AURORA ENERGY RESEARCH

Design Options and Impacts of a German Capacity Mechanism

Public Report

27 June 2024

German Power & Renewables Service:

Dive into key market analysis and forecasts for the German power and renewables market

AURORA

Power & Renewables Service

Forecast Reports & Data

Biannual forecast reports with quarterly data updates

- **Forecast data of** wholesale and capture prices to **2060** with annual, monthly and quarterly granularity **under Central, Low, High,** with **Net Zero** Scenarios biannually.
- **Capacity development**, generation mix, interconnector capacity, capacity buildout, and exports
- **Regional capture prices (**5 wind & 2 solar PV regions in Germany)
- Weather sensitivities (under the central scenario) in the databook
- Negative prices and impact of 6-hour/ 4-hour / 3-hour / 2-hour / 1-hour-rule periods, technology costs, and imbalance costs
- **Guarantees of Origin (GOO)** market statistics and price forecast

Market Summary Reports

Take an in-depth look back at the past month's technology and market updates*

Strategic Insights

3 Strategic Insight Reports

Three in-depth thematic reports on topical issues

Policy Updates

Timely research notes on recent changes to policy and regulation, demonstrating the impacts and opportunities for market participants

3 Group Meetings

Three Group Meeting roundtable events **in Berlin** with key market participants such as developers, investors, financiers, utilities, grid operators, and government officials

Analyst Support

Biannual workshops and support from our bank of analysts, including native speakers and on-the-ground experts

*Monthly Market Summary Reports are available only for German and GB Power & Renewables Market Service

Join key players from across the German Power sector at our subscriber-exclusive Group Meetings

AURORA

Source: Aurora Energy Research

Table of Contents

AURORA

Curious about our offerings and services?
Would you like more information on the content of this report?

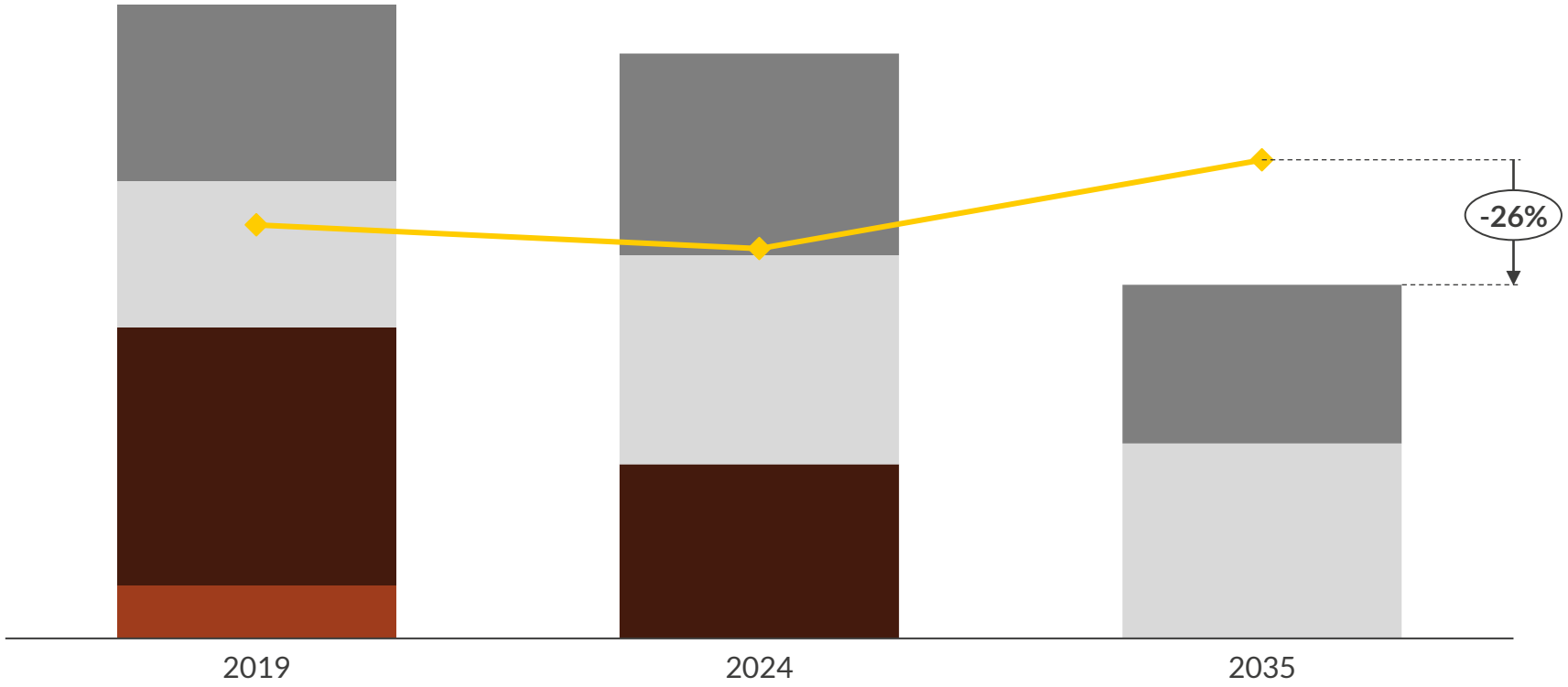
Then get in touch!

Kevin Caballero Henkel, Commercial Associate

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

AURORA

Peak residual demand[1] and dispatchable capacity without new builds[2]
GW



Share of peak residual demand[1] covered by dispatchable capacity
%

153% 150% 74%

Peak residual demand[1] | Gas[3] | Other dispatchable technologies[4] | Hard coal & lignite | Nuclear

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

- 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 H_2 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 KWS[1]

AURORA

Up to **10GW of new H_2-ready gas plants** form the core of the Power Plant Strategy (KWS)

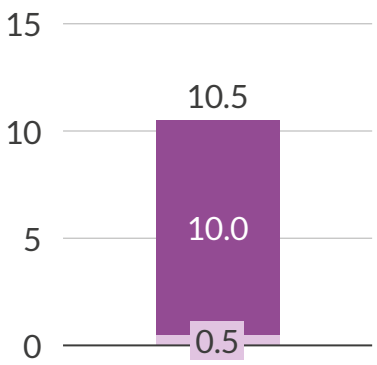
New H_2-ready natural gas power plants

- Auctions to be held for 10GW of capacity to receive CAPEX subsidies
- Full conversion to hydrogen[2] required between 2035 and 2040[3]
- OPEX subsidy to cover the fuel price difference to natural gas[4]

H_2 power plants

- Pure H_2 plants for research and exploratory purposes

New capacity announced



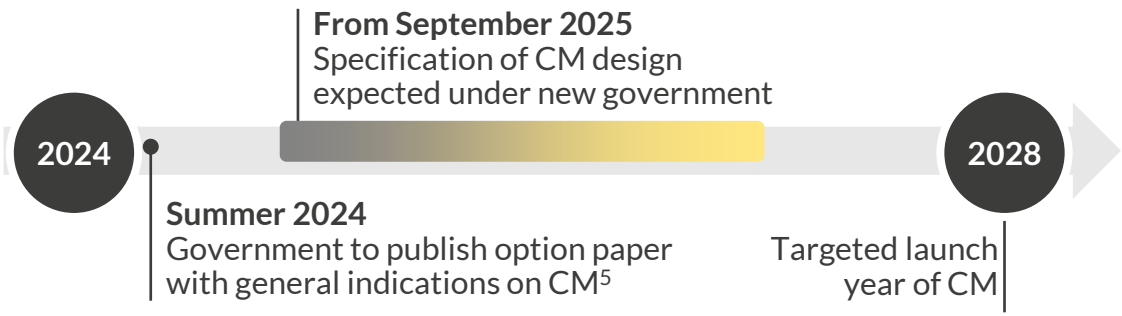
Auction for Long Duration Energy Storage (LDES) technologies

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

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

Announcement of a **capacity mechanism**

- The government has committed to developing concepts for a **market-based capacity mechanism** to be **launched by 2028**.
- Focus for this mechanism is on **technology neutrality**, i.e., allowing different generation technologies, storage, and demand-side response options to participate.
- The new gas-fired power plants incentivised via the **Power Plant Strategy** are meant to be **"fully integrated" into the capacity mechanism**.



Focus of today's session

⚠ 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

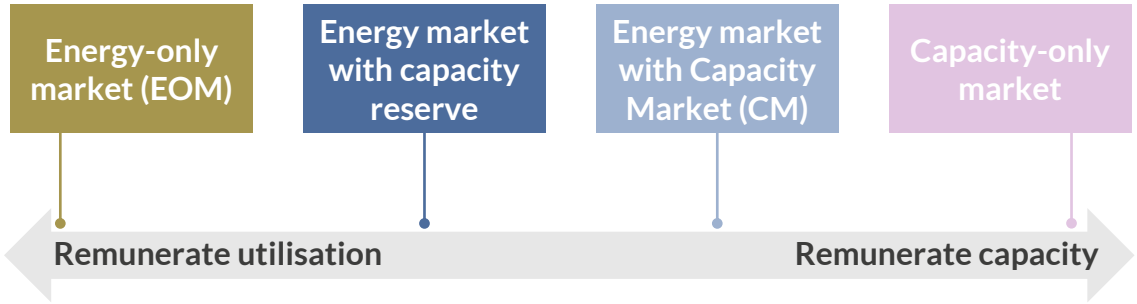
Table of Contents

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

AURORA

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 EOM[1], producers receive remuneration regardless of whether generation occurs or not.

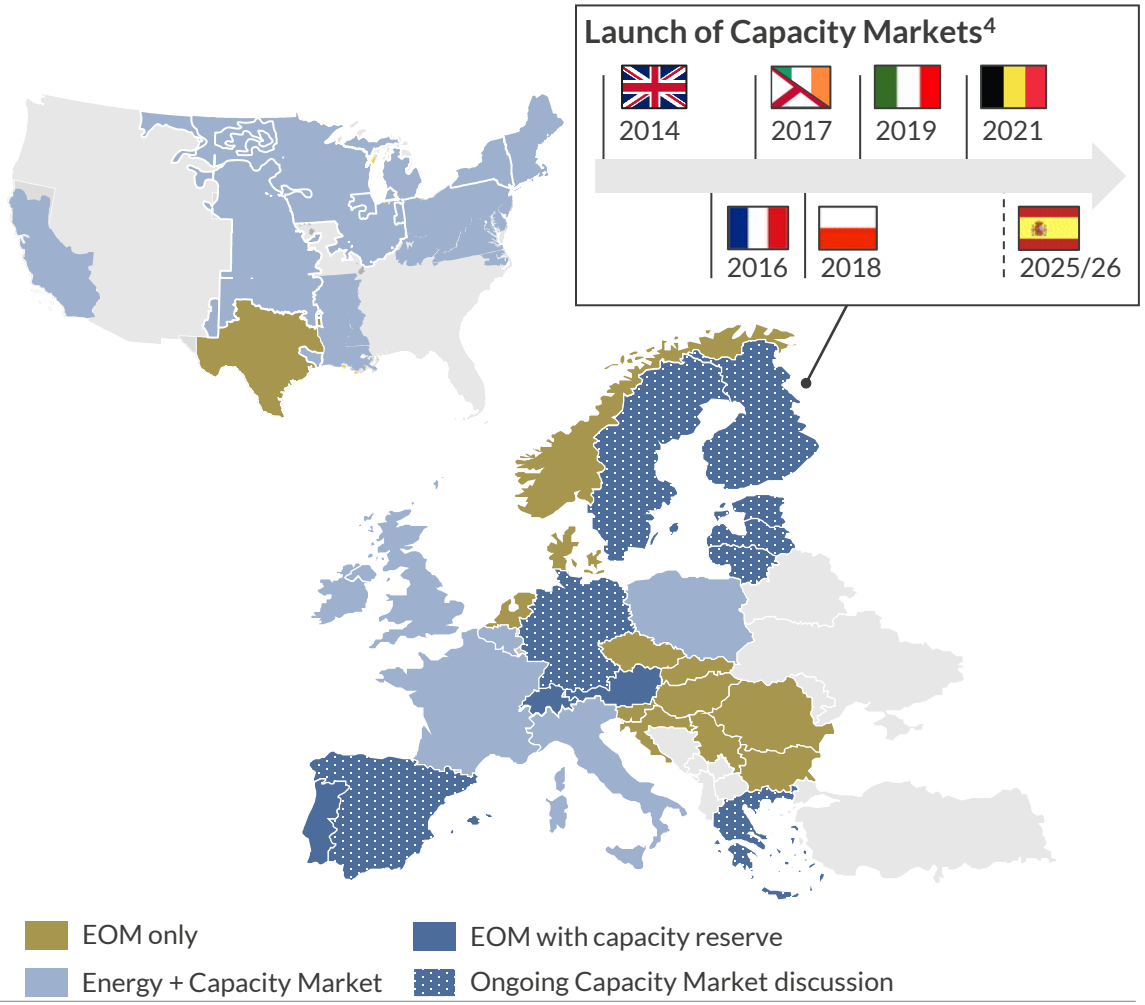


- An increasing number of countries have set up CMs over the past decades:

In Europe, CMs have been implemented in six countries. Eight more countries, including Germany, are currently debating the introduction of a CM[2].

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 reforms[3].

Examples of power market designs in the US and Europe



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

AURORA

Assessment of different capacity remuneration mechanisms

Type	Obligation	Example	Ease of administration	Openness to innovation	Security of supply level	Long-term investment incentives	Application
Centralised	Central	Central authority[1] holds yearly auctions to procure system-wide required capacity.	◑	◔	◕	◕	
Hybrid	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.	○	◑	◕	◑	MISO
Decentralised	Decentral	Power suppliers and large consumers must secure capacity certificates issued by generators and DSR[2].	◔	◕	◑	◔	California ISO, SPP
Cap futures	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

○ Very low ◔ Low ◑ Moderate ◕ High ● Very high

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.

Sources: Aurora Energy Research, Netztransparenz, EEX, ICE

Table of Contents

Curious about our offerings and services?
Would you like more information on the content of this report?

Then get in touch!

Kevin Caballero Henkel, Commercial Associate

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

AURORA

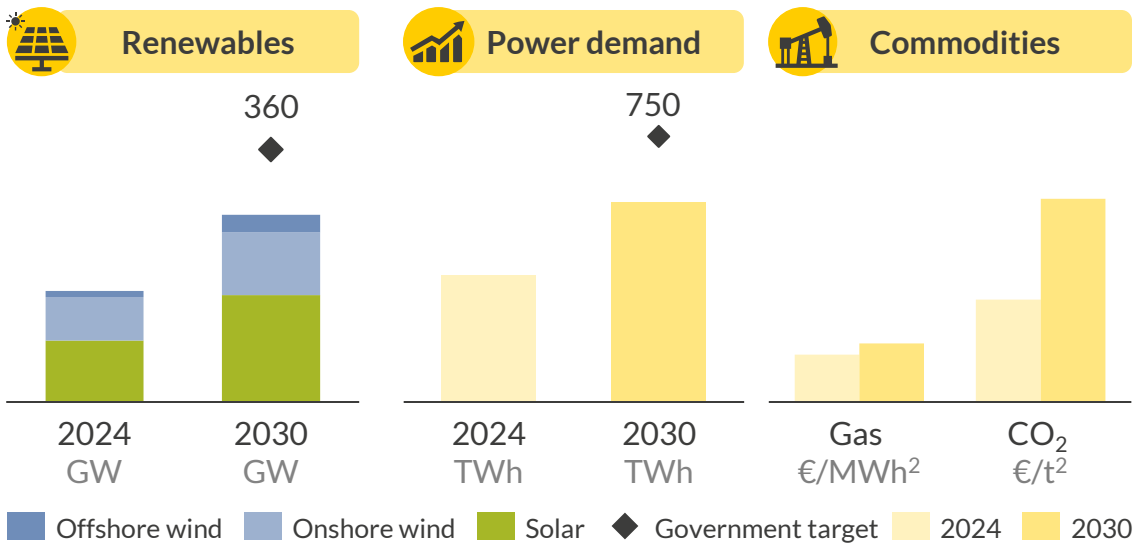
The subsequent discussions and analyses are based on the following scenario:

Aurora Central scenario (as of April 2024)

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 (KWS[1]), alongside a conservative view of future policy measures and market developments.



Centralised Capacity Market

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	Key assumptions[3]	Deep-dive
Auction criteria and financing	Procurement target	Defined based on power demand trends across weather years	1
	Auction and contract framework	T-4 (new builds) and T-1 auctions (existing), 15-year (new builds) and 1-year contracts (existing)	2
	Pricing	Descending clock, pay-as-clear auctions and moderate price cap	3
	Refinancing	N. A.	4
Participation criteria	De-rating factors	Technology-specific based on benchmarks across European CMs	5
	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	
	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 H_2 plants can be built, i.e. plants running exclusively on H_2.

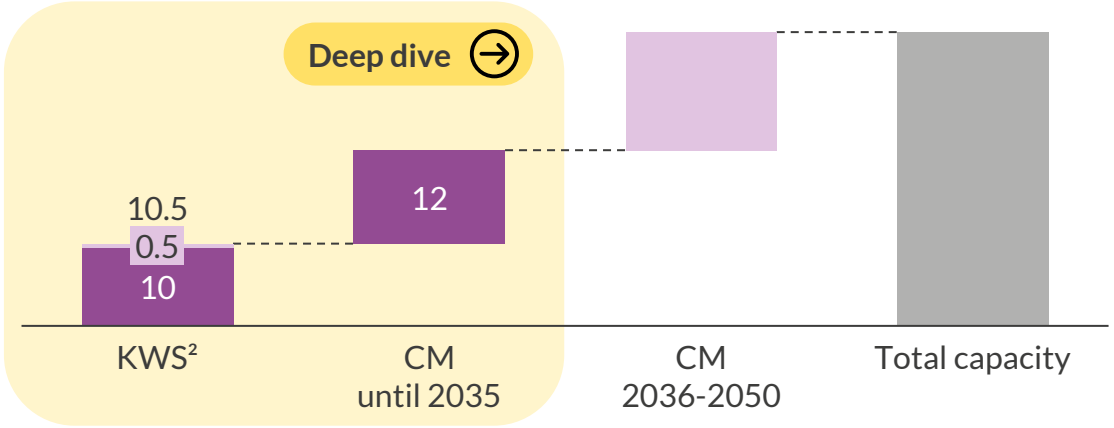
Source: Aurora Energy Research

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

AURORA

Capacity buildout

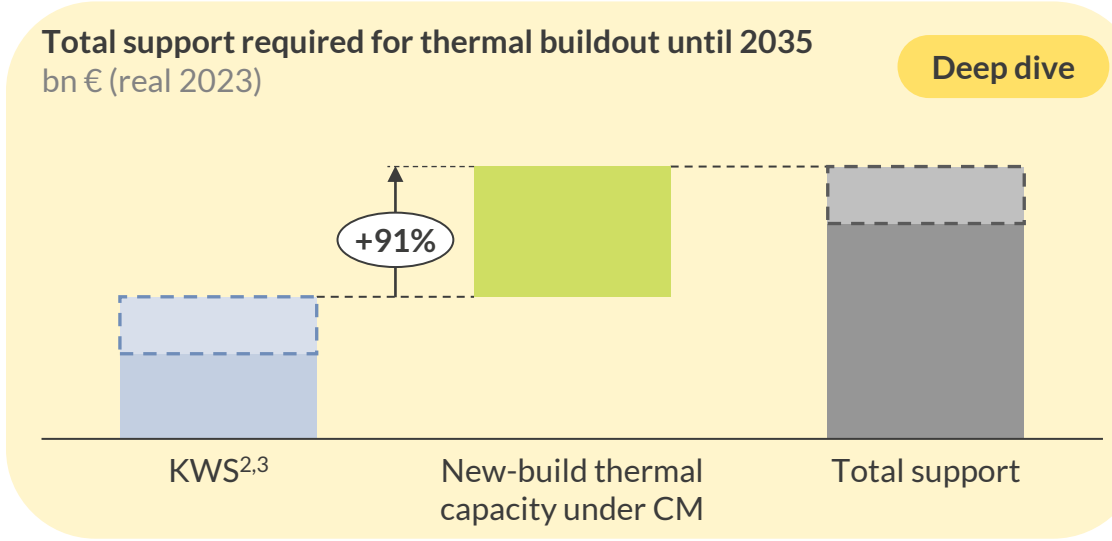
New-build thermal capacity[1]
GW



- By 2035, an additional 12GW of H_2-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 H_2 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, H_2 CCGT plants only start building once H_2 prices decline, allowing for higher energy revenues.

Government support

Total support required for thermal buildout until 2035
bn € (real 2023)



- The buildout of H_2-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 consumers[4], implementation of a Capacity Market could cost around **0.4 ct/kWh per year** on average between 2029[5] and 2050.

H_2-ready gas plants Pure H_2 plants

1) Net buildout not accounting for refurbishments/replacements of existing plants. 2) Power Plant Strategy (*Kraftwerksstrategie*). 3) Upper and lower bound of Aurora estimates based on CCGT, OCGT, and recip costs and different technology splits.
4) Assuming no reductions or exemptions for specific (groups of) consumers. 5) Reflecting first delivery period following first CM auction in 2028.
Source: Aurora Energy Research

Table of Contents

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

AURORA

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 load[1] falls below a certain threshold, e.g., 3 hours in total per year in the UK.

Key policies influencing the Capacity Market target

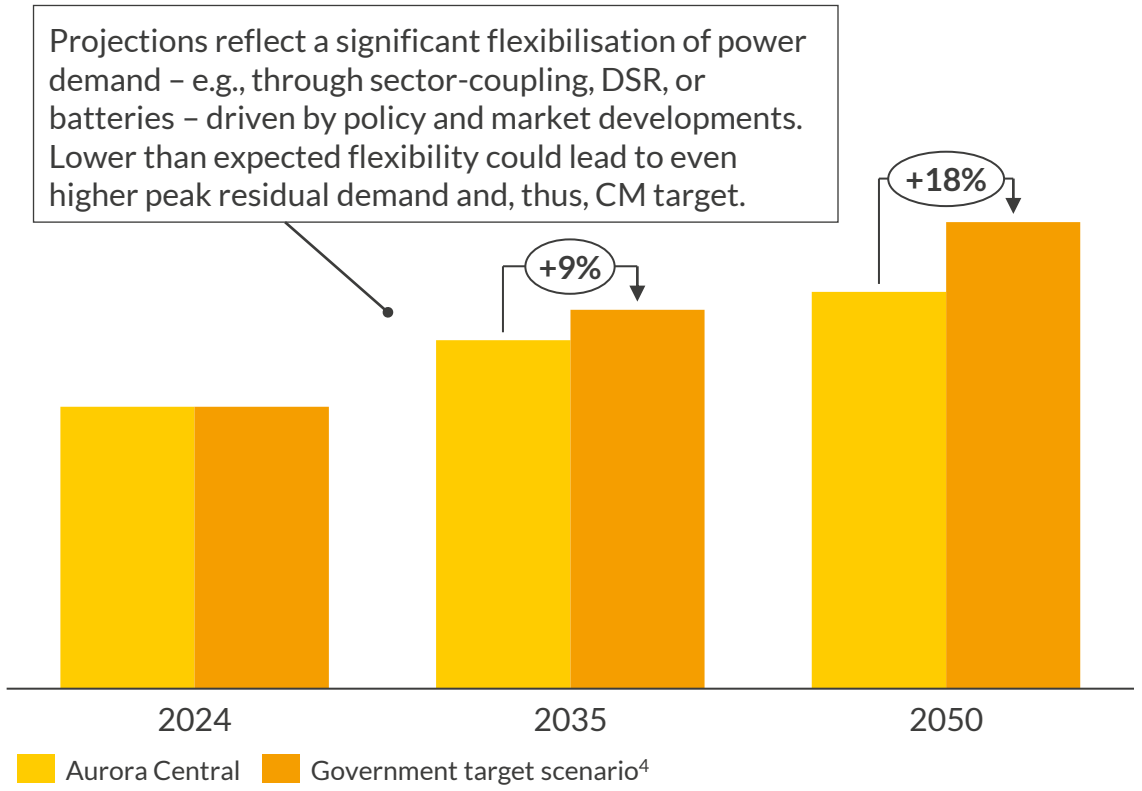
- While policy targets are defined for all major power demand segments in order to promote decarbonisation, their achievement remains uncertain:

Demand segment	Government target	Aurora projections compared to government target[2]
H_2 production	10GW$_{H2}$ electrolysers by 2030	↓
Electric vehicles	15mn by 2030	↘
Heat pumps	About 6mn by 2030[3]	↘
Total demand	750TWh by 2030	↓

↓ Significantly lower ↘ Moderately lower

Peak residual power demand in Germany

TWh



Key takeaway for Germany

1 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.

Sources: Aurora Energy Research, BMWK, Consentec, Netzentwicklungsplan Strom

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

AURORA

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]
	1[2]	3	15
	1	10	10
	1	1 or 15[3]	15
	1	1-7[4]	1-17[4]

Key takeaways for Germany

1. 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.
2. 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.

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

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

AURORA

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	✓ CMs procure capacity without distinction
Sufficient market competition	✓ Most power markets feature high levels of competition
Perfect information for all participants	✗ Lack of complete information on investment costs for new-build capacities

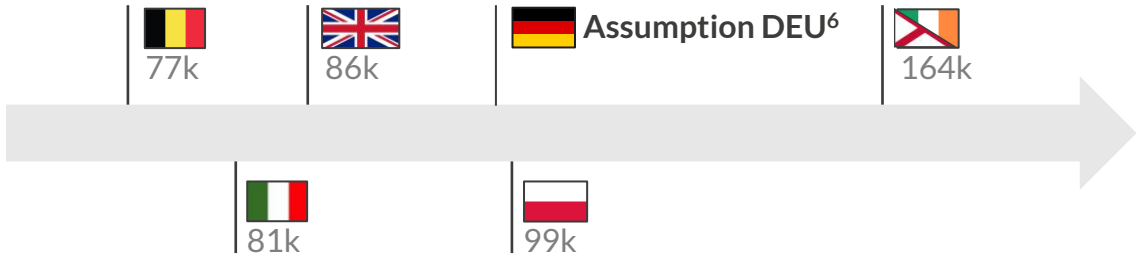
- Due to imperfect information, most CMs[1] apply a pay-as-clear pricing mechanism. This also allows to reduce administrative complexity if coupled with descending clock auctions.

Price cap

- Defined by the procuring entity, price caps set the maximum possible bid for each auction[2].
- In competitive auctions, the price cap indirectly impacts the participation of different technologies through its relation to their missing money[3].
- 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 CRM[4] 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 Europe[5]

€/MW per annum



Key takeaways for Germany

1. Due to imperfect information, pay-as-clear is the preferred pricing scheme, allowing for more efficient auction results.
2. 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.

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.

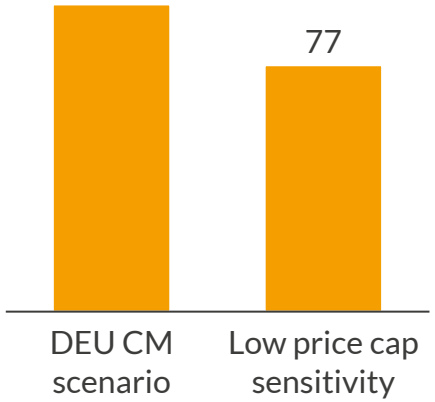
Sources: Aurora Energy Research, BDEW, Elia, SEM-O

3 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

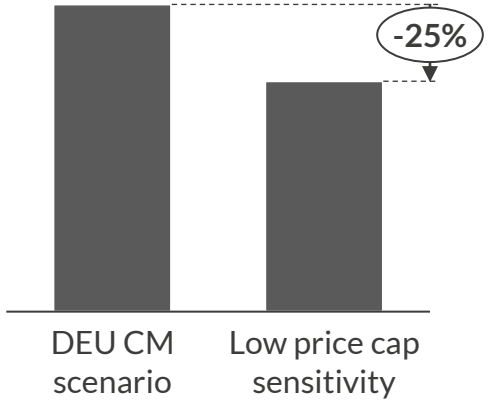
AURORA

Get in touch if you'd like to dive deeper into this content

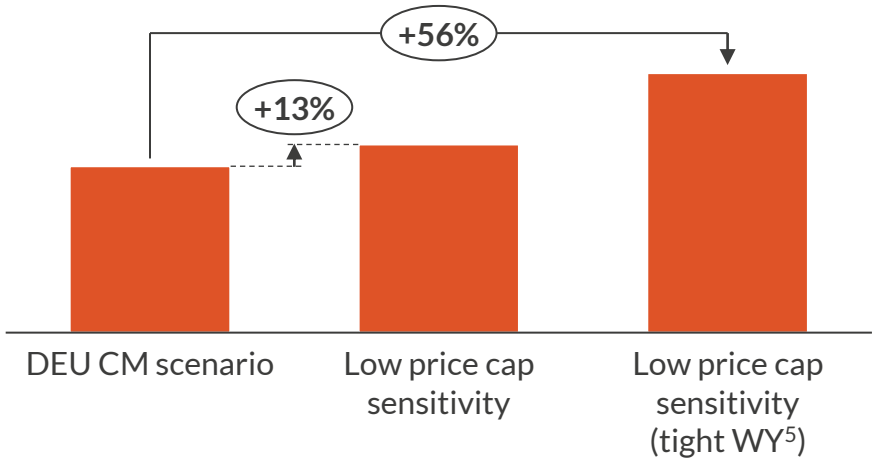
DEU Capacity Market price cap
k €/MW p.a. (real 2023)



New-build CCGT[1] capacity 2032-2040[2]
GW



Net power imports for example year 2033
TWh



- Lowering the CM price cap to the level of the minimum cap currently applied in Europe[3] 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 switch[4] from gas to H_2.
- 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.

1) All new-build CCGTs are H_2-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.

Source: Aurora Energy Research

Table of Contents

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

AURORA

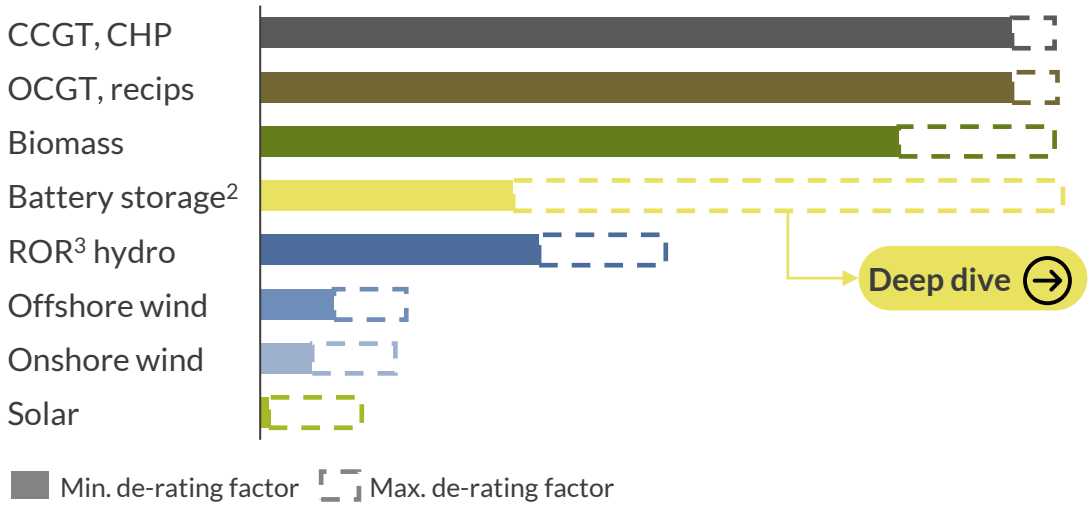
% De-rating factors

- 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:

Capacity payment €/year	=	Auction clearing price €/MW/year	x	Capacity MW	x	De-rating factor %

Minimum/Maximum de-rating factors for latest EU T-4 auctions[1]

%



Battery de-rating factors Deep dive

- De-rating factors for batteries depend on:

Duration

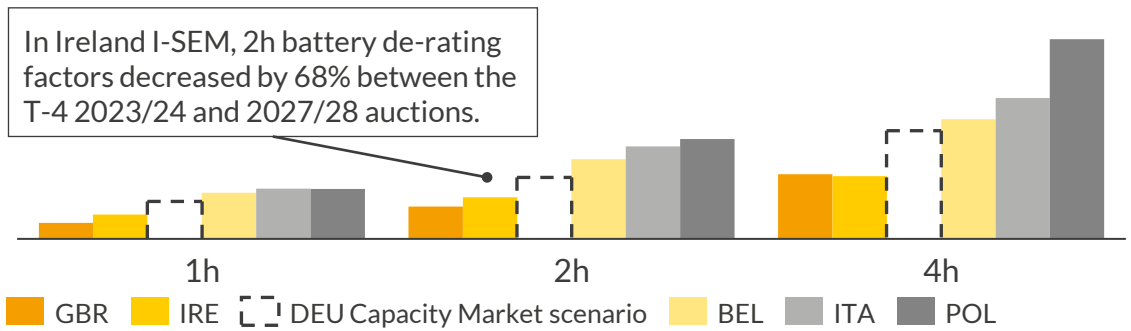
- The shorter the duration, the lower the de-rating factor.
- Battery contribution to security of supply is limited by their ability to respond to long-lasting stress events.

Capacity

- 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 auctions[1]

%



Key takeaway for Germany

1 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.

Sources: Aurora Energy Research, PSE, Ministry of Climate and Environment, Elia, Terna, ARERA, EirGrid, SONI, National Grid, Consentec, BDEW

Table of Contents

Curious about our offerings and services?
Would you like more information on the content of this report?

Then get in touch!

Kevin Caballero Henkel, Commercial Associate

Key takeaways

AURORA

1. 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.

2. 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.).

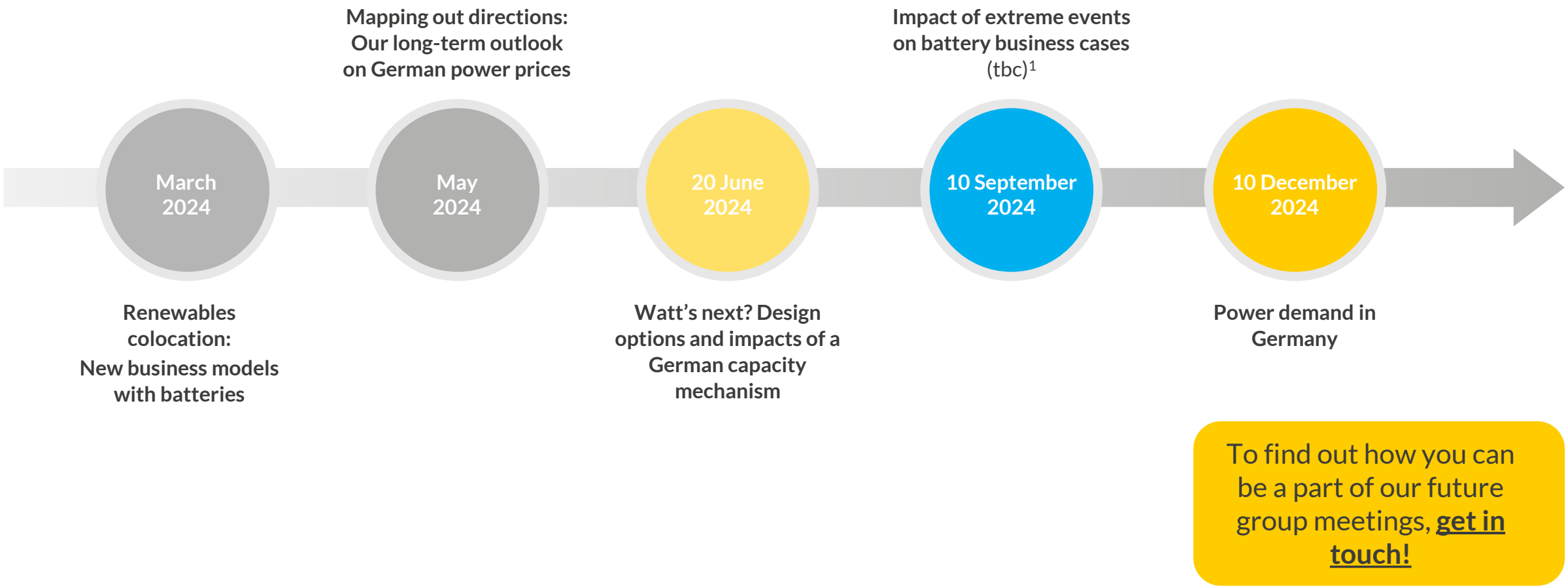
3. In a centralised Capacity Market, Germany is recommended to hold auctions at least 4 years prior to delivery to provide sufficient lead time for buildout of new assets. The price cap should be set high enough to incentivise buildout and avoid an increase in import reliance. De-rating factors must be carefully tailored to the German context, as they significantly influence the profitability of various technologies.

4. 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 H_2, 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.

5. 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 German Power & Renewables and Flexible Energy Market Services



To find out how you can be a part of our future group meetings, **get in touch!**

1) Available for subscribers to the German Flexible Energy Market Add-on Service.

Subscribe to powerful forecast and data services for tailored research into market developments, policy interpretation, and topical energy market issues

AURORA

Subscription Analytics: Forecasts & Insight Analysis

Power & Renewables Service

Robust, transparent analysis, widely used and trusted amongst major market participants

Bankable forecasts to support asset financing and in-depth analysis to underpin your investment strategies

Flexible Energy Add-On

Detailed analysis and granular forecasts for power, balancing, and ancillary service markets plus investment case data for a wide range of battery storage and gas peaker business models

Grid Add-On

Granular analysis of network constraints and impact on the economics of generation and flexibility assets, including scenarios with varying network capacity

Hydrogen Service

Crucial analysis into market sizing and drivers

Dedicated insights following policy developments and project activities across power, heat, transport, and industry

Software Solutions

ORIGIN

Putting our power market model into your hands

AMUN

Quantifying the true value of your wind project in minutes

CHRONOS

The leading battery analytics software

SOLARIS

Solar market software

(coming soon)

EOS Subscriber Platform

AURORA EOS

Contact: Kevin Caballero Henkel, Commercial Associate

Disclaimer and Copyright

AURORA

General Disclaimer

This document is provided "as is" for your information only and no representation or warranty, express or implied, is given by Aurora Energy Research Limited and its subsidiaries from time to time (together, “Aurora”), their directors, employees agents or affiliates (together, Aurora’s "**Associates**") as to its accuracy, reliability or completeness. Aurora and its Associates assume no responsibility, and accept no liability for, any loss arising out of your use of this document. This document is not to be relied upon for any purpose or used in substitution for your own independent investigations and sound judgment. The information contained in this document reflects our beliefs, assumptions, intentions and expectations as of the date of this document and is subject to change. Aurora assumes no obligation, and does not intend, to update this information.

Forward-looking statements

This document contains forward-looking statements and information, which reflect Aurora’s current view with respect to future events and financial performance. When used in this document, the words "believes", "expects", "plans", "may", "will", "would", "could", "should", "anticipates", "estimates", "project", "intend" or "outlook" or other variations of these words or other similar expressions are intended to identify forward-looking statements and information. Actual results may differ materially from the expectations expressed or implied in the forward-looking statements as a result of known and unknown risks and uncertainties. Known risks and uncertainties include but are not limited to: risks associated with political events in Europe and elsewhere, contractual risks, creditworthiness of customers, performance of suppliers and management of plant and personnel; risk associated with financial factors such as volatility in exchange rates, increases in interest rates, restrictions on access to capital, and swings in global financial markets; risks associated with domestic and foreign government regulation, including export controls and economic sanctions; and other risks, including litigation. The foregoing list of important factors is not exhaustive.

Copyright


AURORA
ENERGY RESEARCH