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Electricity Market Design Study

Dr. Stefan Thomas, Fiona Bunge
Mitsuaki Ota, Kenichi Onishi

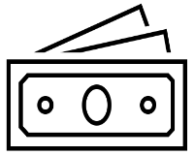
1. Structure of the study

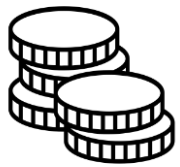
Executive Summary

1. **Introduction**
2. **Needs for the future electricity market design to support the energy transition**
   - 2.1 Scoping of needs for electricity market reform, and selection of priority area(s) for the study
   - 2.2 Existing policies and market design in Japan, and analysis of the challenges
   - 2.3 Existing policies and market design in Germany/EU, and analysis of the challenges
3. **Analysis of reform options to foster investment in flexibility resources**
   - 3.1 Screening of reform options
   - 3.2 General analysis of the selected options
   - 3.3 Analysis of applicability for the selected options in Japan
   - 3.4 Analysis of applicability for the selected options in Germany/EU

1. Structure of the study

2.1 Relevance of the challenges in Germany and Japan





Challenge	Relevance of the Challenge Germany	Relevance of the Challenge Japan
1 Coordination		
1a Wholesale markets	Not as urgent as it seemed in 2022	Less relevant for GJETC
1b Flexibilities	High	Less relevant for GJETC
2 Investment		
2a Renewables	High (but policy is established)	High (but policy is established)
2b Flexible Power Plants	High	High in the long run
2c Non-Fossil Flexibility Option	Very high	High in the long run
3 Signals for local differentiation		
3a Wholesale markets	Disputed	Less relevant for GJETC
3b Renewables	Moderate	Less relevant for GJETC
4 Power Prices/Costs	Moderate	Less relevant for GJETC

2.1. Common Understanding on Flexibilities

"*Flexibility is the modification in the generation and/or consumption pattern of electricity according to an external signal in order to meet energy system needs.*" (Mandatova and Mikhailova, 2014; similar also in Eurelectric, 2014)."

Three uses of flexibility:

1) portfolio optimization in energy markets
2) balancing (in balancing power markets)
3) management of network constraints/congestions

Source: Eurelectric, 2014

Four dimensions of Flexibility

1) time
2) spatiality
3) technology
4) risk profile

Source: Kara et al. (2022)

2.1. Possible case applications: types of flexibility resources

Flexible low carbon power plants (relevance: high in both countries)	**Other flexibility options (relevance: diverse, medium to very high; often higher in Germany in the short term, in Japan lower or later)**
Hydrogen (green or blue) Power Plants	Demand response
Gas Power Plants ready to be converted to 100% hydrogen or ammonia	Grid-integrated batteries
Flexible use of biomass power plants	Building- integrated batteries
	Battery electric vehicles
	Electrolysis
	CHP or heat pumps and other electric heat generators in connection to heat storage
	Cold storage
	Flexible electric production lines (e.g., Aluminium) in connection to product storage

3.1. Potential reform options to stimulate investment in flexibilities

Flexible low-carbon power plants	"energy only" market with reserve assets (Current German model)
	Specific capacity instruments
	"Systemic investment framework" (Uniform capacity instruments for new and existing assets; variants: a) with uniform price; b) with differentiated prices for new and existing assets)
Other flexibility resources	**Direct support or regulation**
	Specific capacity instruments
	Uniform capacity instruments, including both power plants and other flexibilities; variants a) or b) as above
	Regulation/standards on investment in flexibilities; e.g. legal requirements to make energy-using equipment (eg heat pumps, BEVs/charging points) or energy generators remote-controllable, install BEV charging points
	Rethink rules for the forecast of power capacities required to meet demand, to assess and enable Demand-Side Flexibility in Capacity Remuneration Mechanisms
	Providing incentives for using flexibilities, eg DR and storage, to TSOs/DSOs in their regulated revenue
	Allow future costs for necessary expansion of (smart) distribution grids in revenue regulation of DSOs; also in benchmarking calculations; cancel benchmarking for gas DSOs (need to reduce and partly dismantle grid)

Sources: Expertenkommission (2023); European Commission (2022); CAN-Europe (2023); DIW (2023); RAP (2023)

3.1. Potential reform options to stimulate investment in flexibilities

Other flexibility resources	Indirect support or regulation
	Roll-out of smart meters/submeters (necessary precondition for many flexibilities)
	Indirect support through enabling regulations and price signals for the use of flexibilities, providing an indirect incentive to invest
	Nodal pricing (to provide regionalized price signals)
	Allowing aggregators/value stacking (from different markets and resources) in all markets and mechanisms
	Energy communities/energy sharing/peer-to-peer trading
	Regional flexibility markets, e.g. for all flexibilities, or for use of renewable power that would otherwise have to be curtailed
	ToU power prices (and feed-in tariffs)
	Grid fee system incentivizing use of flexibilities (ToU, RTP; interruptible grid use, eg BEV)
	Making taxes and levies time-dependent too
	Market incentives for system-serving behavior
	Waiving grid fees, levies, and energy taxes for storage and electrolysis

Sources: Expertenkommission (2023); European Commission (2022); CAN-Europe (2023); DIW (2023); RAP (2023)

3.1.2. Six Reform Options for further analysis:

Capacity markets	1) Uniform capacity instruments with uniform price for new and existing assets	2) Uniform capacity instruments with differentiated conditions for new and existing assets but uniform price for each class	3) Specific capacity instruments using capacity auctions with differentiated products, specific by type of asset: e.g., uniform auction for new assets with type-specific caps or multipliers leading to multiple prices; separate auctions by type
Other specific capacity instruments for flexibilities	4) Examples: fixed payments per kW/kWh of demand response; government grants for batteries or V2G systems		
Other reform options to stimulate flexibility investment	5) Allowing for costs of flexibilities in revenue regulation (TSO; DSO)	6) Time of use or dynamic (real-time pricing) price components for final customers: applied to power prices, grid fees, or taxes	

3.2. General analysis of the selected reform options

Option 1: Systemic investment framework / Uniform capacity instruments with uniform price

Precondition: in not fully liberalized EM, uncertainty in recovering costs, ensuring supply capacity; Assessment of the amount needed

Advantage: 1) secure supply capacity, predictibility of investment returns, 2) mitigation risk of future tight supply, 3) no price increase due to insufficient procured electricity

Disadvantage: 1) increase cost burden for consumers (short run), 2) uncertainty of winning bids may diminish investment security, 3) payments to existing plants may reduce wholesale power prices and thereby increase incremental cost of renewable energy

Role of actors: 1) neutral organization forecasts demand and request power sources, 2) Retail electricity companies

Legislation/regulation: 1) Electricity Business Act; obligation for securing amount of electricity and capacity

Dispatch: participate in energy market like any other resource, also the balancing market and congestion management if not contradicting their use as firm capacity; for storage & DR, aggregation may be needed

Relevance: support some of the *existing* flexible power sources and flexibility resources; incentives from the typical short-term contracts may not be sufficient to stimulate investment in *new* resources

3.2. General analysis of the selected reform options

Option 3: Specific capacity instruments using capacity auctions with differentiated products

Precondition: Same as option 1 and 2

Advantage:

- more effective for the investment in innovative technologies (compared to option 1 and 2)
- Caps: easier for regulatory body to manage
- Separate auctions: easier to manage type and body of regulation
- Multiplier auction: premium factor for non fossil fuels

Disadvantage: May suffer economic efficiency

Role of actors: Same as in option 1 and 2

Legislation/regulation: Same as in option 1 and 2+ specification for implementation

Dispatch: Same as in option 1 and 2

Relevance: See advantages

3.2. General analysis of the selected reform options

Option 5: Allowing the future costs of flexibilities in the regulated tariffs of TSOs and DSOs

Precondition: 1) TSO/DSO network development planning must take potentials of own flexibilities and those of third parties into account; 2) Smart meters are required for some forms of third-party flexibilities

Advantage: 1) possible economic advantage (due to the avoidance of the expansion of grid capacities), 2) provides a more direct way to stimulate the investment in grid-integrated or grid-serving flexibilities 3) the lead time to implement it will likely be shorter than for other instruments.

Disadvantage: the selection of resources will not be made in a competitive way, so may not be at least cost, but under regulatory scrutiny of costs

Role of actors: 1) TSOs and DSOs need to integrate grid-integrated flexibilities and those of third parties, 2) regulator needs to allow the respective costs in revenue regulation

Legislation/regulation: legislation needs to be adapted to mandate the regulator to allow additional costs in regulated revenues, but also consider savings in operation costs due to the investment, while leaving a positive incentive for the TSO/DSO to invest

Dispatch: If the TSOs or DSOs themselves own the flexibility resources installed, they will dispatch it for management of grid constraints as it will be useful. The same holds for third-party flexibilities they may have contracted

Relevance: may be very effective for managing network constraints, by directly stimulating investment in own flexibility resources of TSOs/DSO and proactive use of flexibilities of third parties

3.2. General analysis of the selected reform options

Option 6: Making power prices, grid fees, and possibly even taxes and levies time-dependent (time of use) or even dynamic (real-time pricing)

Precondition: Smart meters, detailed design and processes to implement the time-of-use or dynamic electricity price components, Legislation and/or regulations may be needed to make the offer mandatory for power suppliers, TSOs, or DSOs

Advantage: cost-efficient way of allocation of resources, reducing the overall costs for ensuring the security of electricity supply (DR and storage often cheaper than grid expansion and flexible power plants)

Disadvantage: 1)price signal alone may not be sufficient to overcome organizational barriers and transaction costs for individual consumers, 2) dynamic prices are blind for network constraints within a wholesale market bidding zone. Therefore, they may increase the need for expanding the network capacity. Dynamic grid fees may counterbalance this effect

Role of actors: TSOs/DSOs need to offer the time-variable electricity prices and grid fees, Metering providers need to install smart meters

Legislation/regulation Legislation and/or regulations may be needed to make 1) the provision of smart meters, and 2) the offer of time-of-use or dynamic price components mandatory for power suppliers, TSOs, or DSOs, and metering providers.

Dispatch: The consumer/prosumer will be responsible for the dispatch of the flexibility in response to the price signal

Relevance: Depending on its detailed design and implementation, it may be very effective for stimulating these demand-side flexibility resources.

3.3. Analysis of applicability for the selected options in Japan

Option 1: Uniform capacity instruments with uniform prices	**Option 3:** Specific capacity instruments using capacity auctions with differentiated products, specific by type of asset: e.g., uniform auction for new assets with type-specific caps or multipliers leading to multiple prices; separate auctions by type.
Capacity market auction started since 2020	Long term decarbonized power source auction started since January 2024
• OCCTO(The Organization for Cross-regional Coordination of Transmission Operators) initiates a capacity market auction four years ahead of the actual supply and demand. • The first capacity market auctions for FY2024 were held in FY2020 and have been held four times already.	• The auction will target the new installation and replacement of decarbonized resources like renewables, hydrogen/ammonia, storage batteries, pumped-storage, nuclear as well as the renovation of existing thermal plants into decarbonized ones.

3.3. Analysis of applicability for the selected options in Japan

Option 2: Uniform capacity instruments with differentiated conditions for new and existing assets but uniform price for each class	**Option 4:** Other specific capacity instruments.	**Option 5:** Specific capacity instruments using capacity auctions with differentiated products, specific by type of asset: e.g., uniform auction for new assets with type-specific caps or multipliers leading to multiple prices; separate auctions by type	**Option 6:** Time of use or dynamic (real-time pricing) price components for final customers: applied to power prices, grid fees, or taxes
Not implemented and not planned, since Japan combines options 1 and 3 instead	Not implemented and not planned, since Japan combines options 1 and 3 instead	Not explicitly discussed In 2023 a revenue cap system regarding the tariffs of TSO and DSO was introduced It is possible for TSOs and DSOs to include investment costs of flexibilities, as long as approved by the government. However, current investment focus is mostly set on other factors.	Partially discussed Some retail electricity providers may offer dynamic pricing menus' to maximize profits and reduce costs for consumers. Some TSO/DSO provides the time of use pricing menu on grid fees but there is no political and scientific debate of an obligation for time of use or dynamic pricing in power prices, and taxes.

3.3. Analysis of applicability for the selected options in Japan

Option 3. Long-Term Decarbonized Power Source Auction - Background

- Even if a capacity market is introduced, the prospect of long-term investment recovery is uncertain due to the full liberalization and one-year capacity contracts.
- There are concerns that investments in the power plants, which require long construction periods and large amount of investment, will stagnate.

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- It is necessary to introduce a system to secure long-term fixed income for new power source investments.

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- To ensure the predictability for power generation companies and encourage active investment in decarbonized power plants, long-term decarbonized power source auction is being considered.

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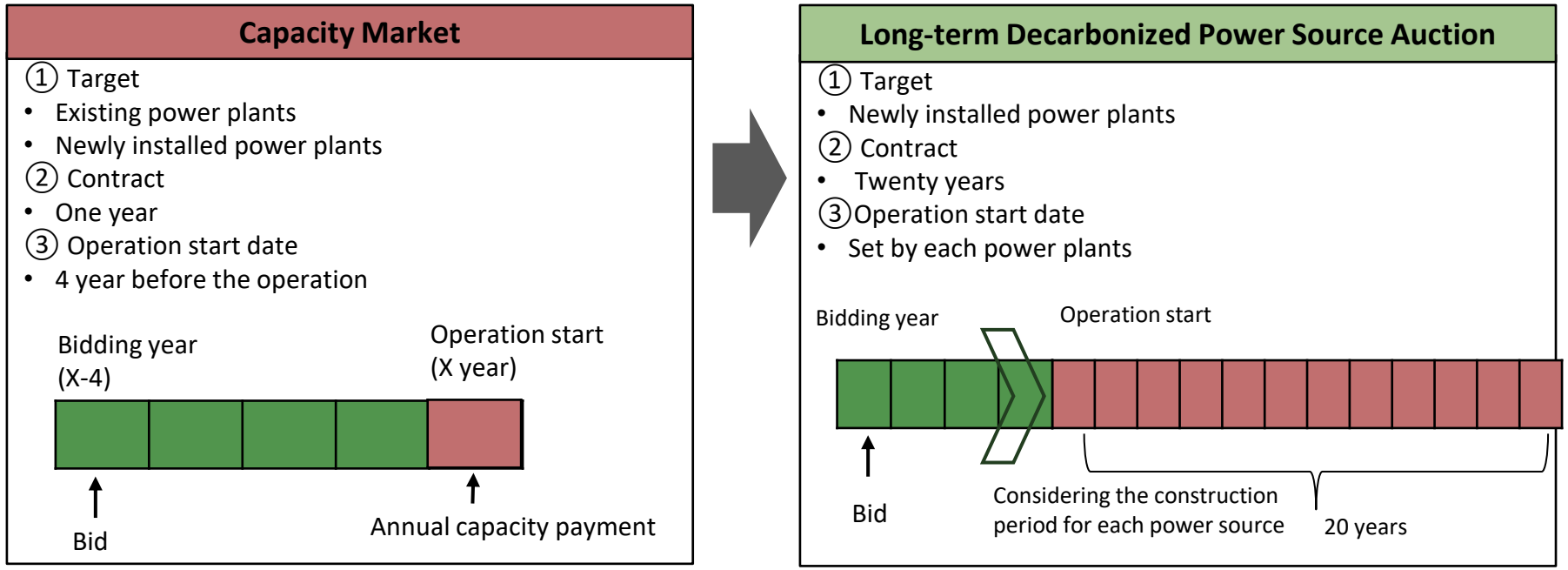
- Furthermore, in order to achieve carbon neutrality by 2050, it is also necessary to invest in new and replacement of decarbonized power plants as well as to replace the thermal power source with decarbonized power one.

3.3. Analysis of applicability for the selected options in Japan

Option 3. Long-Term Decarbonized Power Source Auction – Overview

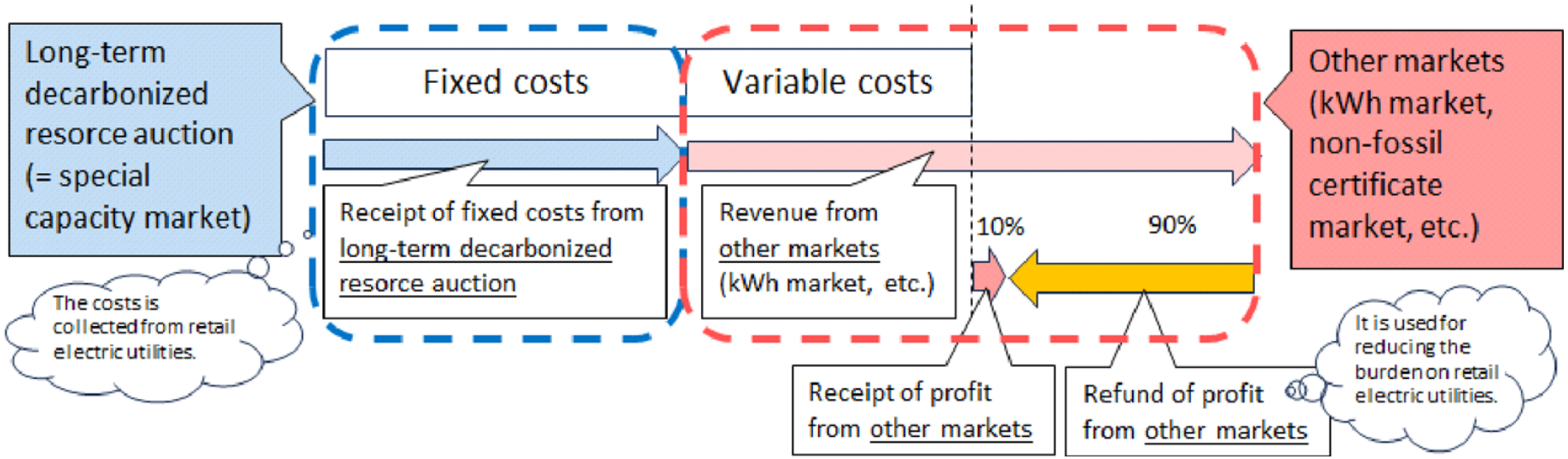
- Long-term decarbonized power source auctions commenced in January 2024.
- This auction targets the new installation and replacement of decarbonized resources like renewables , hydrogen/ammonia, batteries, pumped-storage, nuclear as well as the renovation of existing thermal plants into decarbonized ones.
- Successful bidders receive a fixed cost (construction cost, operation and maintenance cost, capital cost, etc) for 20 years.
- Unlike capacity market, considering the construction lead time, this auction allow for individual operation start date per power sources.



3.3. Analysis of applicability for the selected options in Japan

Option 3. Long-Term Decarbonized Power Source Auction – Problems

- The long-term decarbonized power auctions ensures the fixed cost while the income from variable cost is gained from the other markets.
- Regarding variable costs, if there are no upper limit, power generation companies can potentially earn as much additional income as they want.
- Therefore, this system requires a refund. To be specific, 90% of the profits earned in other markets will be refunded later, but there will be no compensation for losses.
- However, the condition of 90% refund of profits from other markets may not make the system attractive to some power generators.



［Source］https://www.occto.or.jp/market-board/market/oshirase/2023/files/202306_youryou_gaiyousetsumei_long_r.pdf

3.4. Analysis of applicability for the selected options in Germany

Option 1: Uniform capacity instruments with uniform prices	**Option 2:** Uniform capacity instruments with differentiated conditions for new and existing assets but uniform price for each class	**Option 3:** Specific capacity instruments using capacity auctions with differentiated products, specific by type of asset: e.g., uniform auction for new assets with type-specific caps or multipliers leading to multiple prices; separate auctions by type
There are some discussions e.g., in the PKNS on centralized and decentralized capacity markets. However, relevance may be low since existing nuclear and coal power plants shall be replaced anyway Marginally discussed due to the very limited need to maintain an economic viability of operating existing fossil-fuel power plants	See Option 1	– Not implemented yet – With the announcement of the German government's power plant strategy on February 5th, the introduction of a capacity market in 2028 was also announced. It may be of the option 3 type, or a combination with option 1 – The German government plans to discuss an initial concept for this with the European Commission in mid-2024 In the case that a more systematic procurement of capacities will be needed, the Expertenkommission (2023) and PKNS seem to favor this option

3.4. Analysis of applicability for the selected options in Germany: Options 4 to 6 - status today and plans

Option 4: Other specific capacity instruments.	**Option 5:** Allowing for costs of flexibilities in revenue regulation (TSO; DSO)	**Option 6:** Time of use or dynamic (real-time pricing) price components for final customers: applied to power prices, grid fees, or taxes
There are already many such instruments: • Biomass auctions in Renewable Energy Law (EEG) (6 GW by 2030); hydrogen auctions will be cancelled • CHP law (1.4 GW by 2030 plus fixed FIP capacities) • Various power plant reserves (ca. 9 GW outside markets) according to §§13d to h EnWG • Demand Response • Storage for grid operations purpose • Balancing power markets • The 'power plant strategy' (planned: 10 GW of H2 ready gas power plants by 2028) • The 'national energy storage strategy'	• Revenue regulation exists in the form of "incentive regulation" • Scheme needs special allowance for extraordinary investments • These schemes already exist for connecting renewables but not for storage, demand side energy efficiency and demand response • Recent changes of the EU electricity market reform of Art 18 require that Germany will need to create incentives for TSO and DSO to use or procure flexibility services like DR and storage • Changes in Article 27 and 3 of the Energy Efficiency Directive require energy regulators to apply the energy efficiency first principle in their network planning, network development and investment decisions.	• Law on the Restart of the Digitalization of the Energy Transition states that from 2025 dynamic prices must be offered, if smart meters are available • Time-variable grid fees will have to be offered from 2025 to owners of heat pumps and BEVs under the Regulation according to §14a EnWG • We are not aware of further plans by the German federal government at this stage

4.2. Existing and planned / needed instruments under the six reform options (Option 1-3)

	Japan	Germany
Option 1: Uniform capacity instruments with uniform prices	**Existing /** **Frequently discussed**	**Not existing but maybe from 2028 /** **Marginally discussed**
Option 2: Uniform capacity instruments with differentiated conditions for new and existing assets but uniform price for each class	**Not existing /** **Not discussed**	**Not existing /** **Marginally discussed**
Option 3: Specific capacity instruments using capacity auctions with differentiated products, specific by type of asset: e.g., uniform auction for new assets with type-specific caps or multipliers leading to multiple prices; separate auctions by type	**Existing /** **Marginally discussed**	**Not existing but maybe from 2028 /** **Frequently discussed**

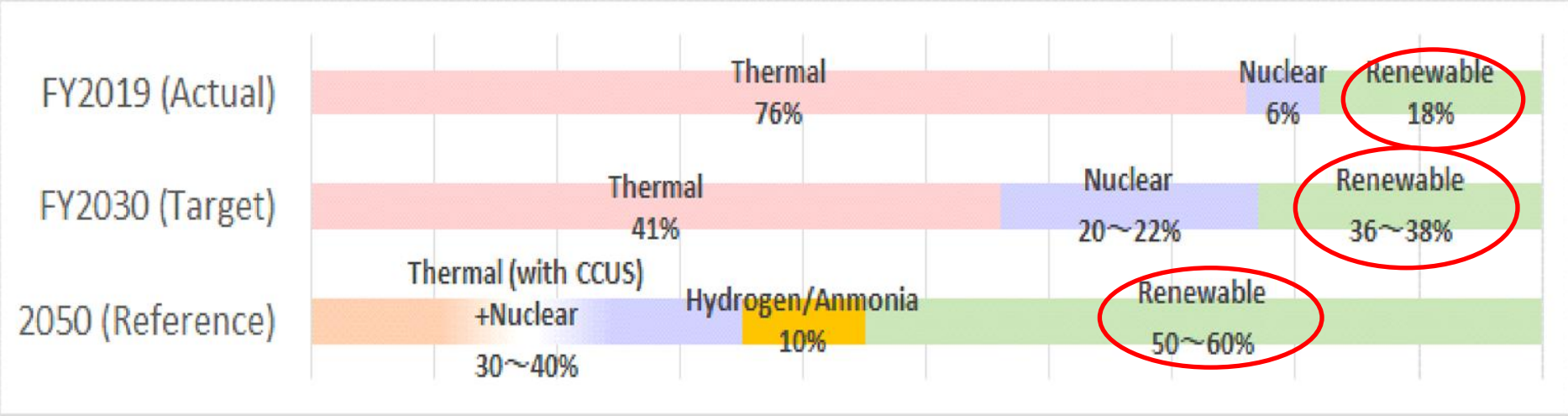
4.2. Existing and planned / needed instruments under the six reform options (Option 4-6)

	Japan	Germany
Option 4: Other specific capacity instruments.	**Not existing /** **Not discussed**	**Implemented in various ways /** **Highly discussed**
Option 5: Allowing for costs of flexibilities in revenue regulation (TSO; DSO)	**Not existing /** **Not discussed**	**Not explicitly implemented /** **Highly discussed**
Option 6: Time of use or dynamic (real-time pricing) price components for final customers: applied to power prices, grid fees, or taxes	**Partially implemented (voluntary) /** **Not discussed**	**Partially implemented from 2025 /** **Highly discussed**

4.2.1. Policy Recommendation

Background: Power Generation Mix in Japan

- In October 2020, Japan announced its goal to achieve carbon neutrality by 2050.
- In the electricity sector, the share of renewable power generation in the generation mix will be 50-60% by 2050.
- In addition, the "6th Strategic Energy Plan" released in 2021 aims for a generation mix of 36-38% renewable power generation.
- As of FY 2019, the renewable power generation accounted for 18% of the generation mix.



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4.2.1. Policy Recommendation

The government systematically procures the supply capacity

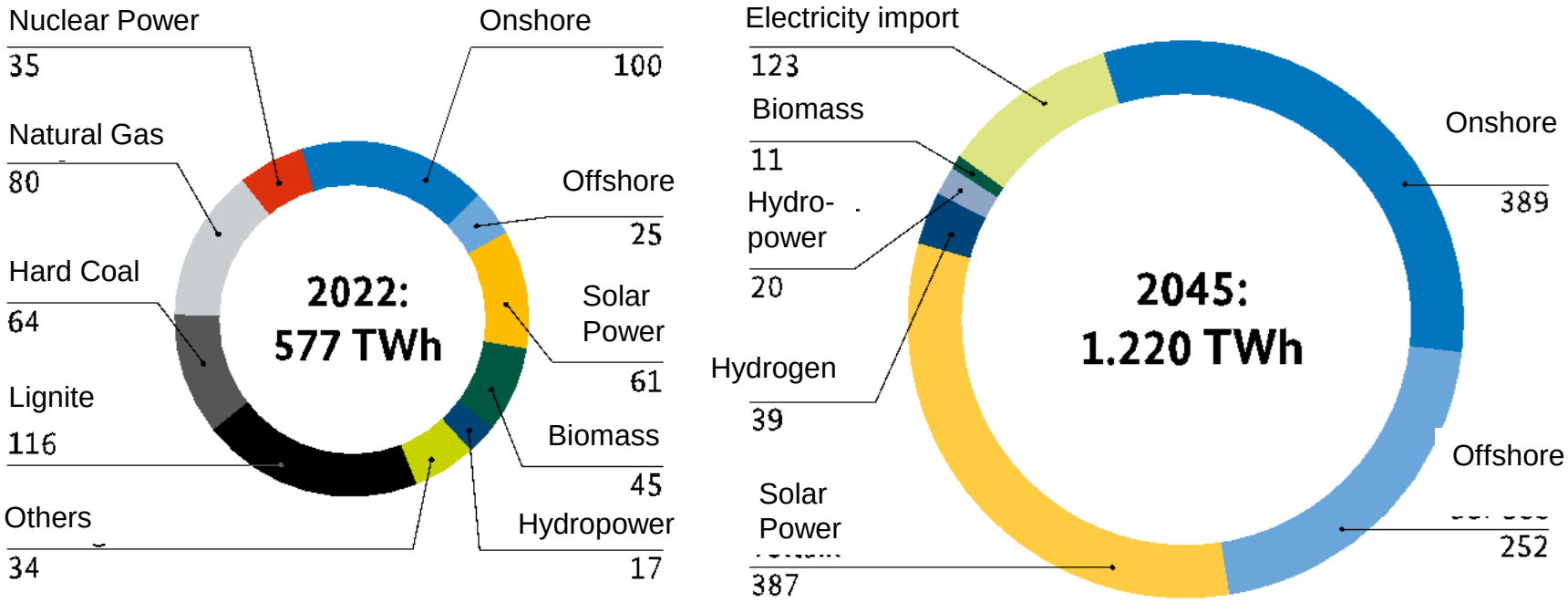
- Electricity industry in Japan has more focused on competition since full liberalization in 2016.
- However, in recent years, as carbon neutral become important policy issue, the expansion of renewables is expected to accelerate further.

- Conversely, with the increase of FIT power plants with low marginal cost into wholesale market, the capacity of thermal power plants, which has traditionally functioned as balancing power sources, is decreasing.
- This highlights the need to secure the balancing capacity, particularly for decarbonized power sources.

- Yet, within the framework of free competition, it is not necessarily possible to systematically procure the necessary capacity.
- Therefore, government support is crucial to facilitate investment.
- Japan has already initiated measures such as capacity market and long-term decarbonized power source auction.
- These policy measures are expected to systematically secure the decarbonized balancing power sources required towards carbon neutrality.

4.2.2. Policy Recommendations for Germany

Background: Power generation mix pathways will be 80% renewables in 2030, 100% before 2045



Source: BMWK (2023), Zwischenbericht der Systementwicklungstrategie (own translation)

4.2.2. Policy Recommendations for Germany

- First step: apply the energy efficiency first principle, using benefit-cost analysis to assess the least-cost potential of
  - large-scale and small scale energy storage; heat storage coupled with CHP and heat pumps; BEVs; demand response; smart grid technologies; electrolyzers
  - in comparison to expanding supply-side resources, such as gas/hydrogen power plants
  - for generation capacity as well as TSO and DSO network planning
- For the capacity market planned from 2028 (reform option 3 or mix with option 1?), give priority to least-cost demand-side flexibility resources over new power plants; for the latter, prioritize CHP plants replacing coal-fired CHP plants, also in auctions up to 2028
- If necessary, create other specific capacity instruments (reform option 4) for demand-side flexibility resources for the period until the capacity market is fully operating, and make sure that the roll-out of smart meters is accelerated
- In addition, make power prices, grid fees, and possibly taxes and levies time-dependent (reform option 6)
- Reform the revenue regulation of TSOs and DSOs to better allow them integration of flexibility costs into network tariffs (reform option 5), instead of grid expansion.

Questions for further discussions:

- On which reform options and aspects could Germany learn from Japan and vice versa?
- How can we best give priority to least-cost demand-side flexibility resources over new power plants in capacity markets / mechanisms?
- Which other general or technology-specific barriers may exist (except the too low revenues from the wholesale energy market and static pricing for end users)? What could be done to remove them?

For further information please visit gjetc.org

Thank you for your attention

Dr. Stefan Thomas – stefan.thomas@wupperinst.org
Fiona Bunge – fiona.bunge@wupperinst.org
Mitsuaki Ota – mitsuaki.ota@tky.ieej.or.jp
Kenichi Onishi - kenichi.onishi@tky.ieej.or.jp
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