japan is experiencing the same decoupling between economic growth and energy demand as other developed economies. It is generally believed that declines of power generation after the shutdown of nuclear power plants are compensated by thermal power stations. However, in 2015 more than half of the decreased output was made up for with greater energy efficiency and renewables[2].

This report examines in depth the current state of, and outlook for, power supply and demand, a critical factor for exploring economic viability of thermal power sources, from the viewpoint of their impact on investment in them, before analyzing risks of investment in coal-fired plants in particular.

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[1] The total of figures found in releases of power companies, the MOE's materials on environmental assessment, news reports, Coal Plant Tracker, etc. It does not include those of the figures mentioned in "Coal Business and Policy Trends ―What Japanese investors should know after the Paris Agreement," published in October 2016 (48 units for 22.8 GW), which were found in plans that have been canceled since the publication and plans that have yet to be officially announced (but have been reported by the press). The capacity of a plant put into operation in September 2016 is included.

[2] See the column by Renewable Energy Institute, "How Japan has managed to substitute nuclear power and the trade balance consequences," 8 March 2017, co-authored by Romain Zissler, Tomas Kåberger, & Amory Lovins.

1. Status of electricity supply and demand since 2011

1.1 Improved energy efficiency and decrease in electricity demand

In Japan, demand for electricity peaked in 2010, trending down after that year (Figure 1). Especially with increases in electricity rates and improved energy efficiency after the Great East Japan Earthquake, electricity sales of former General Electricity Utilities (GEUs) and Power Producers and Suppliers (PPSs) combined have decreased by almost 10% in only five years, from 931.1 TWh in FY 2010 to 841.5 TWh in FY 2015[3].

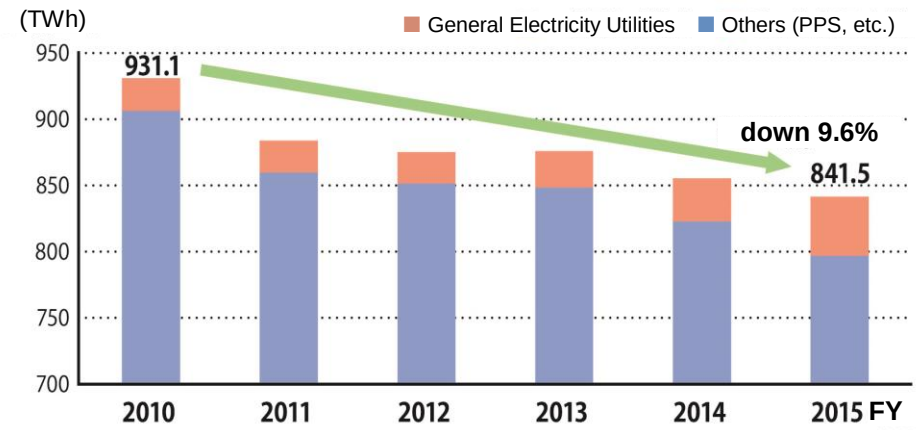


Figure 1 Annual electricity sales

Source: Adapted from 'Electric Power Investigation Statistics,' METI.

Annual peak demand for the former GEUs, typically recorded in summer, has also fallen by 19%, from 179.87 GW in 2010 to 146.41 GW in 2016. Even when a shift of demand to PPSs after the electricity liberalization is taken into consideration, this is a 12% decline from the 2010-level.

Figure 2 compares peak demand forecast made by electricity utilities for summer and actual peak loads. In each of the five years since 2012, when forecasts and actual results were reviewed and released for the first time, the actual demand was much smaller than forecast, by 5.19 to 13.33 GW. This demonstrates that since the Great East Japan Earthquake, energy efficiency has been improved faster than forecast by the national government or electricity utilities.

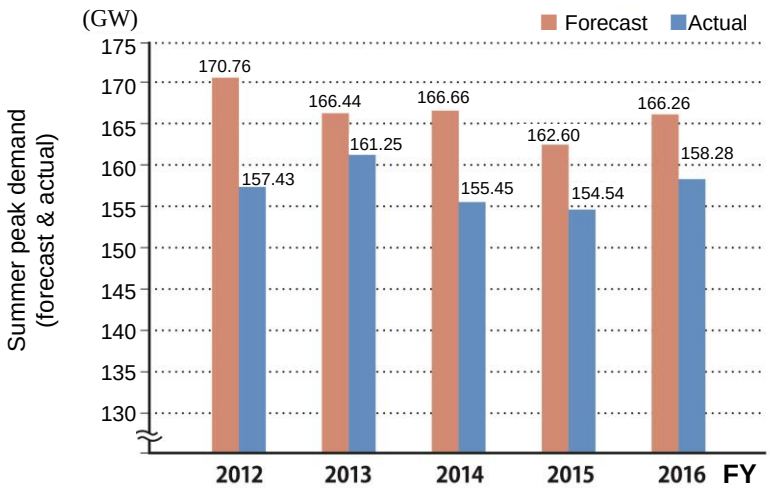


Figure 2 Annual peak electricity demand in summer: Forecast & Results

Source: Adapted from reports produced by the Electricity Supply-Demand Review Meeting, Energy and Environment Council, and the Electricity Supply-Demand Verification Sub-committee, Advisory Committee for Natural Resources and Energy.

(Note) For 2012 - 2015: Data for nine former GEUs only; For 2016: Date for the service areas of the nine electric utilities;

[3] The preliminary report shows that electricity sales in FY 2016 increased by 1.5% on a year-on-year basis. However, caution is needed for comparison with figures for previous years, as significant changes were made to the Electric Power Investigation Statistics since FY 2016.

Despite decreases in power consumption, Japan's real GDP has been growing roughly at an annual average of 1% since FY 2010. Other developed economies have also experienced growth despite decreased energy demand. Japan is not an exception. The conventional assumption that any economy grows with increases of energy consumption no longer holds true.

1.2 Drastic change of the status of electricity supply

1.2.1 Significant increase in renewable energy

After the Fukushima Nuclear Disaster, the state of electricity supply has been changing considerably. A major change can be found in the Feed-in Tariff (FIT) system, put into effect in July 2012, and consequent rapid development of renewable power plants, mainly solar PV stations, and increases in the amount of electricity generated. Renewable plants doubled their capacity from 30.7 GW at the FY 2010-end to 61.37 GW at the FY 2015-end. The ratio of renewable energy in total electricity generated and purchased rose by six percentage points in the six years from FY 2010[4], from 8. 9% to 15.0%.

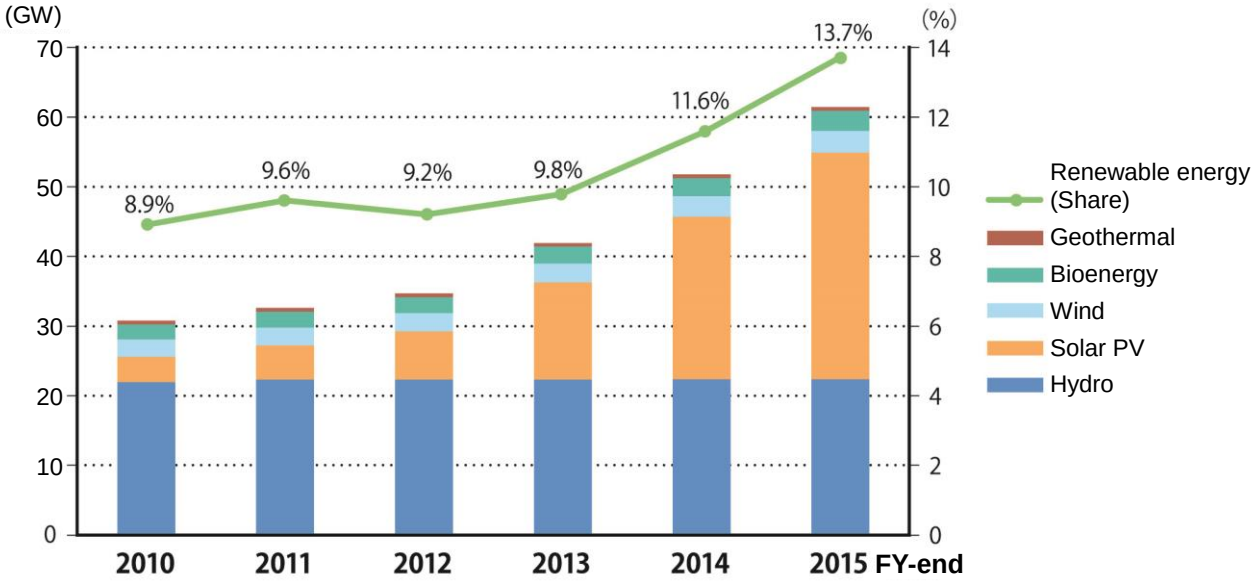


Figure 3 Cumulative installed capacity for renewables, and their shares in electricity generated and purchased

Source: Adapted from: the Agency for Natural Resources and Energy, 'Facilities Approved under the RPS Act,' 'Renewable Energy Facilities Installed,' and 'Survey for Potential Hydro Power'; NEDO (2016) "Installed capacity of Wind Power Plants in Japan"; and Thermal and Nuclear Power Engineering Society (2016), 'Present and Future of Geothermal Generation (2015).'

Solar PV located in the service area of Kyushu Electric Power Company have a larger installed capacity than in any other area in Japan. On April 30, 2017, they output a total of 5.65 GW, meeting 73% of the demand that day, or 7.7 GW. On April 23, 2017, Shikoku Electric Power Company announced that in its service area, solar PV plants recorded an output of 1.61 GW, temporarily reaching 66% of the area demand[5]. These records were documented when power demand is seasonally smaller, but they nevertheless indicate a steadily growing presence of renewables.

[4] The figure shows installed capacities for renewables until the FY 2015-end, as the numbers as of the FY 2016-end have yet to be released.

[5] Shikoku Electric Power Company "Regular Press Conference of the President: Overview," released on May 24, 2017; The Denki Shimbun, June 2, 2017, etc.

1.2.2 Decrease in nuclear power generation

Another major change that took place on the side of electricity supply after the Fukushima Nuclear Disaster is a sharp decline in the supply capacity of nuclear power plants. As of July, 2017, it has been decided that 12 reactors, including those in the Fukushima Daiichi Nuclear Power Plant, will be decommissioned. The remaining reactors are allowed to be restarted only after passing an examination conduced according to revised regulatory standards and obtaining the consent of the local authorities in which they are located. This resulted in all the reactors installed in Japan to be shut down for 22 months between October 2013 and July 2015. The nuclear power plants, which had filled around 30% of the domestic demand before the Great Earthquake, lost their entire supply capacity.

As of July 2017, 12 reactors, at six plants operated by Kansai, Kyushu, and Shikoku Electric Power Companies, have already successfully passed an examination. Five of them have so far gotten restarted,[6] while the other seven are now going through a pre-operation test and other procedures. At the same time, 14 reactors, including one at the Oma Nuclear Power Plant (still under construction), have seen applications filed to the Nuclear Regulation Authority for conformity examination under the new regulatory standards. 18 reactors, including the Shimane-3 Reactor (still under construction), have yet to present applications to the Authority. While a few plants have restarted, the share of nuclear power plants in total electricity generated in FY 2016 was still less than 2%.

Table 1 Current status of nuclear power plants

Status	No. of units	Name of power plant
Decommissioned	12	Mihama 1&2, Ikata 1, Genkai 1, Shimane 1, Tsuruga 1, Fukushima Daiichi 1-6
Application yet to be filed	18	Onagawa 1&3, Kashiwazaki Kariwa 1-5, Fukushima Daini 1-4, Hamaoka 5, Shiga 1, Oi 1&2, Shimane 3, Ikata 2, Genkai 2
Under examination	14	Tomari 1-3, Totsu 1, Onagawa 2, Kashiwazaki Kariwa 6&7, Hamaoka 3&4, Shiga 2, Shimane 2, Tokai Daini, Tsuruga 2, Oma
Permission granted	7	Takahama 1&2, Mihama 3, Genkai 3&4, Oi 3&4
In operation	5	Takahama 3&4, Ikata 3, Sendai 1&2

Source: Adapted from materials released by The Federation of Electric Power Companies of Japan

1.2.3 Downward trend of thermal power generation and decline in their capacity factor

The amount of electricity generated by thermal power plants increased for some time after the Fukushima Nuclear Plant disaster and consequent shutdown of the other nuclear plants. However, the amount has fallen recently with decreases in electricity demand and increases in power generated from renewables.

Of particular note for thermal power plants is remarkable declines of their capacity factor. The capacity factor of a generation plant indicates how much of its capacity the plant effectively uses during a certain period of time, or the ratio of the electricity actually generated during the period when the plant is operating at full load. The annual capacity factor is defined by the formula below:

[Annual capacity factor (%)] =
[Actual annual amount of electricity generated (kWh)] / {[Rated capacity (kW)] × 365 (days) × 24 (hrs.)} × 100

While the capacity factor of thermal power plants rose to 62% in FY 2012 to make up for the reduced supply capability of nuclear power plants, it has turned to a declining trend since FY 2013, two years after the Great East Earthquake, with improvements in energy savings and efficiency and the increase in renewable energy. The figure dropped to 53% in FY 2016 (**Figure 4).**

[6] The No. 3 and No. 4 Reactors of the Takahama Plant, Kansai Electricity Power Company had been shut down since Otsu District Court issued an order to prohibit their restart on March 9, 2016. No. 4 was brought into operation on May 17, 2017, followed by the No. 3, which got restarted on June 6.

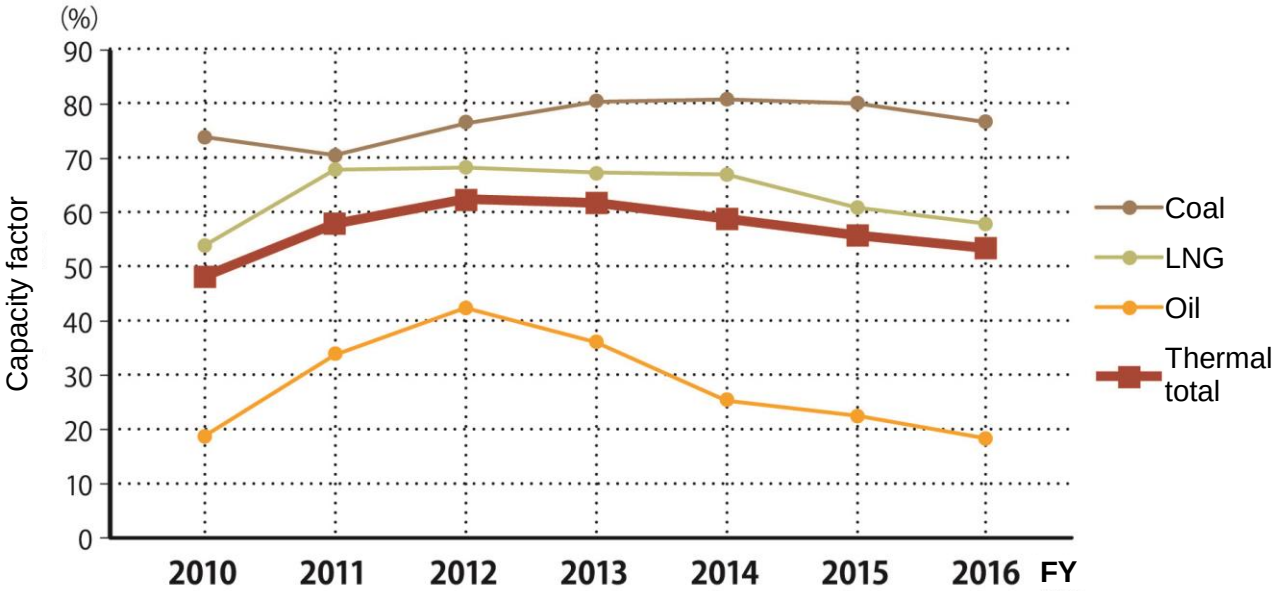


Figure 4 Capacity factors of thermal generation facilities among the former General Electricity Utilities

Source: Adapted from "The Annual Report on Energy," ANRE of METI, and "The Electricity Supply Plan," OCCTO

Among power plants using different fuels, the capacity factor of oil-fired plants peaked in FY 2012 and then fell sharply. Gas-fired power plants (LNG) also saw their capacity factor peak out in FY 2012 before starting to fall rapidly in FY 2014. Coal-fired plants as well entered a downward phase in FY 2014, seeing a faster decline in FY 2016. It is believed that thermal power plants are halted in descending order according to fuel price; first oil, and then gas and coal.

The next section examines the declines in capacity factor among existing thermal power plants in detail.

1.2.4 Analysis of operation hours of thermal power plants – Background of decline in capacity factor

Requested by the Organization for Cross-regional Coordination of Transmission Operators (hereinafter "OCCTO")[7] to release their actual hourly electricity supplies, power utilities started for the first time in April 2016 to offer detailed actual supply results. Using data currently made available by power companies, or annual actual electricity supplies of thermal power plants in FY 2016, this chapter analyzes their operation hours.

Among thermal power plants, coal-fired and coke oven gas stations run on relatively inexpensive fuels. Combined cycle gas-fired plants are more efficient than other types of thermal plants (oil-fired and older-type gas fired-ones), working with a smaller running cost. For greater profitability of the power sources, electricity companies hope to keep their capacity rate as high as possible.

However, as explained further on, our analysis has revealed that all nine power companies whose electric power systems are connected face difficulties in maintaining the capacity factor at a high level for their coal-fired power plants, coke oven gas plants, and combined cycle gas fired power plants.

[7] Organization for Cross-regional Coordination of Transmission Operators, Japan, (OCCTO) was established in April 2015 as STEP 1 of Electricity System Reform to pursue three purposes - securing stable electricity supply, suppressing electricity rates to the maximum extent possible, and expanding choices for consumers and business opportunities. The Organization has been implementing the operation management with fairness and neutrality as an authorized organization that all Electric Power Companies have obligation to enter. (cited from OCCTO website)

The services areas of Tokyo and Kyushu Electric Power Companies are first examined below, as the former has the largest generation capacity planned for new coal-fired plants to be constructed and the latter has the highest increase in solar PV capacity. Following this, findings from the examination of all of the nine power utilities are presented.

Figure 5 shows a curve composed of actual hourly amounts of power generated by thermal plants in TEPCO's service area in the year from April 2016 through to March 2017 (8,760 hours = 365 days x 24 hours), lined in descending order. It indicates that in the service area, the largest hourly electricity produced by thermal plants during the period reached 42.76 GW, dotted on the left end of the curve, while the smallest turned out to be 15.1 GW, seen at the right end.

In the area, coal-fired, coke oven gas, and combined cycle gas fired power plants have a total capacity of 27.30 GW. As seen in the Figure, the actual output of all the thermal power plants, shown by the curve, stayed above 27.30 GW only for 4,469 hours, the left-side part of the chart, among 8,760 hours, or 51% of the total hours. During the remaining hours, even if all the oil-fired and older-type gas-fired plants had been halted, coal-fired and combined cycle gas plants would have been unable to operate at 100% of their rated capacity (full-load operation).

At present, the TEPCO's service area has plans to build new coal-fired and combined cycle gas power units with a total capacity of more than 10 GW. Once all the new generation units are completed as planned, with an upward shift of the capacity by 10 GW, as indicated by the up-pointing arrow on **Figure 5**, coal-fired, coke oven gas, and combined cycle gas fired thermal plants in the area would be able to operate full-load for fewer hours, as little as 130 hours. Decreased hours of potential full-load operation, as stated above, should result in a smaller annual rate of operation among the plants.

As explained in more detail in the section "3.3 Impact of thermal power facility expansion on the feasibility," plans to build new coal-fired units seem to assume a capacity ratio of 70% in examining their economic feasibility. The fact that existing thermal power plants are barely able to operate at full load for only half the potential full-load hours, with a prospect of further declines as a result of construction of more new units, implies they are very likely to fail to secure a capacity factor that allows them to operate above a breakeven line.

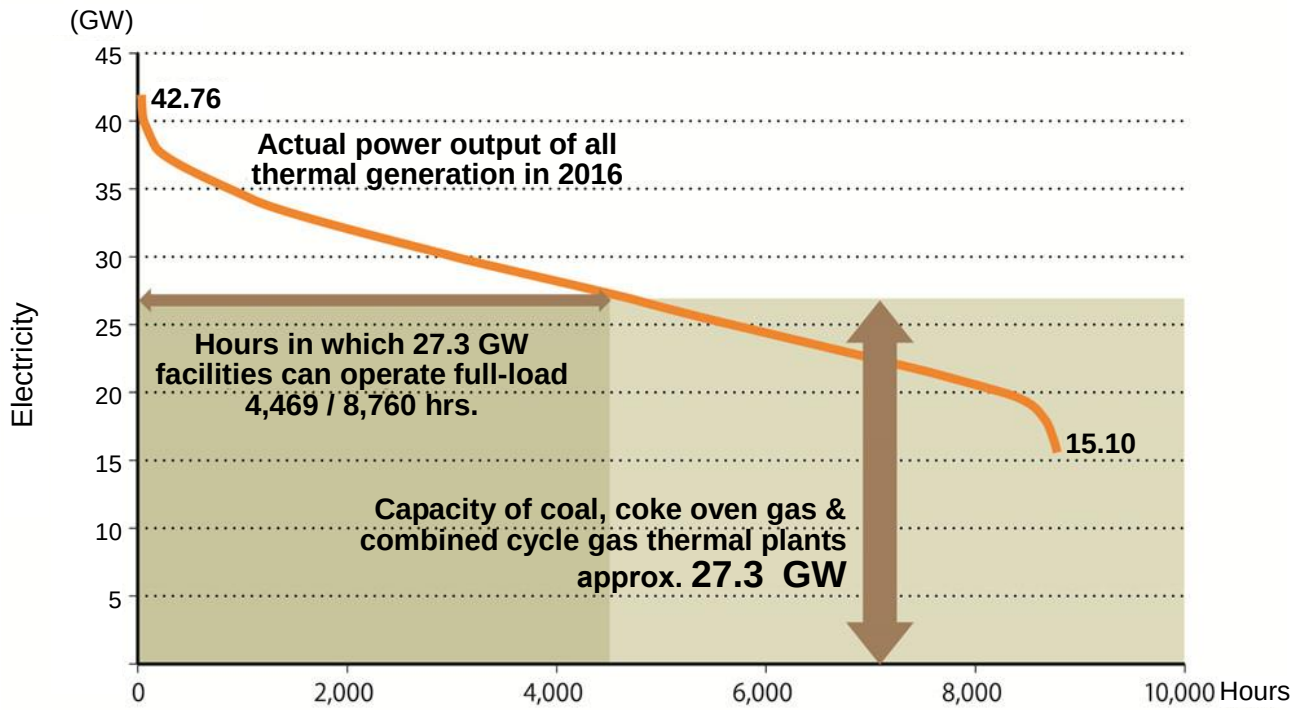


Figure 5 The decline in the capacity factor of thermal power plants in Tokyo Electric Power's service area in FY 2016: Empirical analysis

Source: Adapted from supply and demand data for Tokyo Electric Power's service area.

Note: The capacity above include which Tohoku Electric Power purchased from J-Power's Isogo, and Joban Joint Power, among others, and exclude which TEPCO purchased from thermal plants located out of its service area, such as Soma Kyodo Power Company.

Figure 6 also shows the capacity and output in the service area of Kyushu Electric Power. Actual output of all the thermal power plants stayed above the total capacity of coal-fired, coke oven gas, and combined cycle gas-fired plants, 9.9 GW, for much fewer hours than in TEPCO's service area, less than 20% of annual operation hours (1,703 of 8,760 hours).

One of the factors lying behind these results is the promotion of energy efficiency, reflected by a 13% decline in the amount of electricity generated and purchased by Kyushu Electric between 2010 and 2015, as well as growth of solar PV, which pushed up the share of renewable electricity.

Meanwhile, in Kyushu Electric's service area, one or two of the Sendai Nuclear Plant's reactors were in operation in FY 2016 (one between October 2016 and February 2017, and two during the remaining period). Once the Genkai Nuclear Power Plant, which has already passed the examination of the Nuclear Regulation Authority, comes back into operation, supplies from thermal power plants will further decline, because under the current operation rules nuclear plants have precedence in supply. The possible restart of nuclear power generation, as well as enhanced energy efficiency and greater deployment of renewables, will have great influence on commercial feasibility of new thermal power units to be constructed in the service area with a capacity of almost three GW.

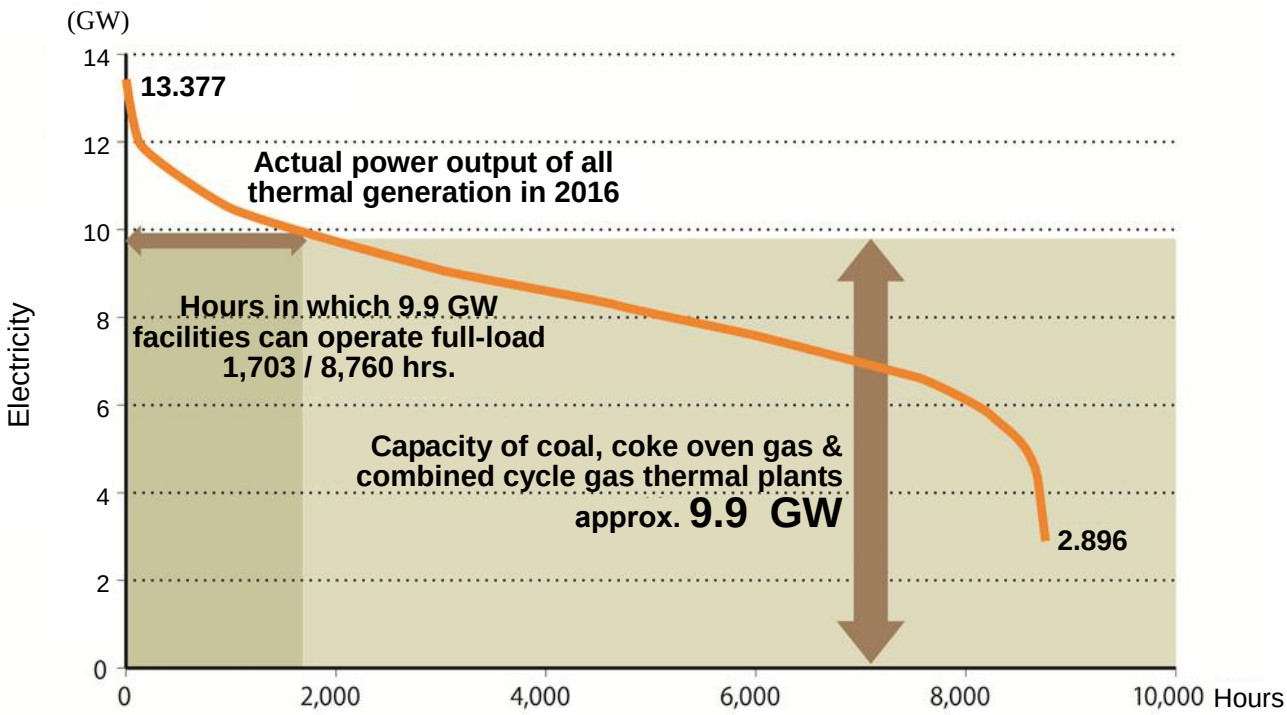


Figure 6 The decline in the capacity factor of thermal power plants in Kyushu Electric Power's service area in FY 2016: Empirical analysis

Source: Adapted from supply and demand data for Kyushu Electric Power's service area.
Note: The capacity above include those other companies purchased from J-Power's Matsuura and Matsushima Thermal Power Plants.

Figure 7 shows findings of data analyses conducted on utilization of thermal power plants in all the other power utilities' service areas in the same manner as for Tokyo and Kyushu Electric Powers', or percentages of hours in which actual output of thermal plants stayed above the capacities of coal-fired, coke oven gas, and combined cycle gas fired plants combined (potential full-load hours).

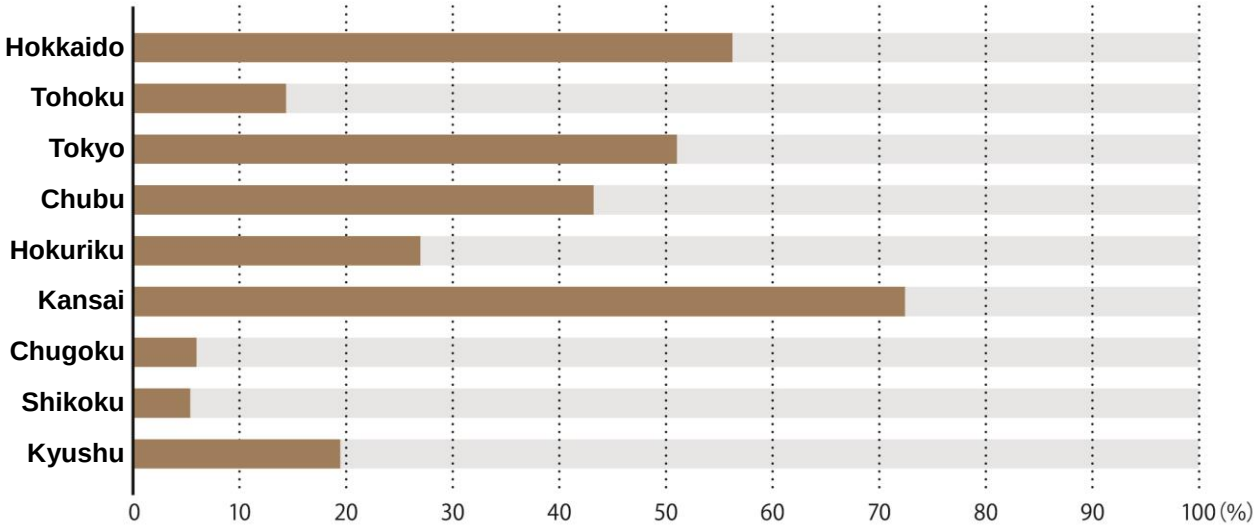


Figure 7 Percentages of potential full-load hours for coal-fired, coke oven gas, and combined cycle gas fired plants: Actual output data for FY 2016

Source: Produced by Renewable Energy Institute.

Note: The percentage for Kansai Electric Power's service area will fall below 50% once any of its nuclear power units comes back into operation. (See 3.1.3 of this report.)

Potential full-load hours went above 50% of 8,760 hours among only three power companies, Hokkaido, Tokyo, and Kansai Electric Powers, while the percentage is lower than 30% among five, Tohoku, Hokuriku, Chugoku, Shikoku, and Kyushu Electric Powers. Underlying factors behind these results are enhanced energy efficiency and growth of renewables, which hold down electricity demand, as well as output control conducted mainly in the daytime in spring and fall, when solar PV plants have high output.

The analysis above is on actual results of FY 2016, and any future advancement of energy efficiency, growth of renewables, and restart of nuclear plants, as well as other factors, would reduce potential full-load hours of coal-fired plants from the current level. (How much Kansai Electric, an electricity company that has the largest potential full-load hours at the moment, will be influenced once the Takahama Nuclear Power Plant gets restarted will be examined in the analysis mentioned later in 3.1.3.)

Besides these factors, if new coal-fired power units will be built, the hours in which the facilities can operate full-load including the new units, will further decline, resulting in a smaller annual capacity factor.

2. Outlook for the future electricity supply and demand

Based on the current state of electricity supply and demand seen in the previous chapter, this chapter examines the future outlook for electricity supply and demand with reference to data and materials offered by the national government and the Organization for Cross-regional Coordination of Transmission Operators, Japan (OCCTO) and its influence over commercial viability of newly constructed thermal power units.

2.1 Outlook for electricity demand

The Ministry of Economy, Trade and Industry estimates future growth of electricity demand in the "Long-term Energy Supply and Demand Outlook" (2015), which states "...while estimating an increase in electric power demand due to economic growth and higher electrification rate, thorough energy efficiency and conservation (power-saving) will be promoted to suppress power demand in FY 2030 to nearly the same level as in FY 2013." As seen in **Figure 1**, demand for electricity (electric power sales) in FY 2015 was around 4% smaller than that in FY 2013, suggesting that actual long-term demand may fall under the long-term supply and demand outlook.

Peak demand, as seen in **Figure 2**, has also been marking sharp declines since the Fukushima Nuclear Disaster. In the "Long-term Cross-regional Network Development Policy" it announced on March 30, 2017, the OCCTO forecasts future peak electricity demand based on recent data released by power utilities. The Long-term Policy, stating "Electricity power demand had been constantly growing since the period of post-war reconstruction and rapid economic growth until peak load reached 182.7 GW (total of the 10 service areas) in FY 2001, a record which has not yet been broken," forecasts "peak demand (summer time) will grow rather slowly, at an annual average of 0.2%, for the next ten years."[8]

As seen above, neither the national government nor the OCCTO expects any large growth in annual demand or peak load.

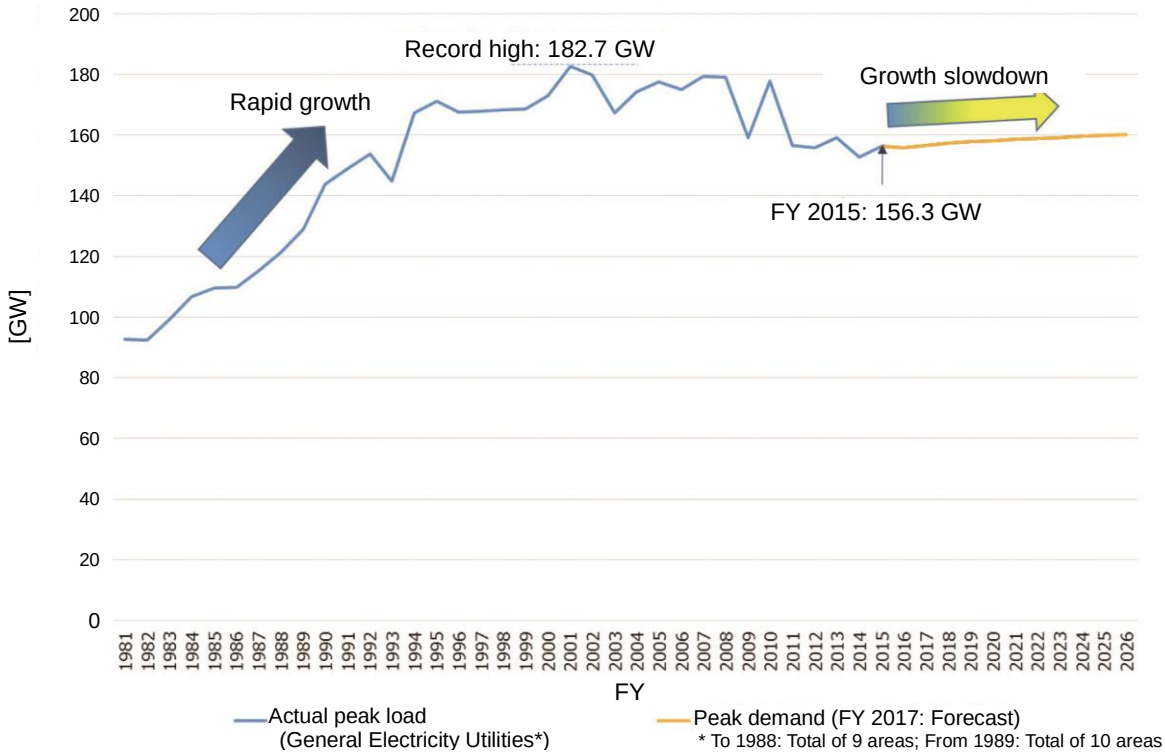


Figure 8 Peak load

Source: OCCTO, "Long-term Cross-regional Network Development Policy" (2017), p. 4

[8] This is after "... taking into consideration factors that depress demand, such as future progress in energy conservation and saving, and population declines, and those which push up demand, such as growth of the economy"

2.2 Outlook for electricity supply

The OCCTO report "Aggregation of Electricity Supply Plans for FY 2017" (hereinafter the "Electricity Supply Plan"), released on March 30, 2017, the OCCTO summarizes supply plans presented by the electric utilities around Japan to the organization in order to provide a long-term outlook of power supply until FY 2026. The Electricity Supply Plan indicates that the supply capacity will stay above national electricity demand (peak load) during the whole period, and that the reserve margin[9] will keep fairly above 8%, or the value considered as appropriate (**Figure 9**).

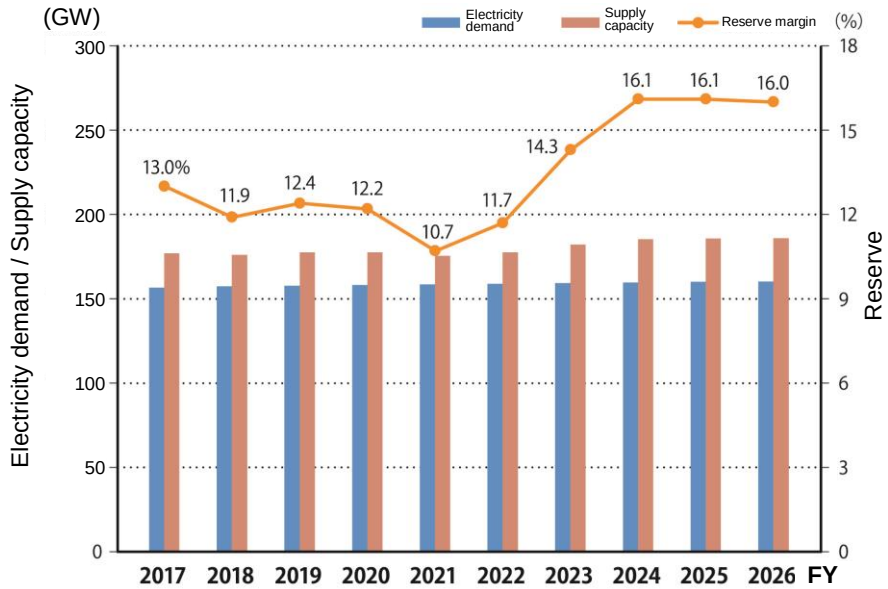


Figure 9 Medium- and long-term forecast of supply and demand balance (national total of service-area demand in August; transmission-end)

Source: Adapted from the OCCTO, "Aggregation of Electricity Supply Plans for FY 2017."

Planned supply capacity of solar PV and other renewable electricity plants will grow by 52% from 68.4 GW in FY 2016 to 103.9 GW in FY 2026 (total of conventional hydro, wind, solar PV, geothermal, and biomass generation mentioned in the Electricity Supply Plan). Among the thermal power plants, increases in the capacity of coal and gas-fired (LNG) stations, 8.33 and 6.00 GW, respectively, and a decreased capacity of oil-fired stations, 2.32 GW, will add up to an increase of 12.02 GW in the total capacity.

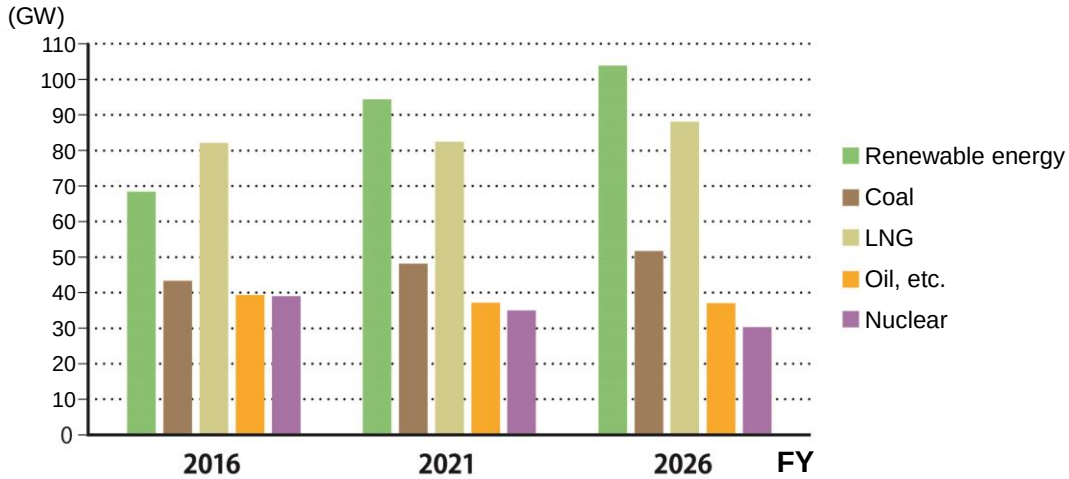


Figure 10 Electricity mix (national total)

Source: Adapted from "Aggregation of Electricity Supply Plans for FY 2017" by OCCTO

[9] "Reserve capacity" refers to part of supply capacity which is maintained as a surplus over demand to supply power with some spare. Reserve margin is defined as a ratio of reserve capacity to demand, represented as: [Reserve margin] (%) = [Reserve capacity] x 100 / [Expected peak load]

As for the amount of electricity produced by fuel type, while the total amount of power generated in FY 2026 (kWh) is expected to remain unchanged from FY 2016, renewable electricity will grow by 40%. Coal-fired plants will produce almost the same amount of electricity, although thermal power plants in total will produce 15% less (**Figure 11**).

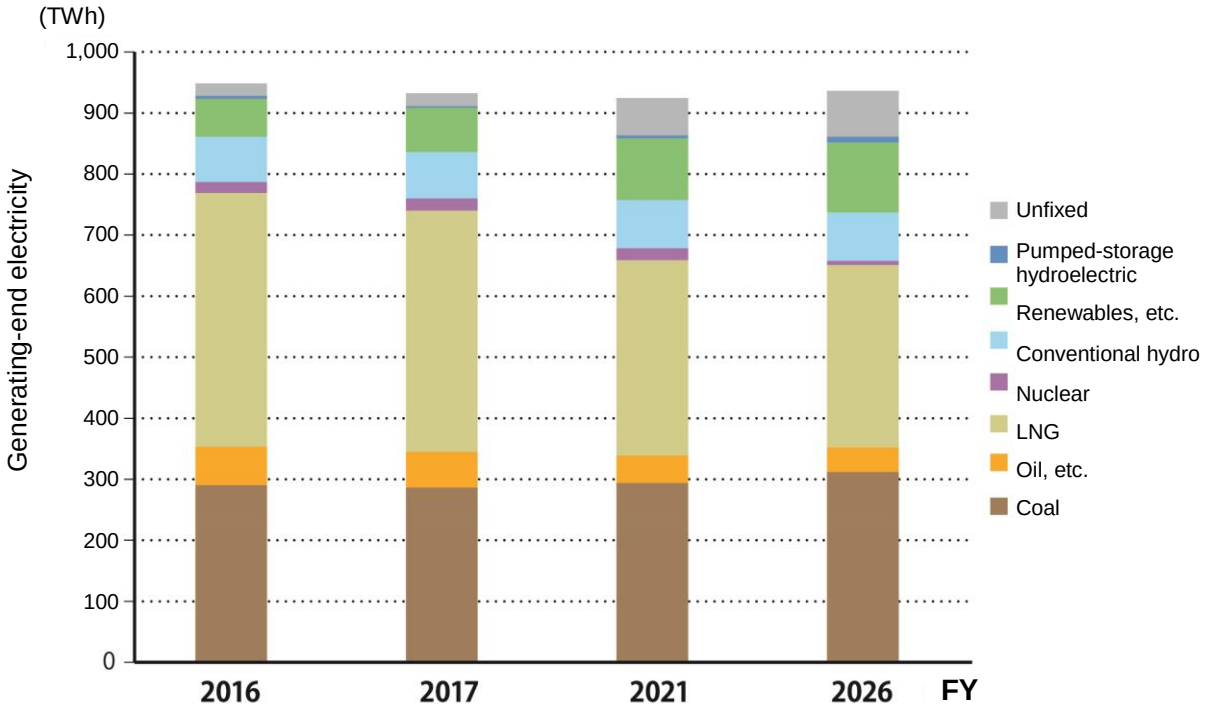


Figure 11 Amount of electricity produced by source (national total)
Source: Adapted from the OCCTO, "Aggregation of Electricity Supply Plans for FY 2017."

What should be noted here are changes in the capacity factor of thermal-power plants. For gas-fired plants, the figure will fall by more than 20 percentage points to 40% in FY 2026. For coal-fired plants, the factor, currently remaining high, will fall below 70% by FY 2026, when most of the generation units now planned will come into operation.

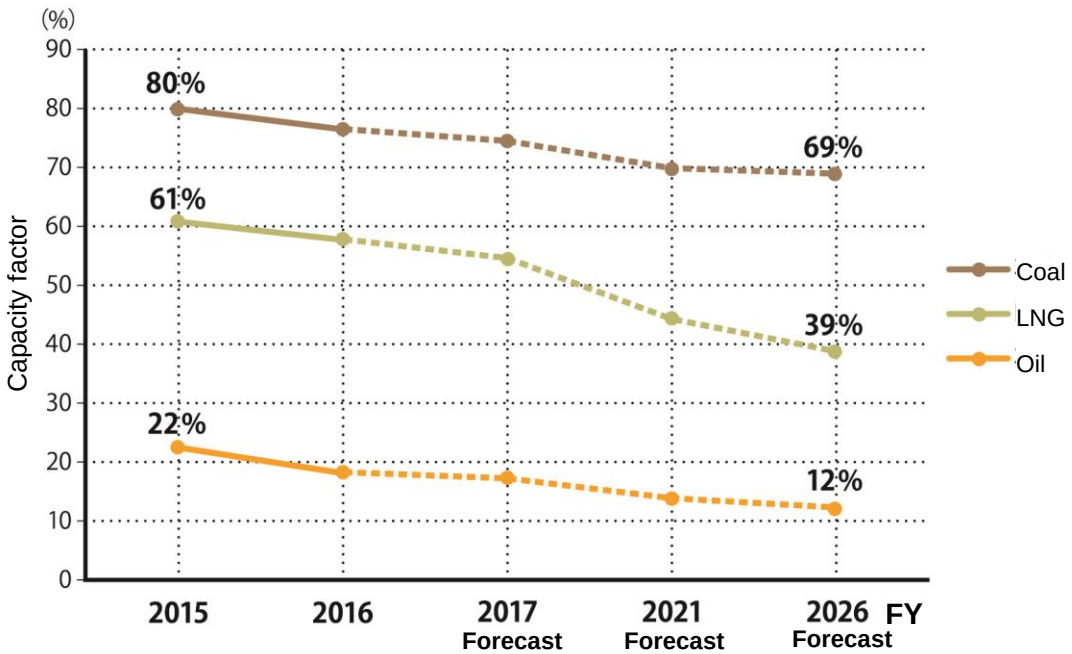


Figure 12 Actual and forecast capacity factors of thermal power plants (national total)
Source: Adapted form ANRE of METI, "The Annual Report on Energy" and "Electric Power Investigation Statistics," and OCCTO, "Aggregation of Electricity Supply Plans for FY 2017."

The “Guidelines for Transmission and Distribution Operations” the OCCTO set in July 2016 states that once electricity supplied to the grid exceeds demand, thermal power plants are the first that must reduce production, followed by biomass, renewable variable power sources (solar PV and wind), and long-term fixed sources (nuclear and hydropower, excluding pumped-storage hydroelectric).

The data shown in OCCTO’s Electricity Supply Plan clearly indicates that greater deployment of renewable energy and enhanced capacity of thermal power plants amid slowing growth of demand force thermal power plants to curtail their output as stated in the Guidelines, resulting in their capacity factor continuing to trend down until 2026.

The next chapter reviews assumptions adopted for the Electricity Supply Plans in terms of capacity of individual power sources to indicate the possibility of further declines in the capacity factor among thermal power plants.

3. The decline in the capacity factor of coal-fired power plants and its effect on the feasibility

3.1 Assumption in the Electricity Supply Plan – Factors to influence the capacity factor of coal-fired power plants

The capacity factor presented in the Electricity Supply Plan for coal-fired power plants is determined based mainly on assumptions regarding capacity of individual power sources. This section examines, among others, what the Electricity Supply Plan assumes about renewable, coal-fired, and nuclear power sources, and how the assumptions should be assessed in reference to the current conditions and future prospects of the individual power sources.

3.1.1 Possibility of expansion of renewable energy power sources

As stated before, the Electricity Supply Plan presented by the OCCTO forecasts that in FY 2026, renewable power generation facilities will have a capacity of 103.9 GW, an increase of approx. 35 GW from 68.41 GW in FY 2016. However, as shown below, the forecast seems based on overly conservative assumptions for the trend of actual deployment of solar PV and wind power generation.

In terms of growth of renewable power plants expected under the FIT scheme, projects with a total capacity of 32.2 GW have already been approved under the FIT Act as of the end of February 2016, and are ready to go forward (Figure 13). The figure includes only the capacity of facilities that have already been approved but have yet to run, and excludes the capacity of projects which have at one point obtained approval but have been nullified under the revised FIT Act when it came into effect on April 1, 2017, or a provisionally estimated 27.66 GW. In addition, approved facilities that have already come into operation as of the end of February 2016 amount to 34.78 GW, meaning that the total capacity of approved facilities reaches 66.98 GW. With the capacity of large-scale hydro plants (12.69 GW) and other renewable sources already introduced before the FIT scheme (20.6 GW) added, the total already reaches 100.27 GW. This represents a capacity that will be attained in near future almost for certain, and by itself almost equals the capacity the Electricity Supply Plan forecasts, 10.39 GW. In fact, more new solar PV and wind power plants should obtain approval, and are likely to provide additional capacity that will constitute an excess over the forecast presented by the Electricity Supply Plan. The potentials are examined below.

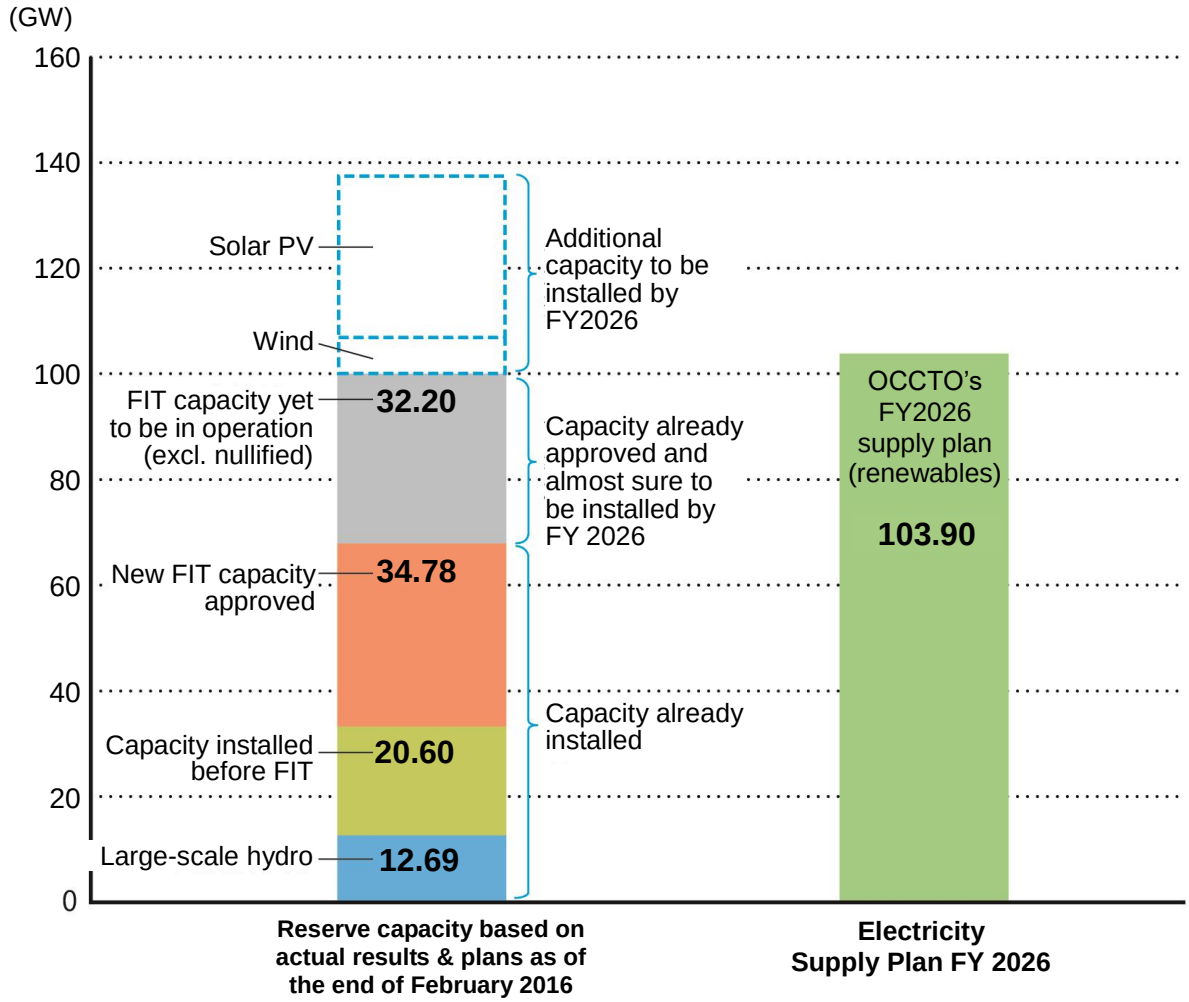


Figure 13 Possible installation of renewable energy: Comparison between the Electricity Supply Plan (FY 2026), and capacity already installed plus capacity approved for FIT but yet to come into operation (as of the end of February 2016)

Source: Adapted from data and materials released by ANRE of METI, JWPA, and RTS Corporation.

Note: In the additional capacity assumed to be installed by FY 2026, "Wind" represents an estimated capacity of projects yet to be approved for FIT, or a capacity of 10.49 GW for projects under development at the end of FY 2016 (estimated by JWPA) less a capacity of 3.83 GW for those already approved for FIT but yet to come into operation as of the end of February 2016. "Solar PV" refers to an FY 2026 forecast presented by RTS Corporation under a scenario of current-pace growth (81.92 GW) less capacity already installed and those approved for FIT but yet to come into operation.

Among renewable facilities, the Electricity Supply Plan forecasts solar PV will increase by 31.02 GW in ten years from FY 2016 to 71.62 GW in FY 2026.

However, this might be an underestimation. Of the total capacity of renewable energy projects already approved for FIT but yet to come into operation as of February 2016, solar PV (50.13 GW) accounts for 84%. Meanwhile, 27.66 GW of renewable energy projects will have their approval nullified under the revised FIT Act, as mentioned before. Should 84% of that nullified capacity, 23.15 GW, were solar PV, the solar PV projects with valid FIT approval and likely to come into operation would be 26.98 GW (50.13 GW less 23.15 GW). This alone accounts for almost 90% of the increase assumed in the Electricity Supply Plan (31.02 GW).

Between April 2016 and the end of February 2017, solar PV projects with a capacity of 3.13 GW were granted new approval. Should new approval also be given for an additional capacity of three GW every year from FY 2017, the total in ten years until FY 2026 would reach 30 GW. Together with a newly installed capacity of 26.98 GW, estimated above based on the capacity approved so far, total solar PV capacity would reach approx. 57 GW. Compared with the estimate, the increase in capacity by FY 2026 the Electricity Supply Plan assumes in its forecast by FY 2026 seems too small.

Future development of solar PV has been estimated by RTS Corporation, a leading solar PV consulting firm in Japan, under two scenarios, "current-pace growth" and "accelerated development."[10] The "current-pace growth" scenario assumes that with no additional measures specifically taken, policy programs, deregulation, technical development, and other conditions will continue on their present paths. The "accelerated development" scenario expects further decline in cost and removal of grid constraints, as well as adoption of more ambitious policy programs, rapid advance in deregulation, and smooth development of related technologies. RTS Corporation estimates that under the "current-pace growth" and "accelerated development" scenarios, installed capacity will reach 81.92 and 97.62 GW by FY 2026, respectively. Even the capacity estimated under the former scenario would be larger than the forecast of the Electricity Supply Plan, 71.62 GW, by almost 10 GW.

As shown here, the Electricity Supply Plan presents too conservative a forecast of installed capacity for solar PV plants in comparison with the actual progress of new approvals after April 2016 and estimates given by RTS Corporation.

Meanwhile, the Electricity Supply Plan forecasts that wind power capacity will reach 7.74 GW in FY 2026, up 4.04 GW from FY 2016, which is argued to be a too conservative estimate, as well. JWPA estimates that 3.38 GW of wind power plants had already come into operation as of the end of FY 2016, while several projects with a total of 10.49 GW are now under development. Combined, they amount to 13.87 GW.

Taking into account the trend of solar PV and wind power generation shown here, actual renewable generation capacity installed as of FY 2026 are quite likely to go beyond 103.9 GW, the forecast presented by the Electricity Supply Plan.

3.1.2 Plan to expand coal-fired power plants twice as much as assumed

In its Electricity Supply Plan, the OCCTO estimates the capacity of coal-fired facilities in FY 2026 at 51.68 GW, an increase of 8.33 GW from FY 2016. However, power companies and other entities have published plans to build new coal-fired power units with a total capacity of 18.6 GW, of which 18 GW are to come into operation by FY 2026, while they plan to decommission generation units with a capacity of 1.51 GW. If new generation units are built as planned, coal-fired generation capacities will increase by 16.49 GW (18 GW less 1.51 GW) by FY 2026. This is double the increase estimated in the Electricity Supply Plan (8.33 GW). Construction of new power generation units are planned all around Japan, as shown below in **Table 2** and **Figure 14**.

[10] RTS Corporation "Forecasting PV installed capacity in Japan toward FY 2020 and FY 2030 (2017 annual report)"

Table 2 Thermal power plants of former General Electricity Utilities (existing and planned new capacity) (MW)

	Total	Coal			LNG			Oil	Coke oven gas
	Existing	Existing	Construction plan	To be decommissioned	Existing	Construction plan	To be decommissioned		
Hokkaido Electric Power	4,490	2,430	110	0	0	1,710	0	2,063	0
Tohoku Electric Power	14,480	6,170	3,800	0	7,010	600	0	1,300	0
Tokyo Electric Power	43,160	6,575	5,780	0	28,950	5,540	2,400	5,478	2,153
Chubu Electric Power	23,420	4,371	1,320	0	16,720	2,380	0	2,326	0
Hokuriku Electric Power	4,400	2,900	0	250	0	420	0	1,500	0
Kansai Electric Power	18,500	3,763	2,500	500	10,290	3,700	0	4,015	430
Chugoku Electric Power	10,640	3,866	3,300	600	2,380	0	0	2,932	1,465
Shikoku Electric Power	6,220	3,935.6	500	160	940	150	0	1,350	0
Kyushu Electric Power	13,740	5,760	1,280	0	4,550	1,600	0	2,000	1,430
Okinawa Electric Power	2,120	1,064	0	0	540	0	0	520	0
Total	141,170	40,830	18,600	1,510	71,370	16,100	2,400	23,480	5,480

Source: Adapted from "Aggregation of Electricity Supply Plans for FY 2017," OCCTO, data and materials from Electricity Supply-Demand Review Meeting and Working Group for Grid, Energy and Environment Council, "Electricity Business Handbook" (Denki-jigyo Binran), FEPC, etc.

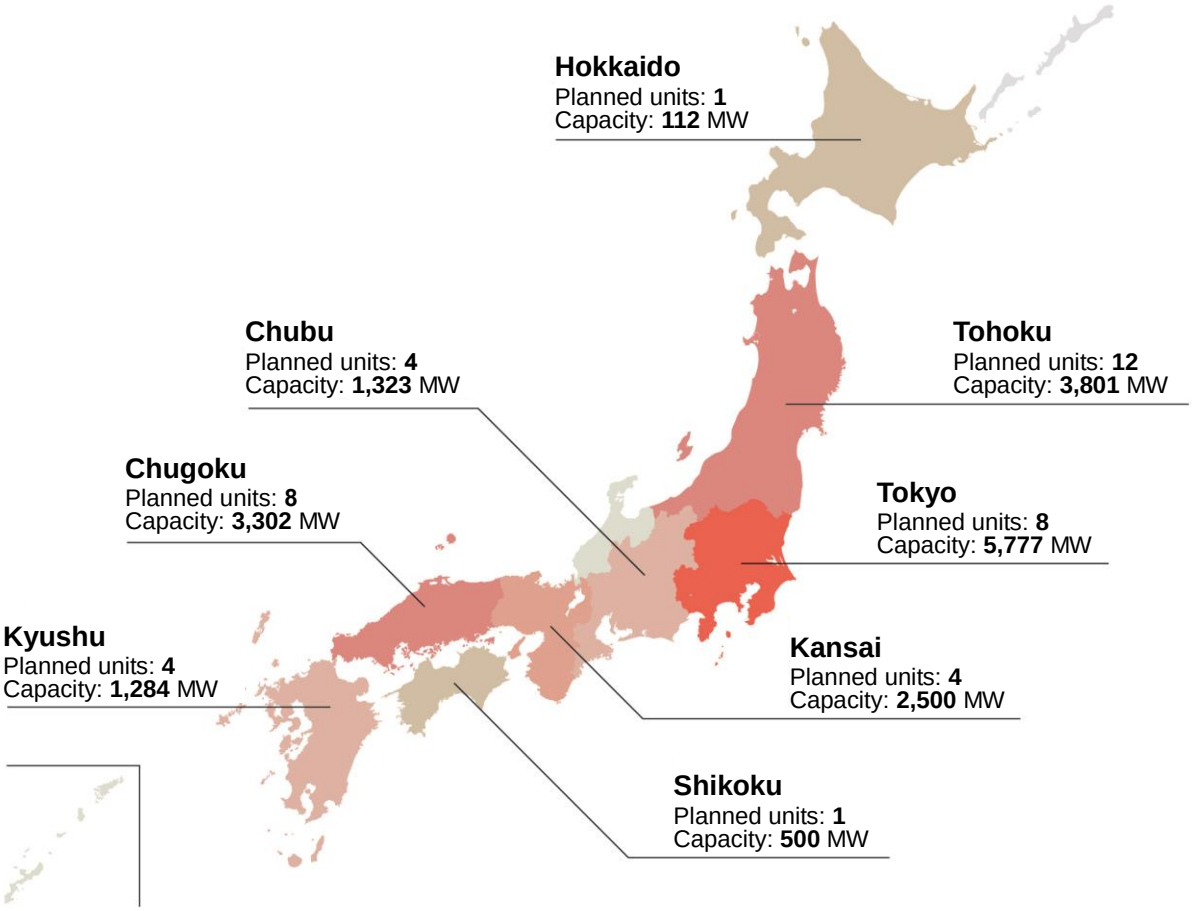


Figure 14 Plans of power companies for building coal-fired generation units in their service areas
Source: Releases from power companies, and environmental assessment data from the MOE

3.1.3 Assumptions about operation of nuclear power plants

One of the most prominent assumptions in the OCCTO's Electricity Supply Plan is that nuclear power plants with a schedule of restart "to be determined" will produce no electricity power. As a result, the Organization estimates that nuclear plants, with a capacity of 30.32 GW in FY 2026, will generate 6.6 TWh of electricity, a mere 0.7% of the possible total amount of power generated. Any accurate forecast is difficult to produce, but as mentioned in the Electricity Supply Plan, how much electricity they will actually produce may significantly differ, depending on how many of them will come back into operation.

In June 2017, Kansai Electricity Power Company restarted Units No. 3 and No. 4 of the Takahama Nuclear Power Plant. According to news reports, the company intends to put Units No. 3 and No. 4 of the Oi Nuclear Power Plant into operation again this autumn, at the earliest. More nuclear reactors may gradually come into operation once they pass an examination.

What impact will nuclear power plants have when they come back into operation? Based on the actual amount of electricity supplied in Kansai Electric Power's service area in FY 2016, we have calculated changes that should be seen in operation hours of thermal power plants when additional output come from Units No. 3 and No. 4 of the Takahama Plants after their restart, using the same method adopted in Chapter 1.2.4.

As seen in **Figure 15**, in FY 2016, coal-fired, coke oven gas, and combined cycle gas fired plants were able to operate at full load for 70% of 8,760 hours. Now that Takahama No. 3 and No. 4 have restarted, the potential full-load hours have fallen to 50% (around 4,000 of 8,760 hours). This analysis has revealed that the restart of nuclear power plants excluded from the Electricity Supply Plan would have a significant impact on thermal power plants.

In addition to restarted nuclear plants, once new coal-fired units planned in Kansai Electric Power's service area come into operation with a capacity of 2.5 GW (2.0 GW net, given that 0.5 existing GW are to be decommissioned), coal-fired, coke oven gas, and combined cycle gas fired plants will be able to operate at full load for even fewer hours, around 1,487 of 8,760 hours, or 17%.

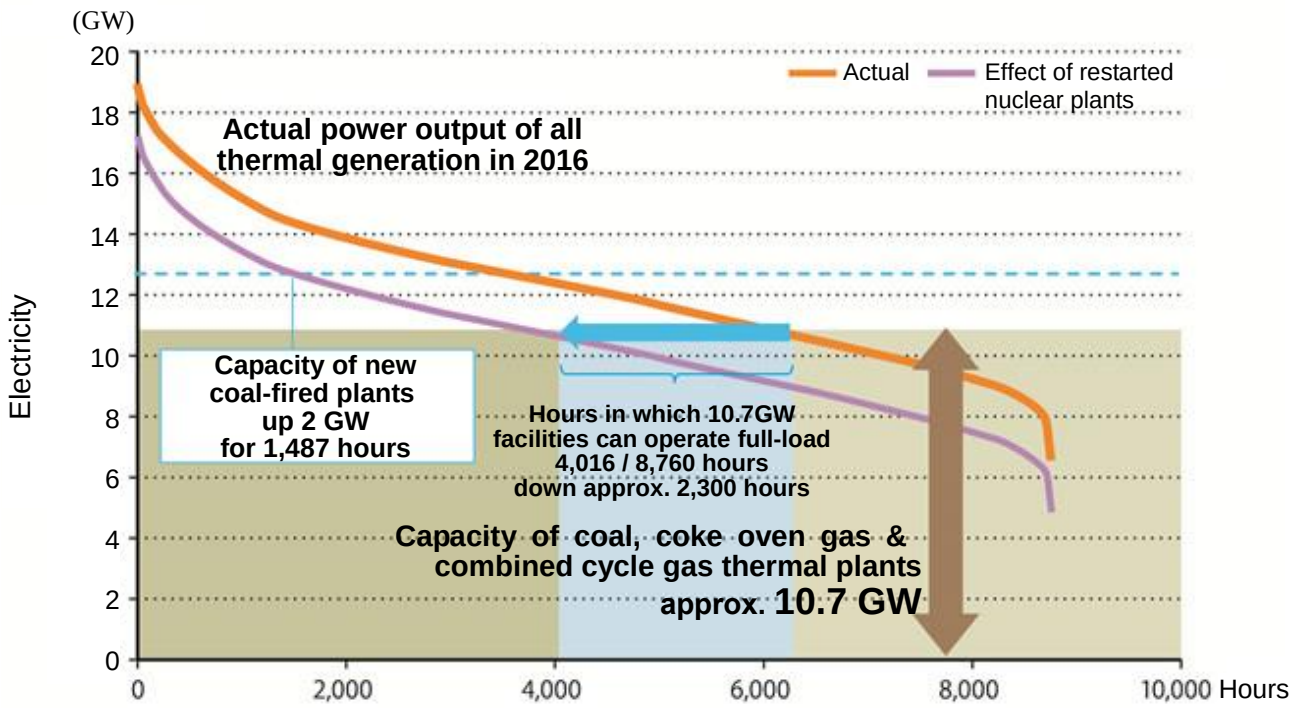


Figure 15 The decline in the capacity factor of thermal power plants in Kansai Electric Power's service area in FY 2016: Empirical analysis

Source: Adapted from supply and demand data for Kansai Electric Power's service area.

Note: The capacity above include other electric companies purchased from J-Power's Takasago Thermal Power Plants, and exclude those for power which Kansai Electric Power purchased from thermal plants located outside its service area.

3.1.4 Characteristics of the assumption in the Electricity Supply Plan

Findings of the examination above indicate that the assumptions of the Electricity Supply Plan have the following three characteristics.

(1) Almost 90% of the installed capacity assumed for solar PV in the Electricity Supply Plan correspond to the total capacity of projects whose approval remains valid under the revised FIT Act but have yet to come into operation. As a result, the Electricity Supply Plan ignores almost all the capacity of new solar PV units that will be obtaining approval. The Plan also counts the capacity of wind power plants too conservatively, compared with those of projects that have already completed environmental assessment or other procedures they must complete before commercial operation.
(2) The Electricity Supply Plan assumes only half the capacity of new coal-fired power units planned and announced by power companies and other entities.
(3) The Electricity Supply Plan assumes that in FY 2026, nuclear power plants will supply only a little electricity, 0.7% of the total, less than that produced by nuclear power units that have already come back into operation in 2017.

It seems that these assumptions are made "on the safe side" in order to factor in highly reliable supply capacity only, adhering to the purpose of the Electricity Supply Plan, "ensure a stable supply of electricity." In this respect, the assumptions would be reasonable.

However, that would not necessarily mean that business risks of new coal-fired power projects could be examined based on the same assumptions the Electricity Supply Plan has adopted. The Plan presents a capacity factor of coal-fired plants in FY 2026 (maintained at 69% even after some decline) based only on conservative assumptions made from the standpoint of securing stable power supplies from other sources. In examining business risks that may appear when additional installation are carried out as planned, plans for new coal-fired power units should rather be reviewed on the assumption that more of the other power sources will come into operation, in order to find how low the capacity factor of coal-fired plants could be at that time.

Below are estimates made from that standpoint, assuming that increased renewable capacity, restarts of nuclear plants, and promotion of energy efficiency would bring down electricity demand below forecasts in the Electricity Supply Plan, to see possible changes in the capacity factor among coal-fired power plants.

3.2 Estimation of the capacity factor of coal-fired power plants in the future

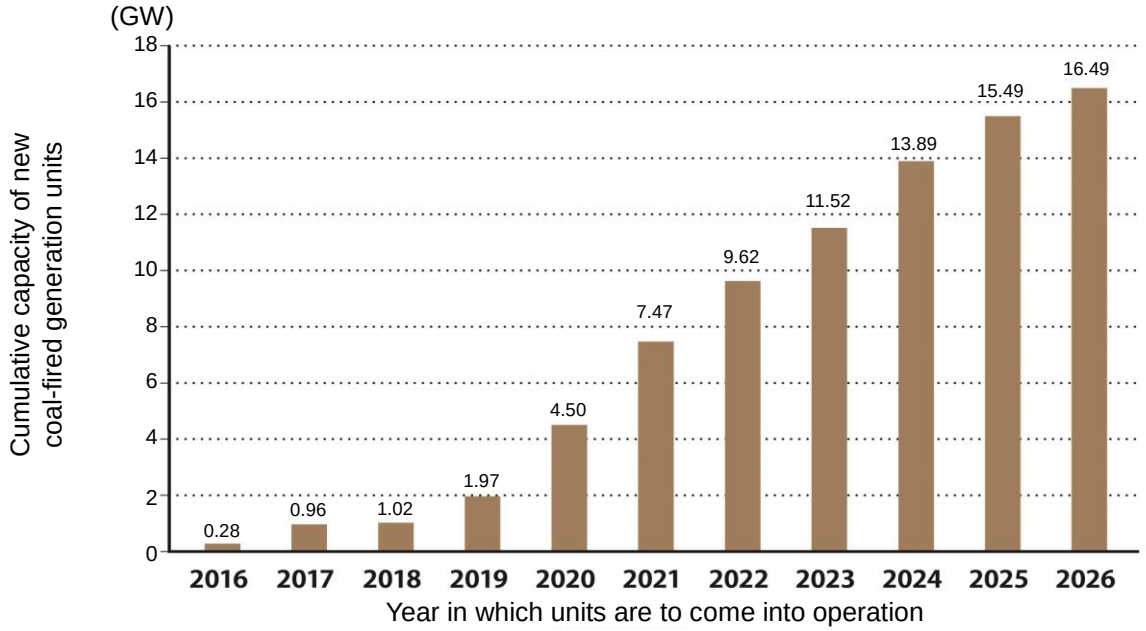


Figure 16 Cumulative installed capacity of planned new coal-fired power units (incl. capacity to be decommissioned)

Source: Adapted from releases from power companies, and environmental assessment data and materials from the MOE

Estimates are made on the assumptions below:

1. All the new coal-fired power units mentioned in the plans announced so far will come into operation. As a result, by FY 2026, 41 new units with a capacity of 16.49 GW will be added to the existing coal-fired plants (**Figure 16**). The additional capacity does not include 1.51 GW set to be decommissioned, nor the unit planned to come into operation in FY 2027.
2. Despite a roughly 10% decline expected in electricity demand in five years from FY 2010, as mentioned at the beginning of this report, here, as a basic scenario, energy efficiency will make little progress, staying at the same level as in FY 2016.
3. As a basic scenario, more of the nuclear power plants will come back into operation than now, providing 10% of the electricity supply. This is almost half their share in the fuel mix the national government forecasts for FY 2030 in the "Long-Term Energy Supply and Demand Outlook," or 20 to 22%.
4. Solar PV plants are expected to be installed with a capacity of 81.92 GW by FY 2026 as mentioned in the preceding section as RTS Corporation's "current-pace growth" scenario.
5. Installed capacity of the other renewable power sources will continue growing proportionally until FY 2026 in such a manner that they will reach the lower threshold for the share of renewables stated in the "Long-term Energy Supply and Demand Outlook" for FY 2030, 22 to 24%.
6. Installed capacity of thermal power plants, other than coal-fired ones, will be the same as stated in the OCCTO's Electricity Supply Plan.

The conditions listed above are used to estimate capacity factors at which individual power sources would run when operated in the order of merit, where those that can produce power with less additional cost for fuel and other inputs will come earlier to meet any demand. (It is also assumed that among the thermal power plants, coal and gas-fired stations and oil-fired stations are preferentially allowed to put into operation 30% and 15% of their installed capacity, respectively, as minimum output.

An estimate made under the assumptions above has revealed that the capacity factor of coal-fired power plants might fall to around 56% in FY 2026, much lower than forecast in the OCCTO's Electricity Supply Plan, 69% (**Figure 17**).

If nuclear power plants will not restart at the level of the assumption above and remain at 5% of electricity supply, the capacity factor of coal-fired plants will be 62%. However, if nuclear plants supply 10% of power while electricity demand declines by about 5% from FY 2016 due to enhanced energy efficiency, the capacity factor of coal-fired plants may fall further to around 49%, below 50%. The decline in electricity demand, 5% in ten years to FY 2026, is merely one-quarter the pace observed during the five years from FY 2010, 10%.

As mentioned in the report released by Renewable Energy Institute in October 2016, "Coal Business and Policy Trends," European countries and China have already seen capacity factors of coal-fired power plants fall below 50%. The estimate presented here suggests that Japan may experience similar situations.

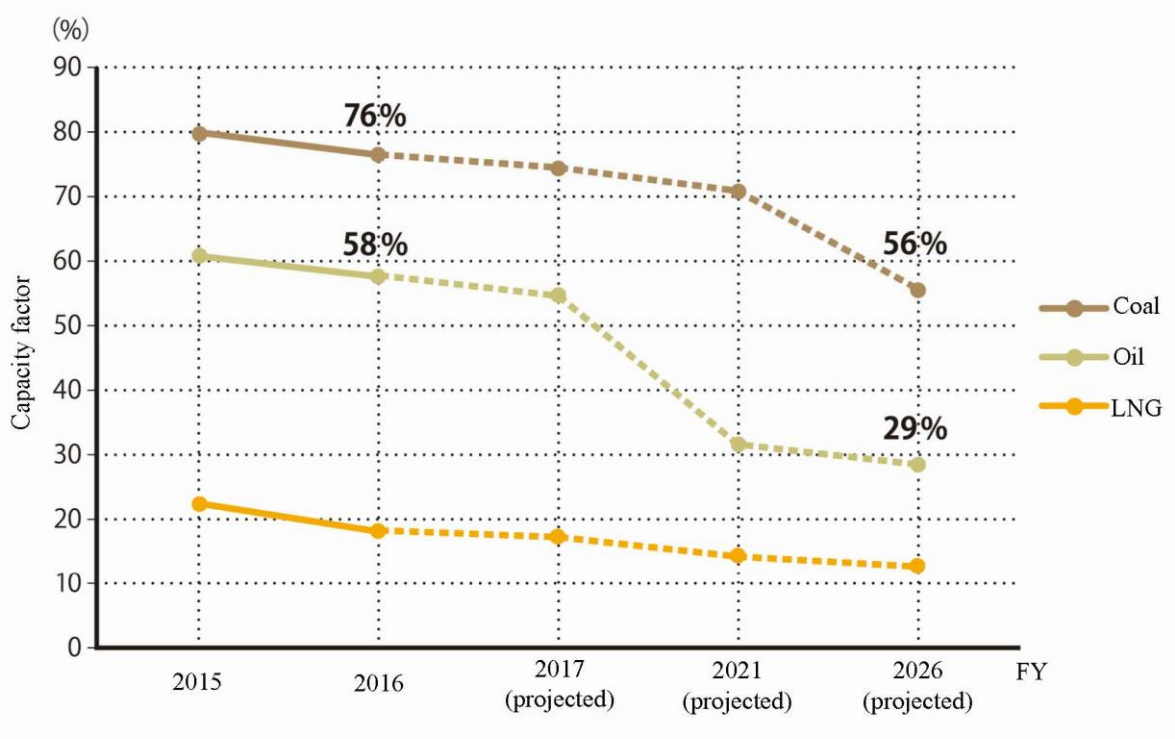


Figure 17 Estimated capacity factors of thermal power if new thermal power plant projects are implemented

Source: Produced by Renewable Energy Institute

3.3 Impact of thermal power facility expansion on the feasibility

What impact will lower capacity factors of coal-fired power plants, as seen in previous sections, give to commercial feasibility of plans for new generation units? Regarding any investment decision, one of the characteristics that should be taken into account when calculating profitability of coal-fired plants is their larger capital cost (construction cost, real-estate tax, etc.) than gas-fired stations'. Based mainly on historic data, the Power Generation Cost Analysis Working Group of the Advisory Committee for Natural Resources and Energy, METI, estimates that capital cost for gas-fired plants amounts to 120,000 yen per kilowatt while coal-fired stations need more than double, 250,000 yen per kilowatt.

That is, constructing gas-fired power units with a capacity of one gigawatt costs 120 billion yen, while coal-fired units with the same capacity need 250 billion yen when constructed. A past case in the construction of coal-fire power plants came to 400 billion yen.

Coal-fired power plants would take longer time to recover investments made in them, as they need more than double the capital gas-fired plants require. They also suffer a larger impact when their capacity factor declines. A lower capacity factor again equates to a longer time needed to recover the invested capital. Any large decline in the capacity factor would have a severe impact on the business of coal-fired plants.

For new coal-fired generation projects currently planned, the individual operators must have assumed a certain capacity factor and years of operation to examine economic feasibility, but the figures utilized in such assumptions are not disclosed. However, the Power Generation Cost Analysis Working Group, previously mentioned, using samples from power plants that came into service within the past seven years, has estimated costs of a model plant, including capital, maintenance, and fuel costs per kilowatt, and CO_2 control expenses. Here, based on actual data, the capacity factor and years of operation are assumed at 70% and 40 years, respectively. It is most likely that many of the plans for new power generation units adopted the two values that represent historic data when examining their business feasibility.

As stated before, the OCCTO's Electricity Supply Plan also indicates a downward future trend of the capacity factor among coal-fired power plants, falling below 70% in FY 2026. In addition, this report estimates that should new coal-fired generation units be constructed as planned at present, with steady growth of solar PV and restarting of some nuclear power plants, the capacity factor might decline further to the 50% level. With advancement in energy efficiency and consequent decline in electricity demand added, it might fall below 50%.

The assumed years of operation for coal-fired power plants, 40 years, is also highly questionable in terms of feasibility. The Paris Agreement, which came into effect in 2016, sets net zero GHG emissions in the second half of this century as a common target for the world. It is pointed out that to reach the target, the electricity generation sector must completely cease emission at least by 2050[11]. Coal-fired plants now planned are expected to come into service in the 2020s. If they should continue working for 40 years, they would be still in operation even in the 2060s.

As Renewable Energy Institute states in its report, "Coal Business and Policy Trends," many developed economies have already decided to give up coal-fired power generation. In such circumstances, the assumption that even in the latter half of the 21st century, coal-fired power plants will be allowed to continue operating in Japan seems unreasonable.

Business plans for building new coal-fired power units seem to assume a capacity factor of 70% and 40 years of operational lifetime. As demonstrated above, both of these assumptions lack feasibility. Any coal-fired plants constructed on these assumptions would be feared to fail to achieve expected profitability, only to produce another stranded asset.

3.4 Companies faced with revisions of new coal-fired power plant projects

The number of plans for building new coal-fired power generation units had been increasing until 2017, when some electricity suppliers announced revision of their plans.

Table 3 summarizes major electricity suppliers engaged in construction of new coal-fired power units, including joint investment. For most of the plans, other than those for small-scale plants, the former General Electricity Utilities or their subsidiaries form a consortium with trading corporations, gas companies, paper manufacturers, and steel makers.

[11] Facts4COP21: Paris Agreement includes ambitious long-term goal, by M. Meinshausen, Australian German Climate & Energy College, The University of Melbourne, climatecollege.unimelb.edu.au, 15th December 2015

Table 3 Major power companies (incl. subsidiaries) contributing capital in construction of new coal-fired power units

Main Stakeholder	Project Implemented		Project Canceled	
	Unit	Total capacity (MW)	Unit	Total capacity (MW)
J-Power	7	3,811		
Tokyo Electric-affiliated	5	3,030		
Kyushu Electric Power	3	3,000		
Chugoku Electric Power	4	2,348		
Tokyo Gas	2	2,000		
Chubu Electric Power	3	1,833		
Kansai Electric-affiliated	4	1,524	3	2,200
Mitsubishi Corporation	5	1,453		
Osaka Gas	3	1,310		
Marubeni	2	1,300		
Kobe Steel	2	1,300		
Ube Industries	2	1,200		
JFE Steel	1	1,070		
Shikoku Electric Power	2	612		
Tohoku Electric Power	1	600		
Nippon Paper Industries	3	373		
(Reference) Total	42	Approx.18,600	4	2,310

Source: Adapted from releases from power companies, environmental assessment data from the MOE, and news reports.
Note: For joint-investment projects, the number of units and their capacity appear in several stakeholders' cells repeatedly. (They are not divided in proportion to their stake.) In the "Reference" row, the number of units and their capacity include those for projects whose stakeholders do not appear in the table. As a result, the sum of figures for the stakeholders does not equal those in the "Reference" row.

Among these electricity suppliers, Kansai Electric Power and its subsidiaries, who have invested in the largest number of projects for constructing new generation units jointly with J-Power, have called off this year plans for a total capacity of 2.2 GW. When Kanden Energy Solution (Kenes), a subsidiary wholly owned by Kansai Electric Power, and TonenGeneral Sekiyu canceled a project for an Ichihara Plant, Chiba, with a capacity of one gigawatt, they issued a press release, saying "[I]n light of their views regarding the feasibility of the project, changes in the business environment and other factors, the two companies have decided not to continue discussions for implementation of the project."

In another press release Kansai Electric Power issued to announce the cancellation of a project for constructing a new unit with a capacity of 1.2 GW at the Ako Power Station, Hyogo, the company stated, "... that, after the announcement of the plan, electricity demand in the Kansai Region decreased amid prevalence of energy savings and increase in energy efficiency, with no prospects of rapid growth, and that, with an energy mix for 2030 set out by the government in July 2015, together with targets for reducing greenhouse gas emissions, stronger measures are required for reducing CO_2 emissions." They seem to have given up the plans because they are commercially unviable given current market conditions, including declining electricity demand, and international climate change initiatives, as has been stated in this report.

KOBELCO and J-Power separately plan to build new coal-fired power units in Hyogo, with a capacity of 2.5 GW between them, to sell power to Kansai Electric Power. According to a news report, however, J-Power, working to build new units at its Takasago Thermal Power Plant, has failed to reach agreement with the intended buyer, Kansai Electric Power, and notified the national and local governments concerned that procedures for environmental impact assessment will be suspended and put off for the time being[12]. As the current level of supply and demand and their outlook is becoming clear, other power producers will probably be compelled to revise their plans.

[12] "Challenging plans for coal-fired units suspended - J-Power puts off the environmental impact assessment intended for renovation of Takasago Plant in Hyogo," published on the Asahi Shimbun, Bloomberg, and others

4. Corporate trends and policy developments that affect future investment in coal-fired power plants

The last chapter of this report deals with trends among companies and developments of policy programs that are expected to have significant impact on plans of coal-fired power plants.

4.1 Departure of electricity-user companies from coal and movement toward de-carbonized economy

Since the Paris Agreement was signed in 2015 and came into effect in 2016 for establishing a de-carbonized world economy, major companies around the globe have been moving fast to replace all the electricity they consume with renewable power. Among such movements, a typical example is "RE100," an international initiative composed of some 100 global companies, including Apple, Google, General Motors, Nestle, and Unilever.

In the United States, participants in Renewable Energy Buyers Alliance (REBA) purchase renewable electricity as a way to develop another 60 GW of wind and solar PV generation capacity by 2025.

Figure 18 Participants in RE100, pursuing 100% renewables
Source: Mr. Damian Ryan, The Climate Group
(materials presented at REvision2017)

Japan has lagged behind these global movements. However, some new initiatives have been started in the country, as shown by a policy proposal announced by Renewable Energy Institute in April 2017. This called for greater deployment of renewable energy among businesses jointly with Apple, Microsoft, and other corporations based overseas, as well as Fujitsu, Ricoh, Shimizu Corporation, Softbank Group, Sony, and other Japanese companies[13]. One of the participants, Ricoh, announced at the same time their entry into RE100 as the first member from Japan.

Moves toward 100% renewables pursue de-carbonization, and spread of such initiatives is sure to help decrease demand for fossil fuel power sources, especially coal-fired power.

Along with this effort for 100% renewable energy, the development of another initiative, called "Science Based Targets," is believed to have significant influence on businesses in their choice of power sources. To limit the rise in temperature at the ground surface to two degrees Celsius above pre-industrial levels, a target stated in the Paris Agreement, the initiative urges companies to set emissions reduction targets aligned with scientific knowledge. Around the world, almost 300 companies have been approved so far to have set a target aligned with the Paris Agreement. As shown in Table 4, six Japanese companies have already obtained confirmation that their targets are scientifically aligned with the Paris Agreement. Another 28 companies are working to set targets. Some of them have started to consider eliminating their CO_2 emissions as a medium or long-term target. In May 2017, Fujitsu announced they aim at reducing their CO_2 emissions to zero by 2050. In October 2015, Toyota released "Toyota Environmental Challenge 2050," which states the company will reduce CO_2 emissions from its new-model cars and factories, and even from the entire life cycle of its products, to as near to zero as possible, an ambitious target.

[13] See the press release "Renewable Energy Institute and Ten Major Companies Make Three Proposals for "Non-Fossil Value Trading Market" to Promote Renewables in the Corporate Sector in Japan," REI, April 22, 2017

Table 4 Approved Japanese companies under the science-based targets initiative

Company	Target
Daiichi-Sankyo	• Reduce GHG emissions from business operations by 35% in FY 2030 from 2015-level. • Have 90% of main suppliers (in procurement value terms) set GHG targets by FY 2020.
Kawasaki Kisen	• Reduce Scope-1 emissions per ton-mile from ships by 25% and 50% from 2011-level by 2030 and 2050, respectively.
Kirin	• Reduce Scope-1 & 2 absolute GHG emissions by 30% by 2030 from 2015-level. • Reduce Scope-3 emissions by 30% by 2030.
Komatsu	• Reduce Scope-1 & 2 emissions per output by 49% by 2030 from 2010-level. • Reduce Scope-3 emissions by 46% from 2012-level.
Konica Minolta	• Reduce absolute GHG emissions (Scope-1, 2 & 3) from value chain by 60% at 2030-end from 2005-level. • Scope-3 reductions cover those from products & services purchased, upstream logistics & distribution, and use of products sold.
Sony	• Reduce GHG emissions from business operations by 42% in FY 2020 from 2000-level. • Under a long-term vision of reducing environmental footprint to zero by 2050, reduce emissions (Scope1, 2 & 3) by 90% by 2050 from 2008-level.

(Reference) Other 28 companies working to set targets:
Asahi Breweries, ASICS, Dai Nippon Printing, Daikin, Dentsu, Fujitsu, Hitachi Construction Machinery, Hitachi, Honda, Kao Corporation, KDDI, MS&AD Insurance Group, Nabtesco, Nissan, Nomura Research Institute, NTT DoCoMo, Ricoh, Seiko Epson, Sekisui House, Shimizu Corporation, Taisei Corporation, Takeda Pharmaceutical Company, Toda Corporation, Toyota, UK-NSI (Nihon Seiki), Unicharm, The Yokohama Rubber, Zeon Corporation

Source: Science Based Targets; http://sciencebasedtargets.org/

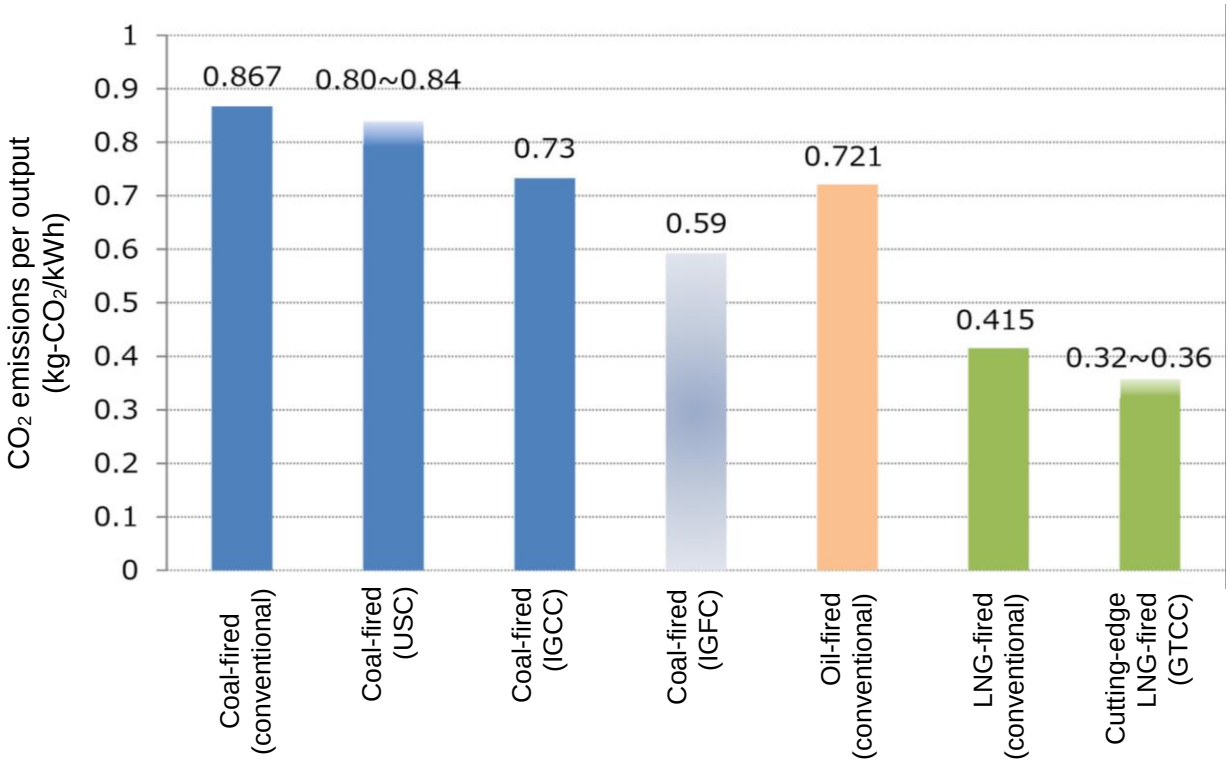
Along with "100% renewable energy" and "Science Based Target," businesses will be significantly influenced, when choosing power sources, by rules established to require them to disclose climate change-related information. The Financial Stability Board, an international organization composed of central banks and financial authorities from 25 major economies around the world, founded the Task Force on Climate-related Financial Disclosures (TCFD) to prepare rules for information disclosure as global standards. The TCFD released its final report in June 2017. The report recommends that businesses in any and all sectors, not only in the finance and energy industries, should be required to disclose their energy consumptions and GHG emissions by power source.

For companies, the rules are not obligatory, and they are allowed to decide voluntarily whether to comply. However, as stated in a report released by Renewable Energy Institute in October 2016, now that investors set greater score by dependence of companies on coal when making decision for investment, the TCFD rules will have significant influence. So far, companies with a market capitalization of 3.5 trillion dollars around the world, including Japan, and financial institutions managing assets worth 25 trillion dollars have declared their endorsement of the disclosure rules.

Since the Paris Agreement came into effect, moves of companies toward de-carbonization, as mentioned above, have been accelerating by the day. Given that Japanese companies do business in the global market, transition to the de-carbonized economy should inevitably spread across Japan.

As shown in **Table 19**, coal-fired power generation emits the largest amount of carbon dioxide among all types of fossil fuel generation. The emission factor of ultra super critical (USC) generation, a coal-fired power generation technology widely used in practice, is more than double that of gas turbine combined cycle (GTCC) generation, also widely used among gas-fired generation methods. Integrated gasification combined cycle (IGCC) generation, a technique that has just been put into practical use for some plants, is also more than twice GTCC in emission factor. Integrated coal gasification fuel cell combined cycle (IGFC) generation, a method believed to achieve the lowest emission factor among all the coal-fired generation technologies, has yet to reach the stage of practical application.

Meanwhile, solar PV and wind power generation is growing in many countries and regions around the world with declines in generation cost, even below the level of coal-fired generation. Renewable energy should also be getting cheaper in Japan, despite some delay, and continuing declines in cost will encourage more of the electricity users to abandon coal-generated power at an accelerated pace.



Source: BAT reference table in FY 2015 Environment White Paper (as of February 2017)

Note 1: HHV, transmission-end basis.
Note 2: Emissions per output from USC and GTCC facilities differ depending on their capacity.

*USC: Ultra Super Critical
*IGCC: Integrated Gasification Combined Cycle
*GTCC: Gas Turbine Combined Cycle
*IGFC: Integrated Coal Gasification Fuel Cell Combined Cycle

Figure 19 CO_2 emissions per output of coal-fired power plants by type of fuel
Source: Materials for the "Study Group for Carbon Pricing," MOE, June 2, 2017

4.2 Government's efforts for greenhouse gas reduction

As evidenced by a reason pointed out by Kansai Electric Power when announcing in February 2017 the cancellation of their plan to expand the Ako Thermal Power Station, "... together with targets (set by the government) for reducing greenhouse gas emissions, stronger measures are required for reducing CO_2 emissions," policy programs formulated by the national governments to achieve targets of the Paris Agreement, an international framework for climate change initiatives, have great influence on coal-fired plants into the future.

When all the 42 new coal-fired power units, with a capacity of 18.60 GW, are added as now planned, the share of coal-fired plants will be too large compared to the percentage assumed in the FY 2030 "Energy Mix" presented in the government's "Long-term Energy Supply and Demand Outlook" (2015). The Energy Mix assumes the amount of electricity generated by coal-fired plants at the same level as in FY 2013 and 2014. The new units constructed as planned would themselves form overcapacity. Unless half the existing coal-fired capacity are shut down, or their capacity factor is lowered significantly, total output of coal-fired plants would not stay in the range assumed in the Energy Mix.

The plans for new coal-fired generation units are not aligned with the "Plan for Global Warming Countermeasures," formulated by the government in 2016. The Plan aims at reducing GHG emission by 26% in 2030 from the 2013-level. This is equivalent to an 18% reduction from the 1990-level. As stated in a report released by Renewable Energy Institute in October 2016, once all the new coal-fired generation units come into operation as planned, they would by themselves emit GHG equivalent to as much as 10% of the 1990-level[14].

In addition, the anti-warming plan and the "Basic Environment Plan" (2012) carry a target of reducing GHG emission by 80% in 2050. Supposing that the target is achieved, the newly constructed coal-fired units alone would emit half the amount of GHG Japan is allowed to release in 2050 all around the country[15]. When all sectors - industry, commercial, residential, transport, and all other users - are required to reduce GHG emissions, why would coal-fired generation plants alone be allowed to release so much? The national Long-term Low-carbon Vision, prepared in March 2017, envisions that 90% or more energy will be supplied from low carbon energy sources by 2050. Practically, the use of coal-fired power plants is not assumed.

As shown above, the current plans for new coal-fired power units are obviously too large compared with the government's Energy Supply and Demand Outlook or Plan for Global Warming Countermeasures, and it is highly likely the government will take some additional actions. One such additional measures that attracts considerable attention recently is introduction of carbon pricing (carbon tax and emissions trading scheme). Around the world, 40 countries, as well as 24 local governments, have adopted some kind of carbon pricing.

[14] See "Coal Business and Policy Trends," REI, October 2016. For the calculation, it is assumed coal-fired power units will operate at a capacity factor of 70%, for 40 and 50 years among newly-constructed and existing ones, respectively.

[15] See "Coal Business and Policy Trends," REI, October 2016.

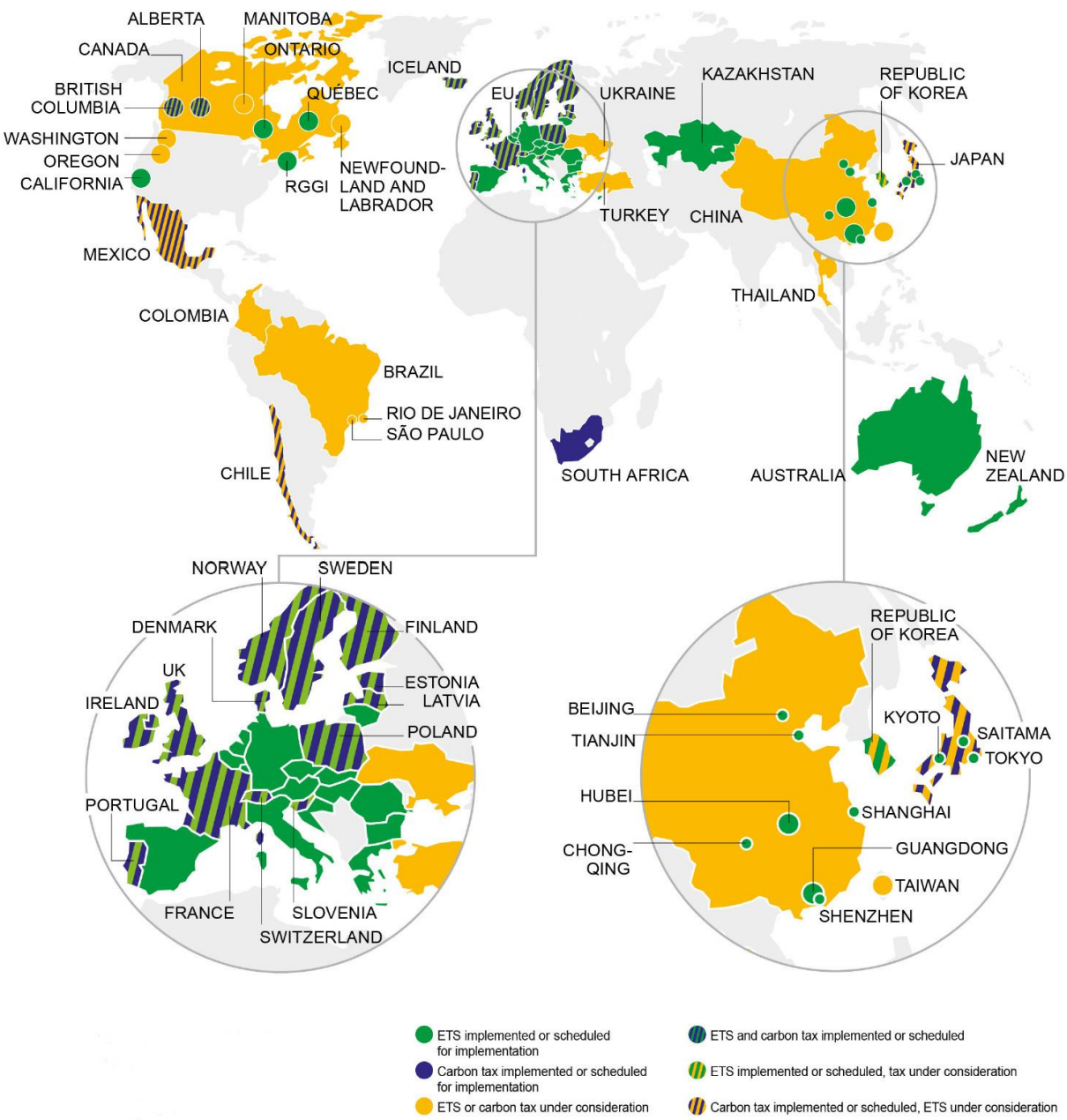


Figure 20 Carbon pricing schemes adopted around the world
Source: State and trends of carbon pricing 2016, World Bank

In Japan, Tokyo and several other local governments have introduced some emissions trading mechanisms. However, no such system has been adopted by the national government. Indeed, a kind of carbon tax was introduced in 2012 in the name of "global warming countermeasures tax," but the tax rate is too low, less than 10% of similar taxes adopted by European countries, to work effectively as a carbon tax.

The national government set up the Study Group for Carbon Pricing in May 2017 to start work for introducing a more effective mechanism. The initiative, together with other diverse efforts of businesses to pursue de-carbonization, as described above, should help reduce demand for coal-fired power generation.

Conclusion

Despite increasingly critical eyes cast at coal-fired generation around the world, the Organization for Economic Co-operation and Development (OECD) finds large growth of coal-powered electricity after the 1990s in only two of its member states, Japan and South Korea. In the latter of the two, newly elected president Moon Jae-in has declared as his policy that the country should depend less on coal-fired power generation, as well as nuclear power, and instead develop more renewables, bringing Japan into sharp relief as an outlier on the globe.

This report, estimating the capacity factor of coal-fired power plants in FY 2026, has pointed out that this indicator will fall far below 70%, a common assumption for business plans, to 50%, or even below.

At the global level, reviews under the Paris Agreement will be conducted in 2018 to examine progress in emissions reduction. The signatories of the Agreement are required to file a long-term reduction strategy by 2020. As was seen in the MOE's announcement to commence the studies for carbon pricing, the government of Japan must take actions to fulfill the commitments it has made before the international community, as impact of climate change will continue getting graver.

Japanese companies have started to pursue greater deployment of renewable energy as part of their medium- and long-term global warming solutions and energy strategies. In Japan, companies and institutional investors are beginning to widely disclose information related to climate change and advertise their efforts to withdraw from fossil fuels, especially coal, and turn to 100% renewable energy. Given that even a coal-fired plant using the "cutting-edge technology" emits double the amount of CO_2 a conventional gas-powered station does, leading global companies see coal as the last energy source they would choose to utilize.

Plans of four new coal-fired power plants were cancelled in 2017 for the first time since its steady increase from the Great East Japan Earthquake. For the operators planning for the remaining 42 plants and financial institutions involved in coal businesses, it should be in their interest to make appropriate investments and financing decisions by forming a clear view of the situation of electricity supply and demand in Japan and the global trend toward a de-carbonized society.

Business Risks of New Coal-fired Power Plant Projects in Japan
The Decline in capacity factor and the Effect on the Business Feasibility

September 2017
(Japanese version was published in July 2017)

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