

Watt's next? Design options and impacts of a German capacity mechanism

27 June 2024

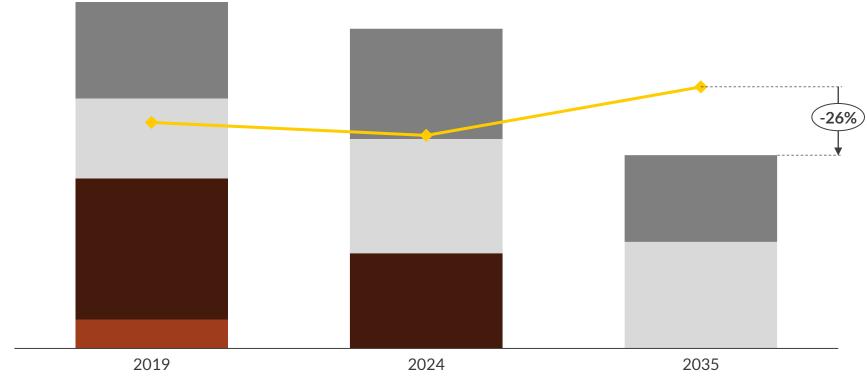




- I. Introduction
- II. Exploring capacity mechanism trends: Centralised vs. decentralised approaches
- III. A central Capacity Market for Germany: What can be learned from other countries?
 - 1. Auction criteria and financing
 - 2. Participation criteria
- IV. Key takeaways

Without new builds, the coal exit and rising demand lead to a 26% gap between peak residual demand and dispatchable capacity by 2035

Peak residual demand and dispatchable capacity without new builds $^2\,\mathrm{GW}$



Share of peak residual demand¹ covered by dispatchable capacity



1) Peak residual demand refers to total net demand minus wind and solar generation. 2) Based on the Aurora Central scenario, but no buildout of non-CHP power plants is assumed. 3) Includes gas CCGTs and peakers. 4) Includes hydro, biomass, pumped storage, battery, and other thermal (i.e., waste plants and on-site industrial thermal power plants).

Sources: Aurora Energy Research. BNetzA

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- In the past, the German power system was characterised by overcapacity, with dispatchable capacity significantly exceeding peak residual demand.
- Due to the coal exit, 40% of the currently installed dispatchable capacity is expected to leave the system by the early 2030s.
- Simultaneously, increasing electrification of industry, transport, and heat as well as the domestic production of green H₂ drive up peak residual demand significantly by 2035.
- Significant buildout of new dispatchable capacity is needed to reduce this gap and ensure security of supply. At the same time, these new assets need to be able to decarbonise swiftly to not jeopardise climate targets.

To ensure buildout of dispatchable capacity, the government committed to introduce a capacity mechanism by 2028 as a complement to the new KWS¹





Up to **10GW of new H₂-ready gas plants** form the core of the Power Plant Strategy (KWS)

Announcement of a capacity mechanism

options to participate.

mechanism.

New H₂-ready natural gas power plants

- Auctions to be held for 10GW of capacity to receive CAPEX subsidies
- Full conversion to hydrogen² required between 2035 and 2040³
- OPEX subsidy to cover the fuel price difference to natural gas⁴

New capacity announced GW 15 10.5 10 5 10.0 0 0.5

H₂ power plants

 Pure H₂ plants for research and exploratory purposes From September 2025
Specification of CM design
expected under new government

• The government has committed to developing concepts for a market-

different generation technologies, storage, and demand-side response

• Focus for this mechanism is on **technology neutrality**, i.e., allowing

• The new gas-fired power plants incentivised via the **Power Plant**

Strategy are meant to be "fully integrated" into the capacity

based capacity mechanism to be launched by 2028.

2024

2028

Auction for Long Duration Energy Storage (LDES) technologies

 Technology-neutral tender for LDES technologies, details still under consideration Summer 2024

Government to publish option paper with general indications on CM⁵

Targeted launch year of CM

→ Please see our multi-client study on the KWS for more information.



Focus of today's session

A

Introduction of both the Power Plant Strategy and capacity mechanism hinge upon approval under EU state aid law.

1) Kraftwerksstrategie (Power Plant Strategy). 2) Not restricted to electrolytic (green) hydrogen; blue hydrogen can also be used as a fuel. 3) Exact conversion date to be defined in 2032. 4) Available until 2040 for max. 800 full load hours per year. 5) Capacity mechanism.

Source: Aurora Energy Research



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contact:

Kevin Cabellero

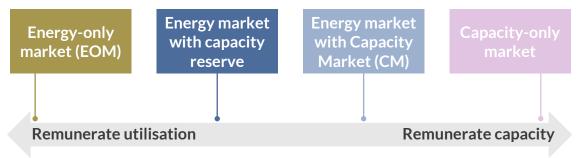
Capacity markets have become more prevalent over the last decades as concerns about dispatchable capacity provision in EOMs have risen





Power market design

 A Capacity Market is an element of market design through which plant operators are paid to make capacity available for a given period in the future. Unlike in an EOM¹, producers receive remuneration regardless of whether generation occurs or not.



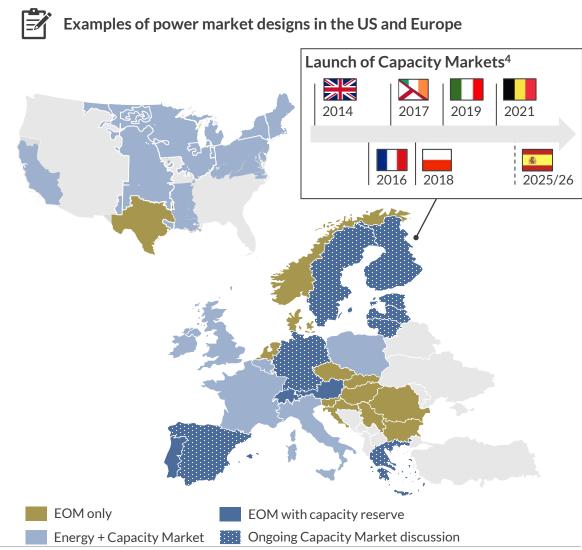
• An increasing number of countries have set up CMs over the past decades:



In Europe, CMs have been implemented in six countries. Eight more countries, including Germany, are currently debating the introduction of a CM².



Capacity markets in the US have been in place for longer, most of them were established in the early 2000s and have undergone or are undergoing reforms³.



¹⁾ Energy-Only Market. 2) Spain is currently at an advanced stage and undergoing consultation of its proposed CM. 3) Due to capacity changes and extreme weather events causing supply issues, several of the US Capacity Markets are currently undergoing revisions of their capacity accreditation and procurement target. 4) Refers to year in which CMs became/are expected to become operational and hold auctions. Source: Aurora Energy Research

High levels of security of supply and relative ease of implementation have led to the widespread adoption of centralised Capacity Markets

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Assessment of different capacity remuneration mechanisms

Obligation	Example	Ease of administration	Openness to innovation	Security of supply level	investment incentives	Application
Central	Central authority ¹ holds yearly auctions to procure system-wide required capacity.	•	•	•	•	New York ISO independent System Operator
Central and decentral	Suppliers procure capacity individually, subject to a system-wide obligation determined by the central authority, which additionally holds auctions to clear residual capacity needs.	0	•	•	•	™ISO
Decentral	Power suppliers and large consumers must secure capacity certificates issued by generators and DSR ² .	•	•	•	•	California ISO
Decentral	Power off-taker enters agreement with power supplier to hedge against peak prices in exchange for a stable revenue stream for the plant operator.	•	•	•	•	New York ISO Independent System Operator
	Central Central and decentral Decentral	Central Central authority¹ holds yearly auctions to procure system-wide required capacity. Suppliers procure capacity individually, subject to a system-wide obligation determined by the central authority, which additionally holds auctions to clear residual capacity needs. Power suppliers and large consumers must secure capacity certificates issued by generators and DSR². Power off-taker enters agreement with power supplier to hedge against peak prices in exchange for a stable revenue	Obligation Example administration Central Central authority¹ holds yearly auctions to procure system-wide required capacity. Central and decentral and decentral Suppliers procure capacity individually, subject to a system-wide obligation determined by the central authority, which additionally holds auctions to clear residual capacity needs. Decentral Power suppliers and large consumers must secure capacity certificates issued by generators and DSR². Power off-taker enters agreement with power supplier to hedge against peak prices in exchange for a stable revenue	Obligation Example administration innovation Central Central authority¹ holds yearly auctions to procure system-wide required capacity. Image: Central authority¹ holds yearly auctions to procure capacity individually, subject to a system-wide obligation determined by the central authority, which additionally holds auctions to clear residual capacity needs. Decentral Power suppliers and large consumers must secure capacity certificates issued by generators and DSR². Decentral Power off-taker enters agreement with power supplier to hedge against peak prices in exchange for a stable revenue	Obligation Example administration innovation supply level Central Central authority¹ holds yearly auctions to procure system-wide required capacity. Image: Central authority¹ holds yearly auctions to procure system-wide required capacity. Image: Central authority yearly auctions to procure capacity individually, subject to a system-wide obligation determined by the central authority, which additionally holds auctions to clear residual capacity needs. Image: Central authority yearly auctions to clear residual capacity needs. Decentral Power suppliers and large consumers must secure capacity certificates issued by generators and DSR². Image: Central authority yearly auctions to procure system-wide required capacity yearly auctions to a system-wide required capacity. Decentral Power off-taker enters agreement with power supplier to hedge against peak prices in exchange for a stable revenue Image: Central authority yearly auctions to procure apacity yearly auctions to a system-wide required capacity.	Obligation Example administration innovation supply level incentives Central Central authority¹ holds yearly auctions to procure system-wide required capacity. Image: Central authority auctions to procure capacity individually, subject to a system-wide obligation determined by the central authority, which additionally holds auctions to clear residual capacity needs. Image: Central authority, which additionally holds auctions to clear residual capacity needs. Decentral Power suppliers and large consumers must secure capacity certificates issued by generators and DSR². Image: Decentral authority, which additionally holds auctions to clear residual capacity needs. Decentral Power off-taker enters agreement with power supplier to hedge against peak prices in exchange for a stable revenue Image: Decentral authority auctions to clear residual capacity needs.

¹⁾ In most cases, the central authority is the Transmission System Operator (TSO) or regulator. 2) Capacity certificates are then traded on market or bilaterally.



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We benchmark various design choices against a technology-neutral central Capacity Market, based on Aurora's Central scenario

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The subsequent discussions and analyses are based on the following scenario:

Aurora Central scenario (as of April 2024)

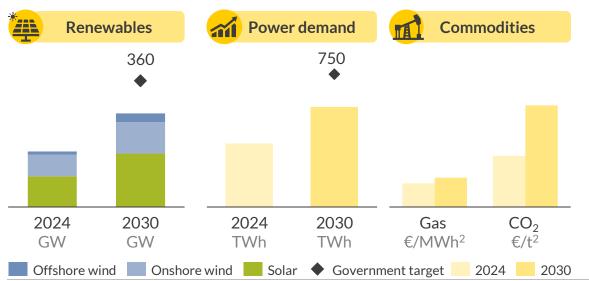


Centralised Capacity Market

Reflecting Aurora's best view on the evolution of the German power market, our Central forecast assumes full decarbonisation of the German economy by 2060.

Policies

Incorporating currently stated policies, including the recently announced Power Plant Strategy (KWS1), alongside a conservative view of future policy measures and market developments.



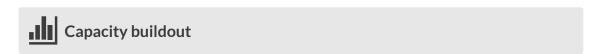
First auctions held in 2028 in line with government announcement and design of the Capacity Market based on lessons learned from other countries:

Design elements		Design elements	Key assumptions ³	Deep- dive
pue	©	Procurement target	Defined based on power demand trends across weather years	1
Auction criteria and financing	== -×	Auction and contract framework	T-4 (new builds) and T-1 auctions (existing), 15-year (new builds) and 1-year contracts (existing)	2
Auction	<u>\</u>	Pricing	Descending clock, pay-as-clear auctions and moderate price cap	3
4		Refinancing	N. A.	(4)
teria	%	De-rating factors	Technology-specific based on benchmarks across European CMs	5
Participation criteria		Emissions criteria	Lignite, hard coal, and oil plants excluded; gas new builds are H_2 -ready and switch gradually ⁴ to H_2 ; ban of gas new builds ⁵ after 2035	
Parti	mi mi	Locational signals	N. A.	(6)

1) Kraftwerksstrategie (Power Plant Strategy), 2) Real 2023. 3) Key assumptions behind the DEU Capacity Market scenario. 4) Between 2036 and 2040. Carbon Capture and Storage (CCS) is not assumed to be adopted at large scale for power sector decarbonisation. 5) This implies that past 2035, only pure H₂ plants can be built, i.e. plants running exclusively on H₂.

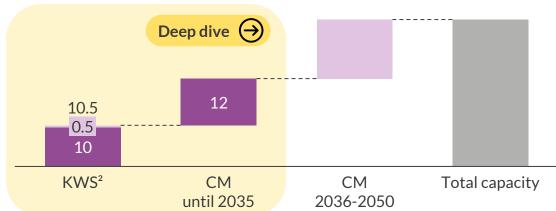
Complementing the KWS, a central Capacity Market could incentivise 12GW of additional thermal buildout by 2035



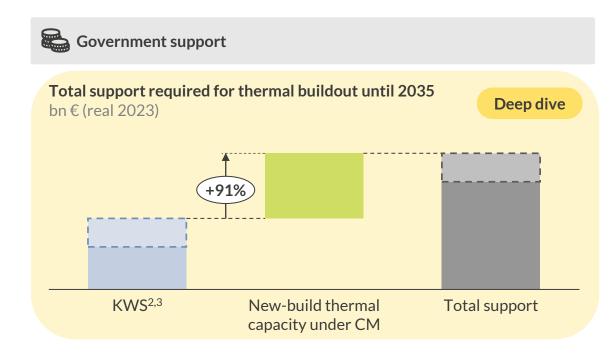


New-build thermal capacity¹

GW



- By 2035, an additional 12GW of H₂-ready gas plants could be supported under a CM, adding more capacity than foreseen by the Power Plant Strategy.
- Assuming a ban on new-build conventional gas plants after 2035, we expect pure H₂ plants to provide additional capacity by 2050 under the CM.
 - Initially, buildout is dominated by peakers due to their lower CAPEX relative to CCGTs.
 - However, H₂ CCGT plants only start building once H₂ prices decline, allowing for higher energy revenues.



■ The buildout of H₂-ready gas plants until 2035 under the CM comes at similar costs as buildout under the KWS.

Additional support

- Next to thermal buildout, other technologies are expected to benefit from the Capacity Market as well, such as batteries (⇒ Deep dive).
- Under our DEU Capacity Market scenario, if split evenly across all power consumers⁴, implementation of a Capacity Market could cost around
 0.4 ct/kWh per year on average between 2029⁵ and 2050.

H₂-ready gas plants Pure H₂ plants



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CM targets depend on demand trajectories and will be challenging to define given uncertainty in demand levels and flexibility in Germany





Procurement target

Capacity Market target

- The Capacity Market procurement target is set to guarantee sufficient capacity will be available to meet future power demand.
- It is usually calculated in a way that the expected period of loss of load¹ falls below a certain threshold, e.g., 3 hours in total per year in the UK.

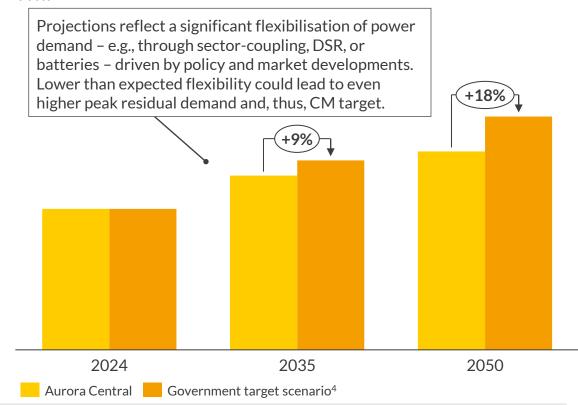
Key policies influencing the Capacity Market target

 While policy targets are defined for all major power demand segments in order to promote decarbonisation, their achievement remains uncertain:



Peak residual power demand in Germany

TWh



Key takeaway for Germany

Uncertainty in future demand levels and demand flexibility in Germany poses a challenge for estimating the Capacity Market target, potentially leading to overestimation which could result in over-procurement of new-build assets.

¹⁾ Loss of load refers to times when power demand is higher than available generation. 2) Reflecting DEU Capacity Market scenario. 3) Derived from a government concept paper. 4) Equivalent to Aurora's Net Zero scenario.



T-4 auctions are used frequently and provide sufficient lead time for buildout, while 15-year contracts facilitate lower bids from new assets





Auction timing

Auction timing indirectly influences the types of new-build technologies able to participate in the Capacity Market due to varying lead times depending on the type of power plant.

Lead time before delivery in centralised European Capacity Markets Years

Country	Min.	Max.	Intermediate	Ad-hoc auctions
	1	4	2 (from 2025)	_
	1	4	-	-
	1	4	-	2-3
	1	4	3	2
	1	5	-	-



Contract duration

Contract duration indirectly influences bids from new-build plants. Shorter contracts mean capacity payments are spread over fewer years, requiring providers to seek higher annual funding to cover the missing money gap.

Contract duration in centralised European Capacity Markets Years

Country	Existing plants	Refurbishing plants	New builds
	1	1	1-15 ¹
	12	3	15
	1	10	10
	1	1 or 15 ³	15
	1	1-74	1-174

Key takeaways for **Germany**

- To provide sufficient time for the buildout of new plants, auctions should be held a minimum of 4 years in advance, with additional auctions closer to the provision date to be able to address short-term capacity gaps.
- Contract lengths of 1 year for existing plants and 15 years for new-build plants have proven successful in other markets. Additional diversification of contract lengths could support capital-intensive refurbishing of plants or favour plants with low emissions.

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¹⁾ In Belgium, new builds can apply for multi-year contracts of up to 15 years if meeting the investment thresholds. 2) Demand-side response (DSR) can be awarded multi-year contracts of up to 15 years. 3) In Italy, an existing plant can request to be considered a new plant if a minimum investment threshold is reached (214k €/MW for delivery years 2024/25). 4) In Poland, refurbishing and new plants can receive contracts of up to 7 or 17 years respectively depending on their emission intensity and investment costs. Sources: Aurora Energy Research, Elia



Most European Capacity Markets have opted for pay-as-clear pricing with price caps between 77 and 164k €/MW p.a.





Price formation

- Auctions can award capacity remuneration:
 - at the level of the individual bid ('pay-as-bid'), or
 - at the level of the highest accepted bid ('pay-as-clear').
- In theory, both methodologies should lead to similar auction results under the following conditions:

Condition

Status in European markets

Homogeneous product

Sufficient market competition

Perfect information for all participants

- CMs procure capacity without distinction
- Most power markets feature high levels of competition
- Lack of complete information on investment costs for new-build capacities
- Due to imperfect information, most CMs¹ apply a pay-as-clear pricing mechanism. This also allows to reduce administrative complexity if coupled with descending clock auctions.

M Price cap

- Defined by the procuring entity, price caps set the maximum possible bid for each auction².
- In competitive auctions, the price cap indirectly impacts the participation of different technologies through its relation to their missing money³.
- Price caps differ between European CMs and have seen changes over time:
 - Belgium has the lowest price cap of 77k €/MW p.a. as the extension of the nuclear exit reduces capacity requirements.
 - The price cap in the Ireland I-SEM CRM⁴ has been steadily increased from 138 to 164k €/MW p.a. since 2019 to incentivise required thermal capacity buildout in light of a high-cost environment and supply chain issues.

Capacity market price caps in Europe⁵

€/MW per annum













Key takeaways for Germany

- Due to imperfect information, pay-as-clear is the preferred pricing scheme, allowing for more efficient auction results.
 - Price caps should be sufficiently high to allow for thermal capacity buildout, accounting for their missing money. To reflect cost changes and capacity needs, they should be adjusted on an ongoing basis.

Sources: Aurora Energy Research, BDEW, Elia, SEM-O

¹⁾ Belgium is the only country that opted for a pay-as-bid methodology. 2) The price above which no more remuneration is awarded. 3) Along with the contract length. 4) Capacity Remuneration Mechanism. 5) Referring to the latest main auction for new builds. In GB, £75k/MW. 6) Reflecting the DEU Capacity Market scenario.



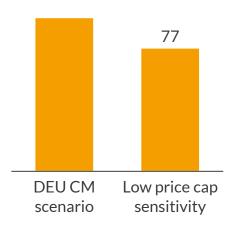
If the CM price cap is not set sufficiently high, CCGT buildout could go down by up to 25% between 2032-2040, increasing import reliance

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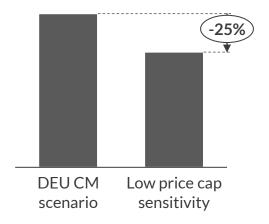
To dive deeper into this, contact:

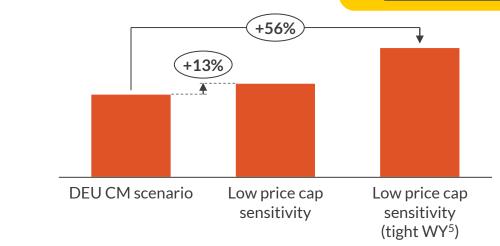
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DEU Capacity Market price cap k €/MW p.a. (real 2023)



New-build CCGT¹ capacity 2032-2040²





Net power imports for example year 2033

TWh

- Lowering the CM price cap to the level of the minimum cap currently applied in Europe³ could reduce CCGT buildout under the CM by up to a quarter.
 - Until 2040, CCGTs increasingly rely on CM revenues as energy revenues decrease over time, rendering CCGTs less profitable with lower CM prices.
 - A key driver, and uncertainty, behind decreasing energy revenues of CCGT plants is the drop in full load hours between 2035 and 2040, caused by an assumed gradual fuel switch⁴ from gas to H₂.

- While power demand could still be covered despite lower CCGT buildout, this would come at the cost of increased reliance on imports, with net imports potentially rising by up to 56% in 2033 under a tight weather year.
- However, the availability of power imports could become more uncertain in the future, especially as periods of high (residual) demand will increasingly occur simultaneously across Europe.

Key takeaways for Germany

1

When designing the CM price cap, the timeline and approach for the decarbonisation of gas assets should be considered, as they will strongly impact energy revenues (and thus capacity payments required) for new-build gas plants.

2

To ensure a balance between efficiency (i.e. reducing CM costs through tight price caps) and security of supply, close coordination of capacity adequacy measures with other countries, ideally at EU level, is advisable.

Source: Aurora Energy Research CONFIDENTIAL 15

¹⁾ All new-build CCGTs are H₂-ready. 2) Excluding new-build plants under the Power Plant Strategy. 3) Reflecting the price cap of 77k €/MW in the Belgian Capacity Market. 4) Fuel switch occurs between 2036 and 2040. 5) Weather year.



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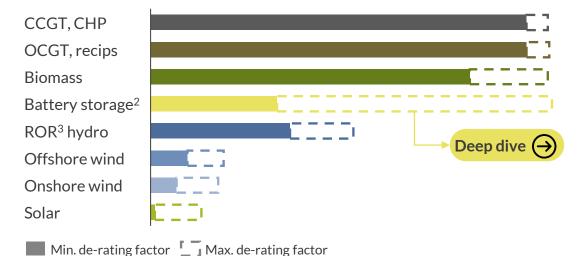
To guarantee security of supply, adoption of binding de-rating factors reflecting availability of technologies in tight periods is advisable



% De-rating factors

De-rating factors reflect the contribution that a specific technology can make to security of supply in case of a scarcity event and determine the annual Capacity Market payment:

Minimum/Maximum de-rating factors for latest EU T-4 auctions¹



Battery de-rating factors Deep dive

De-rating factors for batteries depend on:

Duration (i)



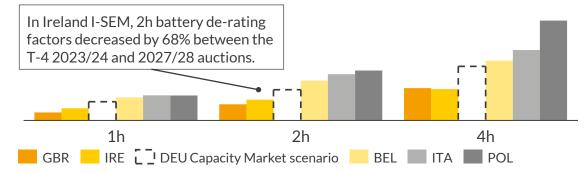
- The shorter the duration, the lower the de-rating factor.
- Battery contribution to security of supply is limited by their ability to respond to longlasting stress events.

Capacity 4



- The more batteries are active in the Capacity Market, the lower their de-rating factor.
- The benefit of having additional batteries in the system decreases.

Battery de-rating factors for last T-4 auctions¹



Key takeaway for Germany



Binding de-rating factors, recalibrated regularly to reflect changing availabilities and capacities, are recommended to ensure security of supply. Given Germany's relatively high buildout, we assume its battery de-rating factors to be placed in the lower half of European levels.

¹⁾ GBR, IRL I-SEM: 2027/28 T-4 auction; ITA: 2024 T-4 auction; BEL: 2024 Y-4 auction; POL: 2028 T-5 auction. 2) De-rating factors for 4h batteries. 3) Run-of-river.



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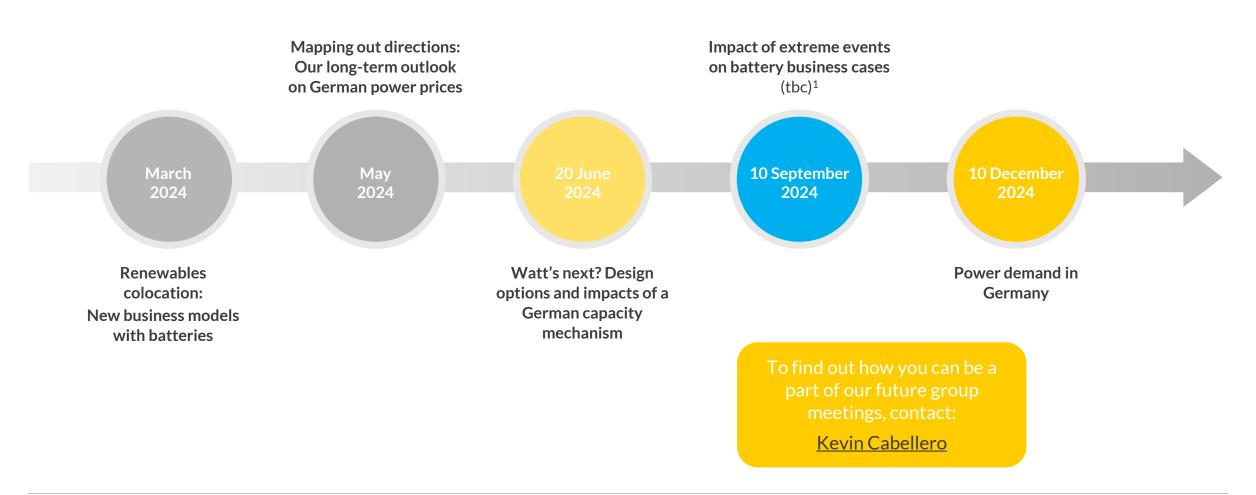
- Capacity Markets have gained prevalence in recent decades as many countries grapple with concerns over security of supply within Energy-Only Markets. Germany is now considering introducing a capacity mechanism as a complement to its Power Plant Strategy to address the growing capacity gap. The design of the capacity mechanism is currently under discussion.
- Policy diffusion has prompted many countries to adopt centralised Capacity Markets, driven by the demonstrated relative ease of administration observed in other markets and high levels of supply security. While these markets typically align in auction timing (mostly T-1 and T-4) and contract durations (typically 1-15 years), they show significant differences in price caps (ranging from 77-164k €/MW p.a.).
- In a centralised Capacity Market, Germany is recommended to hold auctions at least 4 years prior to delivery to provide sufficient lead time for buildout of new assets. The price cap should be set high enough to incentivise buildout and avoid an increase in import reliance. Derating factors must be carefully tailored to the German context, as they significantly influence the profitability of various technologies.
- When designing a German Capacity Market, it is crucial to consider decarbonisation policies, including timelines and instruments for promoting plants to switch from gas to H₂, as they affect key aspects like procurement targets and the optimal price cap. Additionally, continuous adaptation and coordination with neighbouring countries is key to balance Capacity Market costs with security of supply.
- A centralised Capacity Market for Germany, aligning with established auction and participation criteria of other markets, could facilitate a 12GW thermal buildout by 2035. Annual average costs for this mechanism, if evenly distributed among consumers, would amount to 0.4 ct/kWh on average between 2029 and 2050, and could be funded through a levy, in line with approaches in other markets.

Source: Aurora Energy Research

Upcoming and recent topics for the

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Contact: Kevin Caballero Henkel, Commercial Associate, kevin.caballero@auroraer.com

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