December 22, 2023 The 446th Forum on Research Work

Topics for Electric Power Policy in FY2024
—Providing stable electricity supplies—

The Institute of Energy Economics, Japan
Ken-ichi Onishi
Electric Power Group, Electric Power Industry Unit

Key points of this report

- ✓ The widespread introduction of renewable power plants bolstered by policy-based support has reduced the utilization of thermal power plants, and there is less incentive for operators to maintain and build new power plants.
- ✓ Power shortages were observed on March 22, 2022, centered around the Tokyo area due to a spike in demand due to the cold weather and reduced solar power generation.
- ✓ According to supply & demand predictions for the FY2023 winter, all areas will be able to maintain above the minimum 3% reserve supply capacity required to maintain stable power supplies. After the FY2023 winter, from FY2024 onwards supply capacity reserved on the capacity market will be delivered, meaning stable power supplies can be expected. However, to secure electric power supply (kWh) in addition to supply capacity (kW), ensuring stable fuel supplies over the mid- to long-term is still a challenge.
- ✓ Supply capacity is reserved on the capacity market based on annual contracts, and suppliers are not guaranteed bids at every yearly auction. This system does not provide sufficient incentive to invest in new power plants that must pay back fixed costs over a long period of time.
- ✓ Looking forward, if renewable power plants are widely adopted, measures are required to address mid- to long-term power shortages and bolster dispatchable power plants required for the flexible management of highly variable renewable generation output.
- ✓ To address this challenge and provide an incentive for investment in new power plants, a Long-term Decarbonized Power Source Auction is planned in January 2024 targeting new decarbonized power plants. A Reserve Capacity Scheme is also under review to secure reserve emergency power.
- ✓ The Long-term Decarbonized Power Source Auction requires 90% of other market profits to be refunded, and costs cannot be collected during the facility construction period, which may dampen the incentives for new investment, making further review necessary.

Accelerating closure of thermal power plants in Japan, reduction in new power plants

- The widespread introduction of renewable power plants bolstered by policy-based support has reduced the utilization of thermal power plants. This has reduced the incentive for operators to maintain and build new power plants, and we see a trend of thermal power plants shutting down and a reduction in new power plants.

Diagram 1: Thermal power plant capacity factor

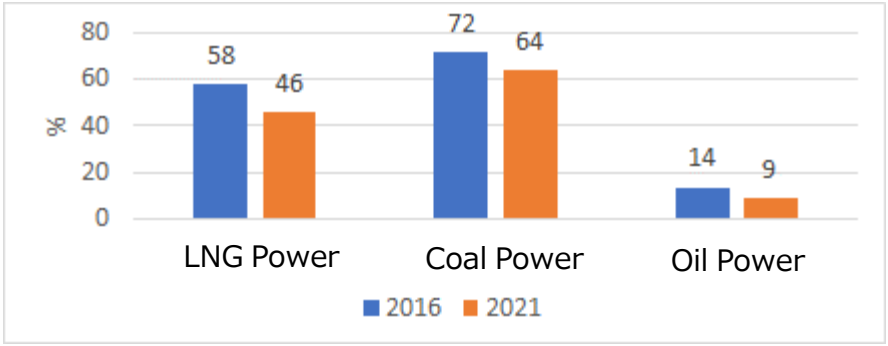


Diagram 2: Reduction in thermal power plants - results and prediction

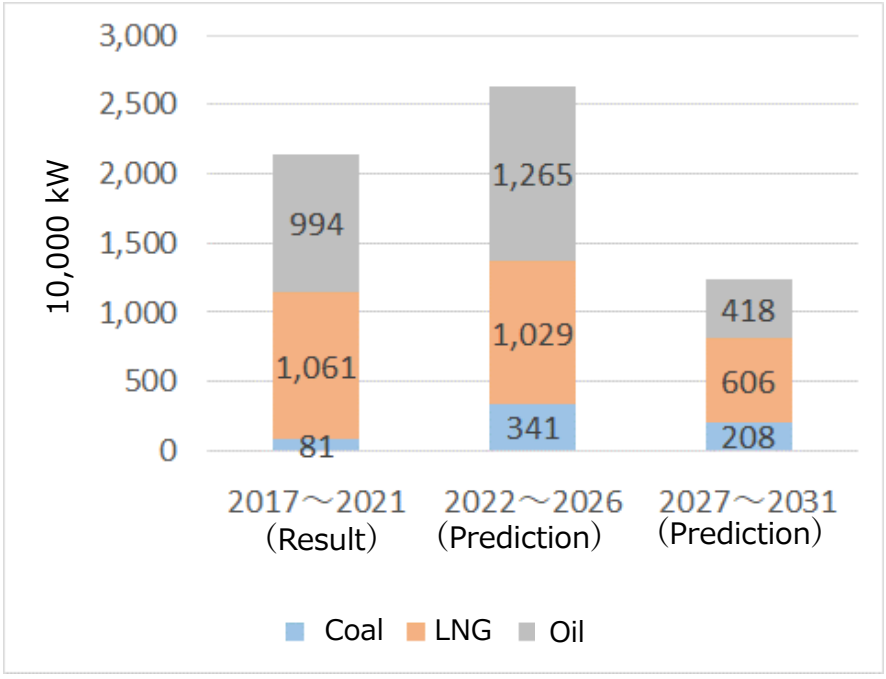
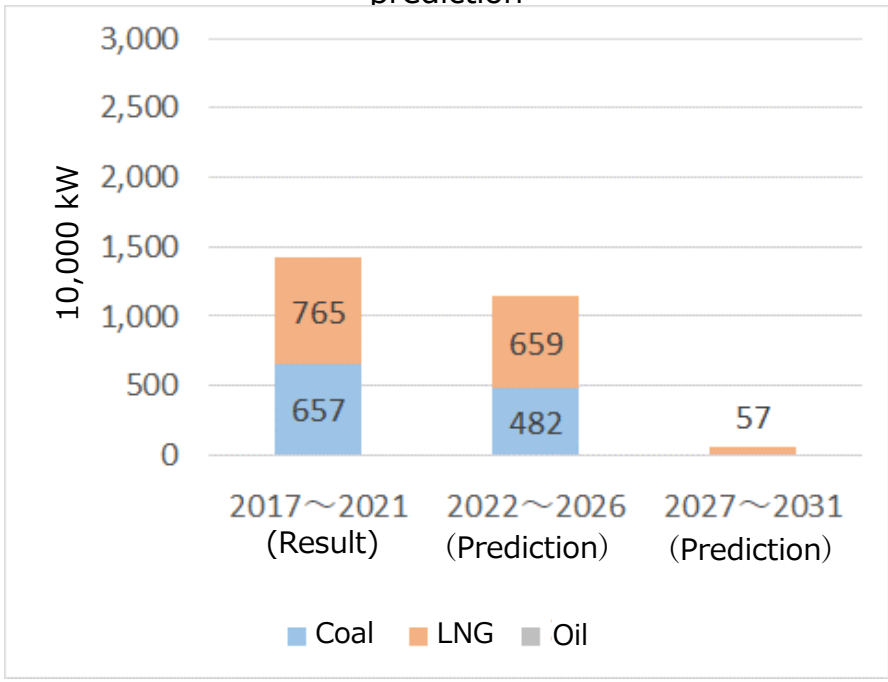


Diagram 3: New thermal power plants - results and prediction



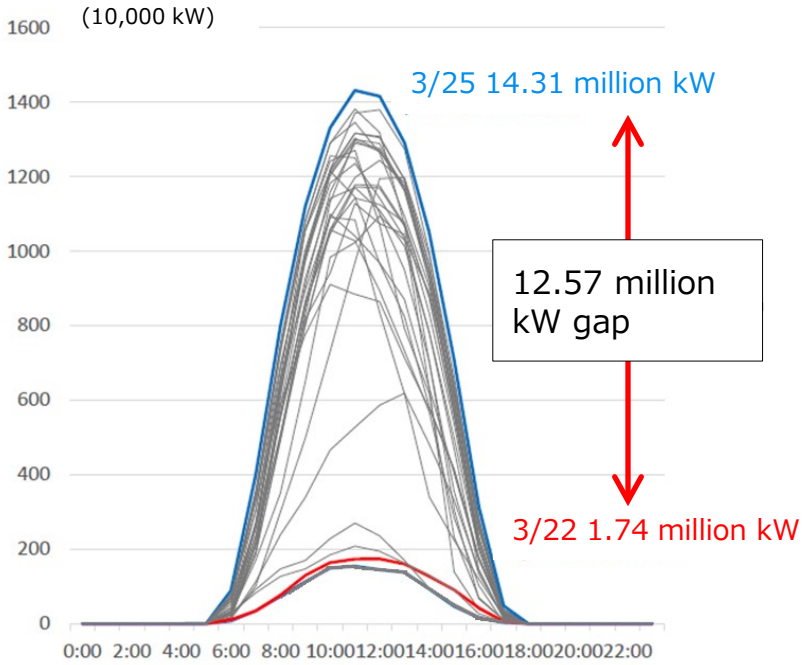
Note: Power plants owned by major energy suppliers are considered shut down after operating for 45 years.

Source: Produced based on materials by the Agency for Natural Resources and Energy

The March 2022 power shortage exposed dependency on solar and insufficient supplies

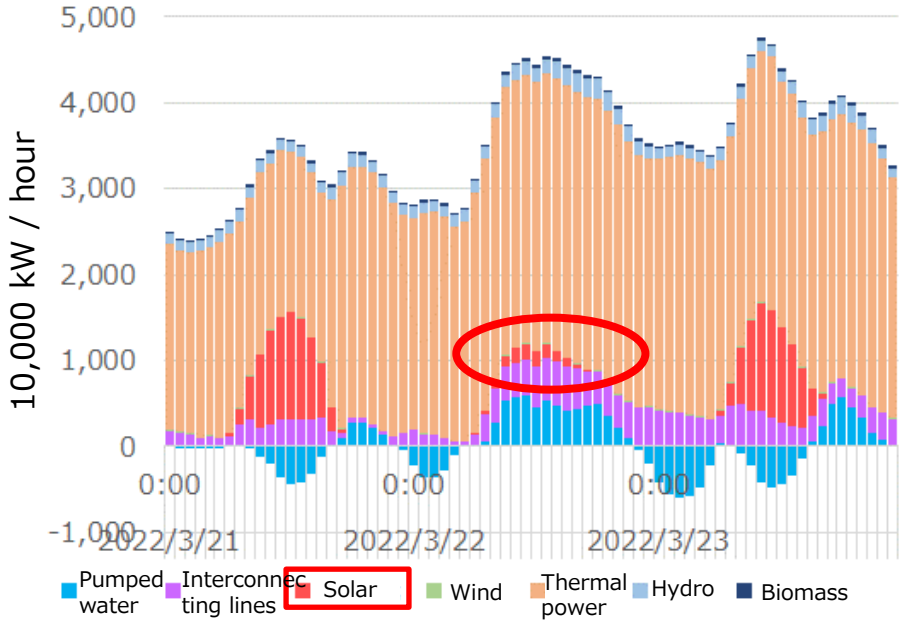
- Power shortages were observed on March 22, 2022, centered around the Tokyo area due to power plants shutting down due to earthquakes and other factors, reduced operating capacity on interconnecting lines, a demand spike due to the cold weather, a major drop in solar power generation, and maintenance being carried out at power plants.
- Recently, reserve supply capacity ratios have been dropping due to reduced power supply.
- Dependency on solar power is growing. Due to the risk of solar power plants suddenly reducing output, measures must be taken to maintain overall energy supplies.

Diagram 4: Solar power generation per day in March 2022 (Tokyo Area)



Source: Produced based on materials by the Agency for Natural Resources and Energy

Diagram 5: Power supply & demand around March 22, 2022 (Tokyo Area)



Source: Produced based on materials by TEPCO Power Grid

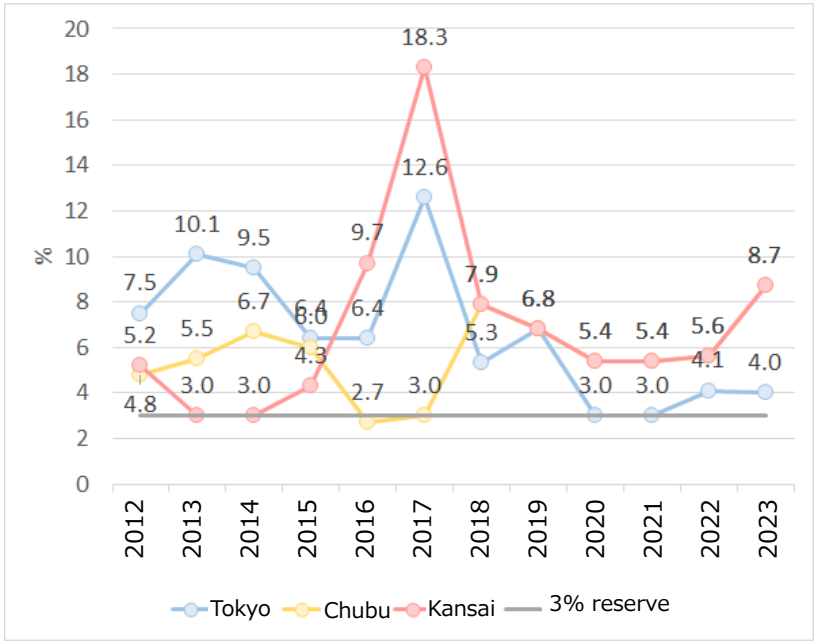
Supply & demand predictions for the FY2023 winter indicate the minimum 3% reserve supply capacity is secured

- Based on power source I' (Reserve supply capacity in response to extreme weather), reserve thermal power output capacity, and inter-area flexibility, all areas are predicted to maintain the minimum 3% reserve supply capacity for Extreme Cold H1 Demand (note 1)
- Since 2016, the Extreme Cold H1 Demand has been growing steadily for the Tokyo area.
- After the FY2023 winter, from FY2024 onwards supply capacity reserved on the capacity market will be delivered, meaning stable power supplies can be expected. However, to secure electric power supply (kWh) in addition to supply capacity (kW), ensuring stable fuel supplies over the mid- to long-term is still a challenge.

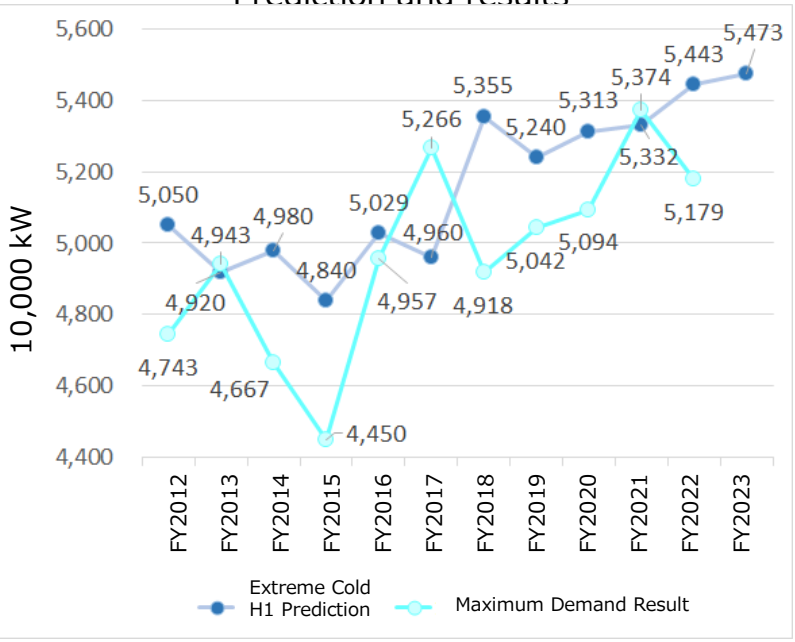
Note 1: Extreme Cold H1 Demand references the maximum electricity demand of the coldest period for the past 10 years

Diagram 6: Supply & demand prediction during the Extreme Cold H1 Demand period (note 2)

Reserve supply capacity prediction for January



Supply & demand for the Tokyo Area
Prediction and results



Note 2: From FY2017 onwards, power source I', thermal power reserve output capacity, interconnecting line utilization, unplanned outages and asymmetry are taken as reference.

Source: FY2013 - FY2015: Created based on the Electricity Supply and Demand Verification Subcommittee Report, from FY2016 onwards: the Electricity Supply and Demand Verification Report

Source: Produced based on materials by the Agency for Natural Resources and Energy

(Reference) Comparison of FY2022 and FY2024 Supply & Demand Predictions

- According to the FY2022 supply & demand prediction published in October 2021, based on Extreme Cold H1 Demand, the area from Tokyo to Kyushu had a reserve supply capacity of 4.5% in July. Tokyo, however, only had an insufficient 0.4% reserve supply capacity in February.
- According to the FY2024 supply & demand prediction published in November 2023, with contributions made by power supply already reserved on the capacity market, over 10% of reserve supply capacity will be maintained in both summer and winter.
- There are still variable factors influencing supply & demand, and it is possible the supply & demand balance will become more severe based on an upward adjustment in demand or reductions in the output due to operating conditions for suppliers.

Diagram 7: Predicted reserve supply capacity vs Extreme Cold H1 Demand

(FY2022 prediction, unit: %)

	Jul.	Aug.	Sep.	Dec.	Jan.	Feb.	Mar.
Hokkaido	12.9	18.9	23.8	14.1	7.3	10.4	16.2
Tohoku	8.4	5.5	7.8	13.2	5.1	10.4	16.2
Tokyo	4.5	5.5	4.0	9.6	2.1	0.4	6.7
Chubu	4.5	5.5	4.0	9.6	6.1	3.2	9.1
Hokuriku	4.5	5.5	8.5	9.6	6.1	5.9	16.4
Kansai	4.5	5.5	8.5	9.6	6.1	25.9	16.4
Chugoku	4.5	5.5	8.5	9.6	6.1	5.96	16.4
Shikoku	4.5	5.5	8.5	9.6	6.1	5.96	16.4
Kyushu	4.5	5.5	19.7	9.6	6.1	5.9	16.4
Okinawa	28.8	29.2	34.3	30.7	31.3	51.2	63.1

(FY2024 prediction, unit: %)

	Jul.	Aug.	Sep.	Dec.	Jan.	Feb.	Mar.
Hokkaido	8.7	13.3	22.5	21.0	10.8	11.0	18.3
Tohoku	8.7	10.1	11.2	21.0	10.8	11.0	18.3
Tokyo	7.9	8.3	10.3	21.0	10.8	11.0	18.3
Chubu	11.6	12.4	11.9	16.4	10.8	11.0	18.3
Hokuriku	11.6	12.4	16.1	16.4	10.8	11.0	18.3
Kansai	11.6	12.4	16.1	16.4	10.8	11.0	18.3
Chugoku	11.6	12.4	16.1	16.4	10.8	11.0	18.3
Shikoku	11.6	12.4	16.1	16.4	10.8	11.0	18.3
Kyushu	11.6	12.4	16.1	16.4	10.8	11.0	18.3
Okinawa	22.9	19.4	22.3	49.9	41.3	39.2	57.5

Source: Produced based on materials from the Organization for Cross-regional Coordination of Transmission Operators, JAPAN

From FY2024 onwards in addition to delivery of supply capacity reserved on the capacity market, the Long-term Decarbonized Power Source Auction will encourage investment in new power plants

- Until FY2023, the Additional Reserve Capacity Public Offering has been implemented to provide supplementary power in response to short notice demand when there is a risk of power shortage, in addition to promoting electricity saving efforts.
- From FY2024 onwards, the capacity market will deliver supply capacity based on actual supply secured four years prior. Additional supply capacity can also be purchased in a supplementary auction up to one year prior to delivery.
- The main auction of the capacity market, however, provides insufficient incentive to invest in new power plants, and a new special auction is planned for the capacity market in January 2024, the Long-term Decarbonized Power Source Auction.
- Furthermore, The Reserve Capacity Scheme is under review to maintain a level of reserve supply capacity aimed at the thermal power not auctioned or bid upon in the capacity market.

Diagram 8: Overview of systems for securing power supply

	Additional Reserve Capacity Public Offering	Capacity Market	Long-term Decarbonized Power Source Auction	Reserve Capacity Scheme
Goal	Short-term supplementary power	Secure mid- to long-term power supply	Secure mid- to long-term power supply	Secure mid- to long-term power supply
Scope	All sources (primarily thermal)	All sources (except FIT sources, etc.)	Decarbonized sources	Dormant thermal power supplies (proposed)
Bidding scale	Millions of kW	180 million kW (for FY2024)	4 million kW / year * Separate call for 6 million kW of LNG thermal for FY2024-26	Millions of kW (proposed)
Year started	FY2021 winter	FY2020 (for power delivered FY2024)	FY2023	Under review
Organizer	TDSOs	OCCTO	OCCTO	OCCTO
Cost burden	Wheeling tariff	Capacity contribution fee (for retail) * Some use wheeling tariff	Capacity contribution fee (for retail) * Some use wheeling tariff	Wheeling tariff (proposed)

The capacity market serves as an intermediary for sourcing mid- to long-term power supply

- With the deregulation of the retail electricity market, the capacity market (kW market) was introduced to secure the required mid- to long-term supply capacity in addition to the existing electric energy market (kWh market).
- In a capacity market auction, the buyer is OCCTO (Organization for Cross-regional Coordination of Transmission Operators) and the sellers are electricity producers.
- OCCTO builds a demand curve based on nationwide power demands, and electricity producers determine the amount of electricity offered and bid prices for each power source.

Diagram 9: Overview of the capacity market

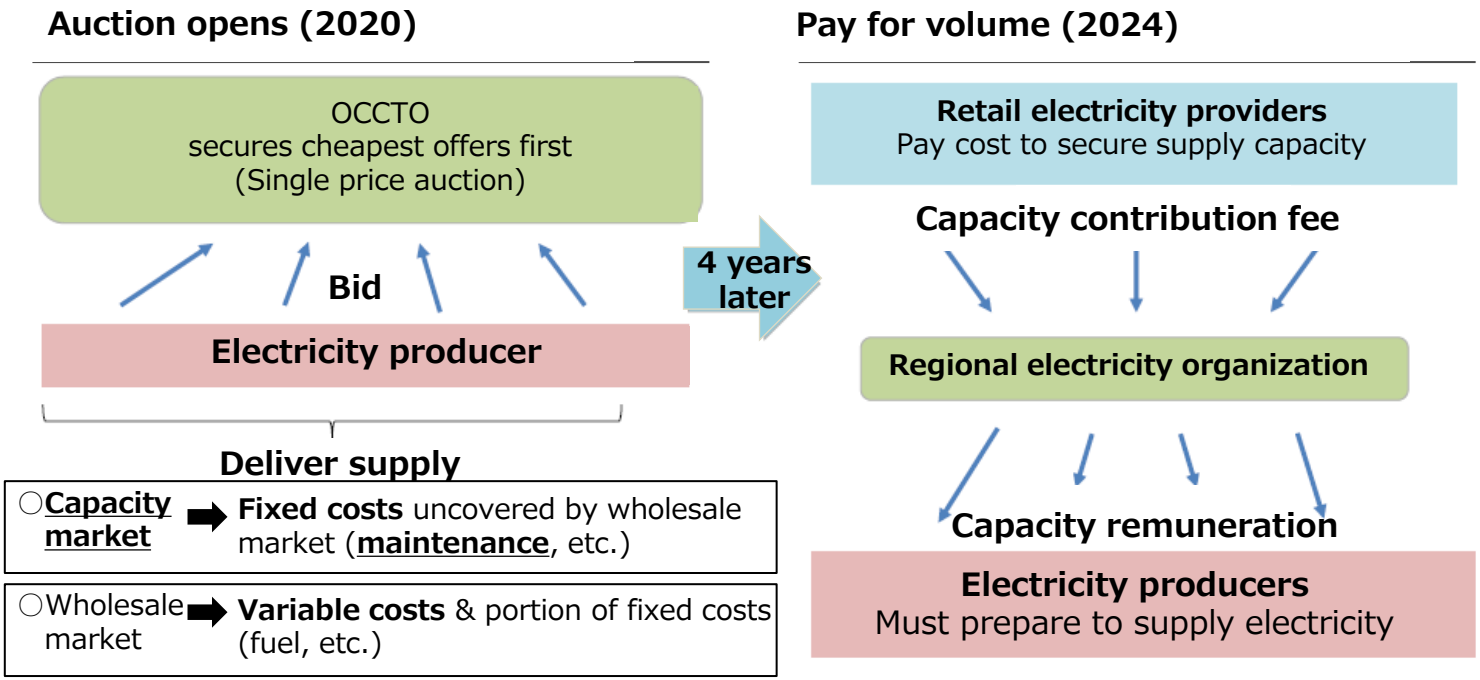


Diagram 10: Capacity market prices (Tokyo area) [yen / kW]

FY2024	14,173
FY2025	3,495
FY2026	5,834
FY2027	Not yet executed

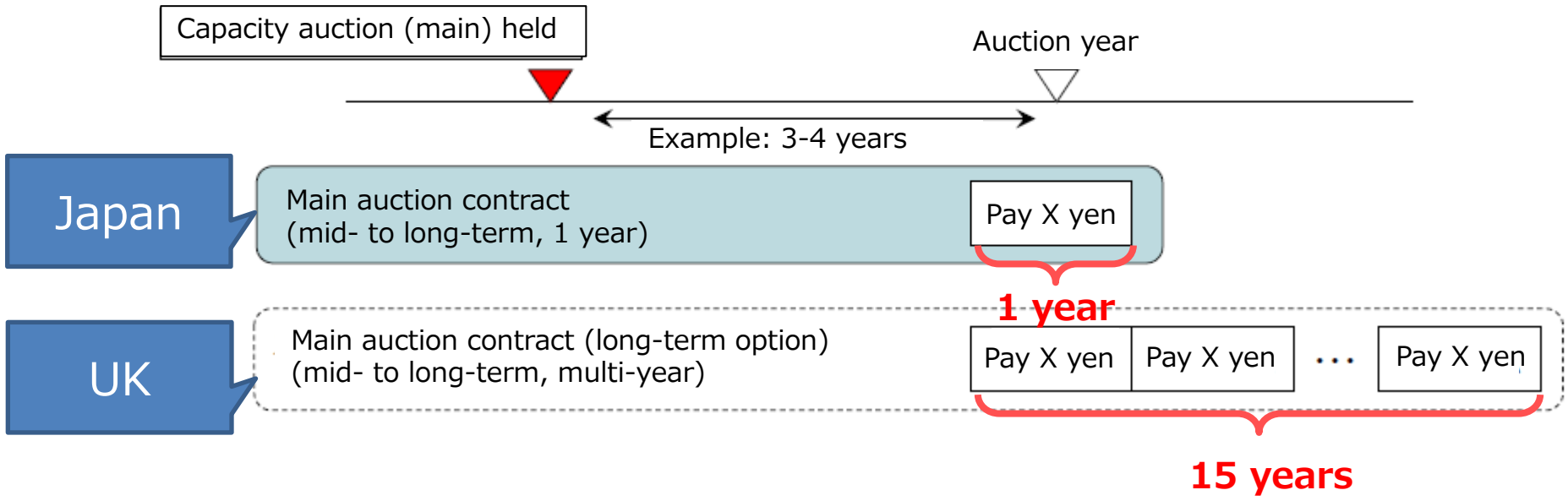
Source: Quoted from "Securing Stable Electricity Supplies" (Nov. 8, 2022), Agency for Natural Resources and Energy
https://www.meti.go.jp/shingikai/enecho/denryoku_gas/denryoku_gas/pdf/055_04_02.pdf

Currently, the capacity market does not allow long-term contracts, and does not incentivize building new power plants

- The capacity market is based on annual contracts and there is no guarantee a bid will be secured every year. This provides little incentive to invest in new power plants, which must recover fixed costs over a long period of time.
- The UK permits 15-year contracts for new power plants.

- Long-term contracts are required to incentivize investment in new power plants.

Diagram 11: Differences in contract periods of the Japan and UK capacity market



Source: Produced based on materials by the Agency for Natural Resources and Energy

Additional measures required for the large-scale introduction of renewable power plants

- Japan deregulated the retail electricity market in 2016 to reduce electricity prices. This deregulation did not account for the large-scale introduction of renewable power plants to achieve decarbonization by 2050.

- To prepare for the future large-scale introduction of renewable power plants, measures must be taken in particular to 1.) account for the mid- to long-term loss of supply due to thermal power plants shutting down, and 2.) to prepare dispatchable power plants that allow flexible management of the variable output of renewable power plants.

- Measures are required to incentivize investment in new power plants to support the large-scale introduction of renewable power plants. Measures are also required to maintain dormant thermal power plants.

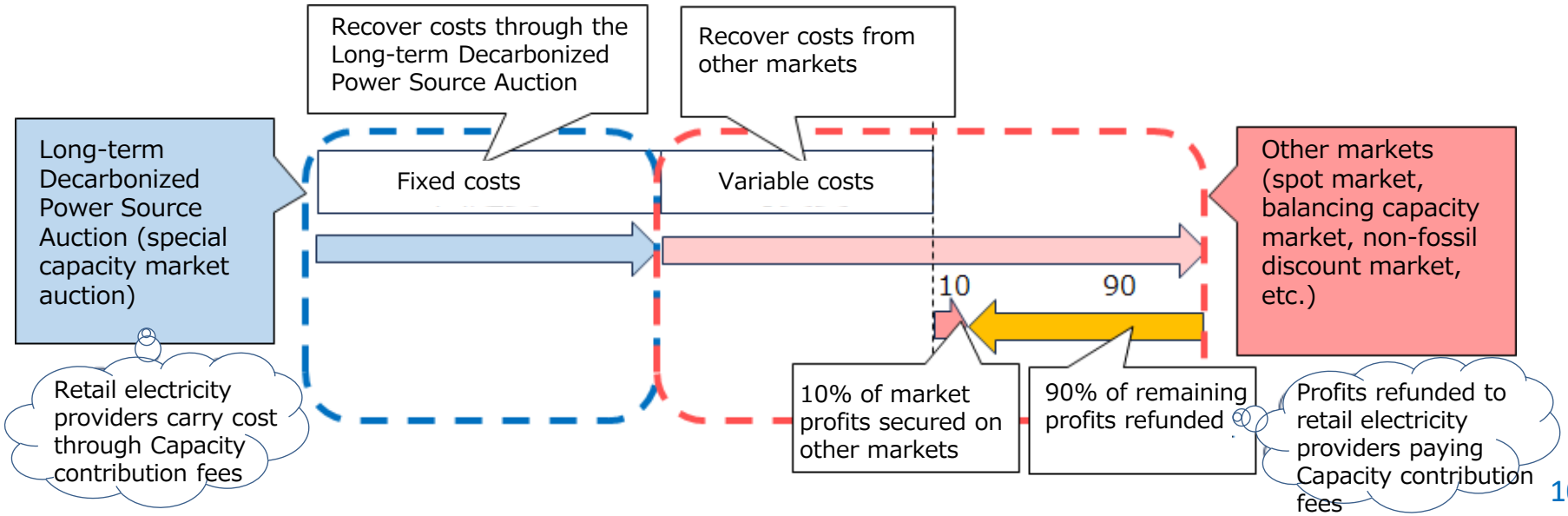
- Mid- to long-term new decarbonized power plants
  (-> Long-term Decarbonized Power Source Auction)
- Maintain dormant thermal power plants(-> Reserve Capacity Scheme)

Long-term Decarbonized Power Source Auction Planned for January 2024

- The first Long-term Decarbonized Power Source Auction is planned for January 2024 to promote investment in power plants that will contribute to achieving carbon neutrality and stable electricity supplies, as well as provide predictability of recovering the associated long-term investments.
- Successful bids provide predictability of recovering fixed costs, but 90% of profits earned on other markets (spot market, etc.) must be returned.

Target plants, planned volume	• New construction and replacement for decarbonized power plants (renewable power plants, hydrogen and ammonia co-firing plants, storage batteries, etc.) (4 million kW annually) • New construction and replacement LNG thermal power plants (6 million kW over 3 years)
Bid price	• Construction costs, operation and maintenance costs, capital costs, etc.
Capacity contract period	• 20 years in principle

Diagram 12: Long-term Decarbonized Power Source Auction cost recovery and profit refunding



90% refund of other market profits may reduce investment incentive

- While there is a low risk of being unable to recover fixed costs with the Long-term Decarbonized Power Source Auction, there is concern the profits from other markets (spot market, etc.) will be limited due to unstable variable costs, technological factors and contract conditions.
- For this reason, the 90% profit refund stipulated in the Long-term Decarbonized Power Source Auction may reduce the incentive to invest in power plants.
- Recovering costs during construction is also a major concern for power plants that have long construction lead times.
- For example, investment incentives in the following power plants may be reduced.

1.) Nuclear power plants (long construction lead time and concerns over sustainable operation due to the technology)

2.) Pumped hydropower plants and storage batteries (unstable variable costs)

3.) Hydrogen and ammonia co-firing power plants (Concern over sustainable operation due to fuel supply contracts)

- To address the above issues, adopting a profit cap after which profits are refunded and a floor below which subsidies are provided, and adopting a framework that allows power plants to recover construction costs can provide greater incentive to invest in new power plants.

Frameworks adopted overseas to guarantee a level of profit for new facility investment and allow recovery costs during construction

- Europe is moving towards adopting a framework that offers predictability of recovering investment costs over the long term. Measures to increase the incentive to invest in new power plants are likely to be one topic of the next Strategic Energy Plan.

○ **Regulated Asset Base (RAB) model**

- The regulator determines a permitted profit level, guaranteeing a degree of profit.
- This method has been approved for new nuclear power plant construction in the UK.
- Operators can recover costs at the various stages of construction, trial operation, and full operation.

○ **Cap & Floor model (two-way contract for difference)**

- Europe is moving towards adopting a cap and floor model that secures a degree of profit by setting upper and lower price limits for newly constructed non-fossil fuel power plants, with operators refunding profits when the price exceeds the cap price, and receiving compensation when the price falls below the floor price.

- In August 2023, Germany announced its intention to hold auctions for 8.8 million kW of new hydrogen-based power plants and up to 15 million kW of new and existing natural gas power plants (with a requirement to convert to hydrogen by 2035) from 2024 onwards. Support measures for these new power plants are under review by the European Commission.

Diagram 13: Regulated Asset Base model

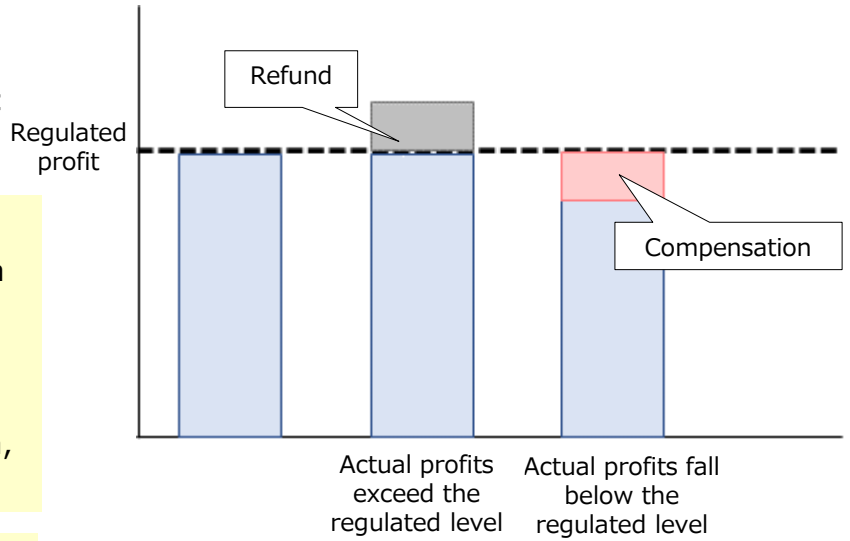
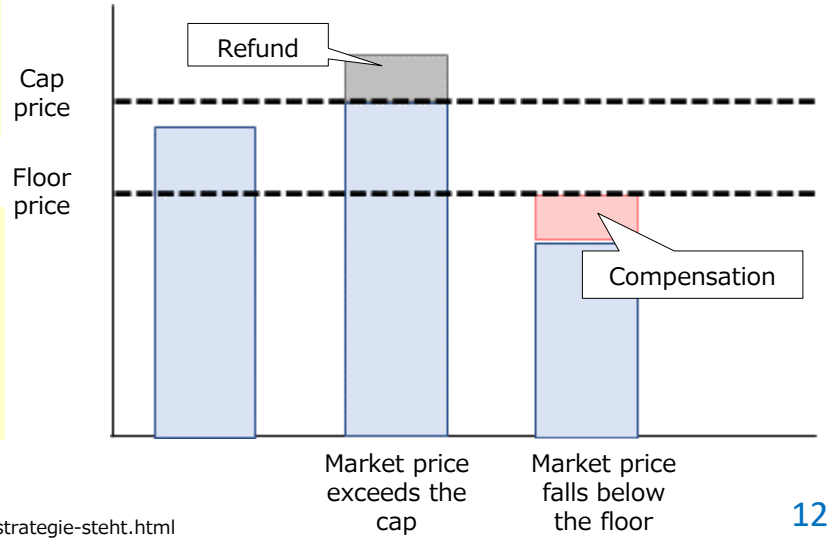


Diagram 14: Cap & Floor model



Source: https://www.bmwk.de/Redaktion/DE/Pressemitteilungen/2023/08/20230801-rahmen-fuer-die-kraftwerksstrategie-steht.html

(Reference) Outlook of mid- to long-term electricity demand

- Going forward, the Long-term Decarbonized Power Source Auction will be leveraged to steadily decarbonize power plants by the target year of 2050 for carbon neutrality while maintaining stable power supplies. The OCCTO review committee is planning to publish a long-term electricity demand prediction to guide the introduction of long-term decarbonized power plants.
- The prediction includes elements expected to have a major impact on electricity demand in the future such as energy saving, electrification, changes in the industrial sector (increased data centers, etc.), at-home power generation, and new technologies.

Diagram 15: New demand created by electrification

- The “Master plan of the cross regional development" published by OCCTO in March 2023 states that the electrification and decarbonization of non-power sector energy consumption (DAC, etc.), and upcoming energy conversion technologies (hydrogen production, etc.) will be achieved by 2050. It is estimated that annual power consumption will increase by approximately 50% above the current level.

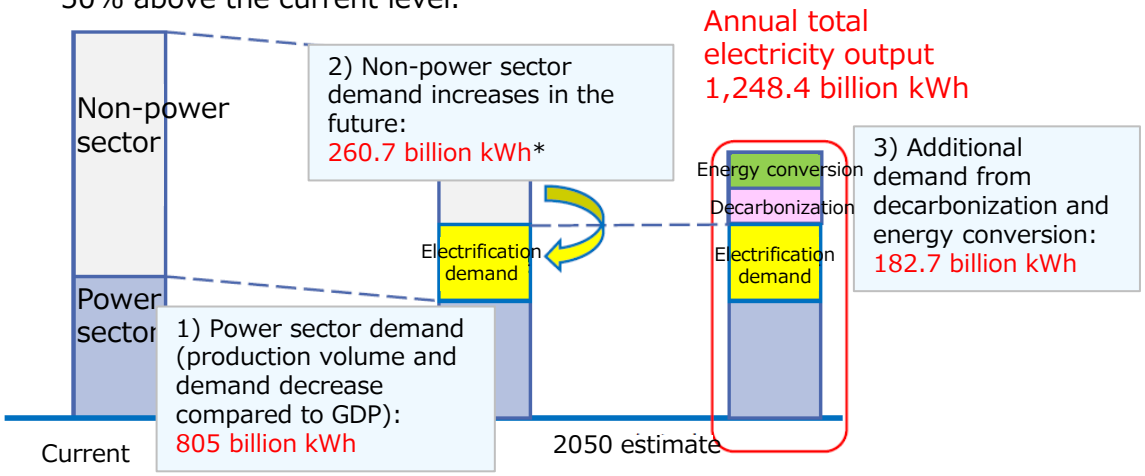


Diagram 16: Additional demand from new data centers

- Opinion is divided on whether data center electricity consumption will increase significantly or not.

(TWh)	Baseline scenario	Increased data center demand case	JST Optimistic Case	JST Modest Case
2016	21	21		
2018			14	14
2030	24	42	6	24
2050	28	110	110	500

- Demand within the TEPCO Power Grid area is expected to increase by approximately 7 million kW in the first half of 2030 due to the expansion of data centers. There are multiple data center construction plans underway in Inzai City, Chiba Prefecture, and electricity demand is expected to increase by 2.5 million kW in the Inzai area by the first half of 2030.

Sources: Quoted from the OCCTO (2023) "Master plan of the cross regional development"
Quoted figures from the Research Institute of Innovative Technology for the Earth (2023) "Outlook of Japan's Electricity Demand by 2050"
Quoted figures from the Japan Science and Technology Agency Decarbonized Society Strategy Center (2021) "The impact of information society progress on energy consumption (Vol.4)”
Referenced the Denki Shimbun "Demand to grow by 7 million kW in the TEPCO PG area in the first half of 2030" (October 12, 2023)

(Reference) Reserve Capacity Scheme under review to maintain dormant thermal power plants

- The Reserve Capacity Scheme is under review to maintain a level of dormant power plants in a state where they can resume operation within a given time window to supply in emergency situations. The output available from the reserve power plants will be marked as quasi supply capacity.

- The oil supply chain must be maintained if oil thermal power plants are used.
- If reserve power plants can make offers on the capacity market after the completion of Reserve Capacity Contracts, it could have a negative effect on market prices.

Target plants, planned volume (proposed)	• Short-term reserve power (approx. 3 months) (1-2 million kW) • Long-term reserve power (approx. 10-12 months) (2-3 million kW) • * Condition to power plants not being bid upon or offered on the capacity market for 2 years.
Provisioning (proposed)	• Operator proposal (total cost) method
Organizer, cost burden (proposed)	• OCCTO organizes, costs recovered from wheeling tariff
Target costs (proposed)	• Dormant maintenance cost (trial run cost, fuel cost, etc.), capital costs
Framework period (proposed)	• 2 to 3 years

Diagram 17: Overview of the Reserve Capacity Scheme