

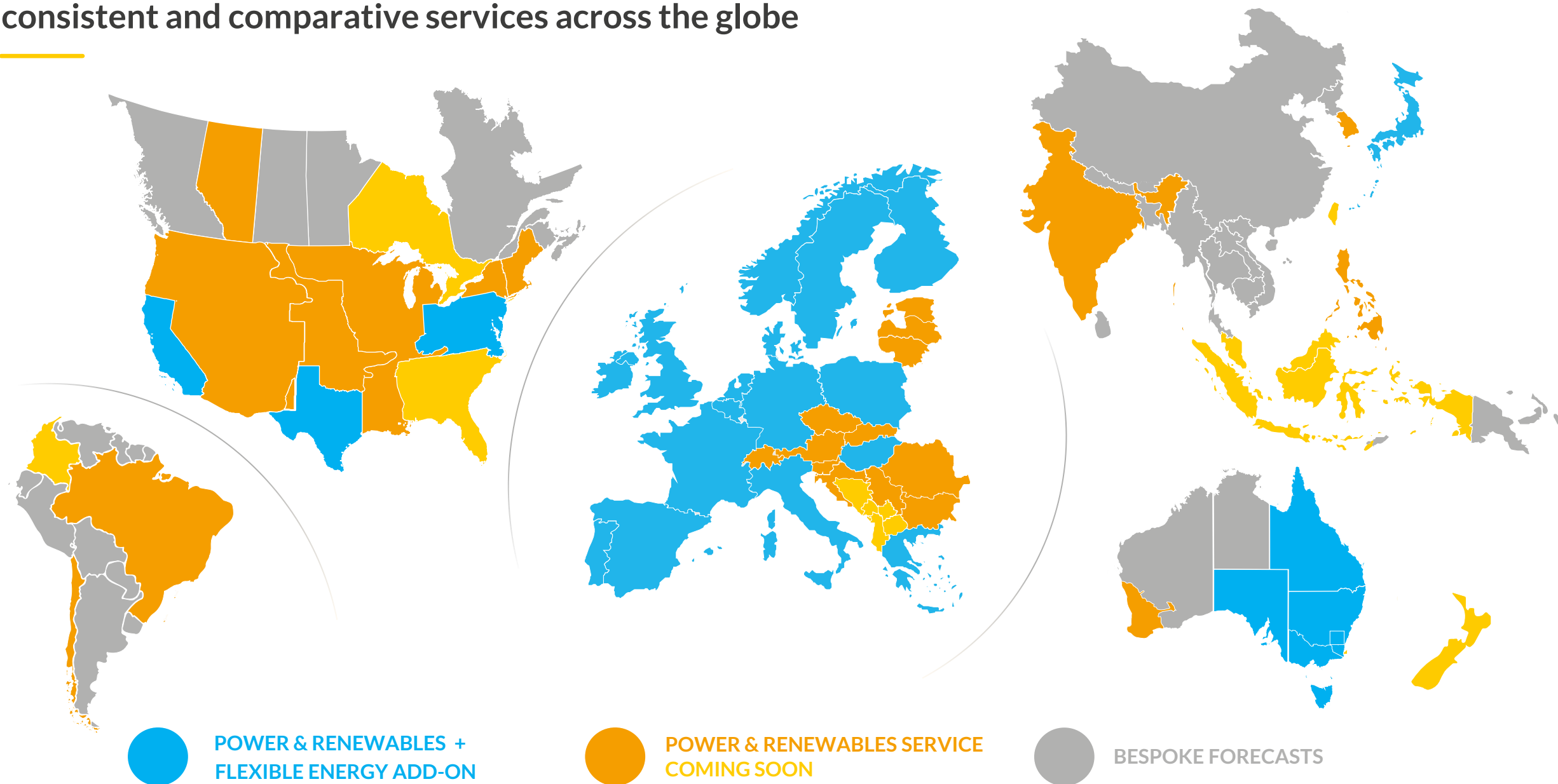
Flexible grid connection agreements in Germany

March 2025

Public Report



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

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- Weather sensitivities (under the central scenario) in the databook
- Negative prices and impact of 6-hour/4-hour/3-hour/1-hour-rule periods, technology costs, and imbalance costs
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*Monthly Market Summary Reports are available only for German and GB Power & Renewables Market Service



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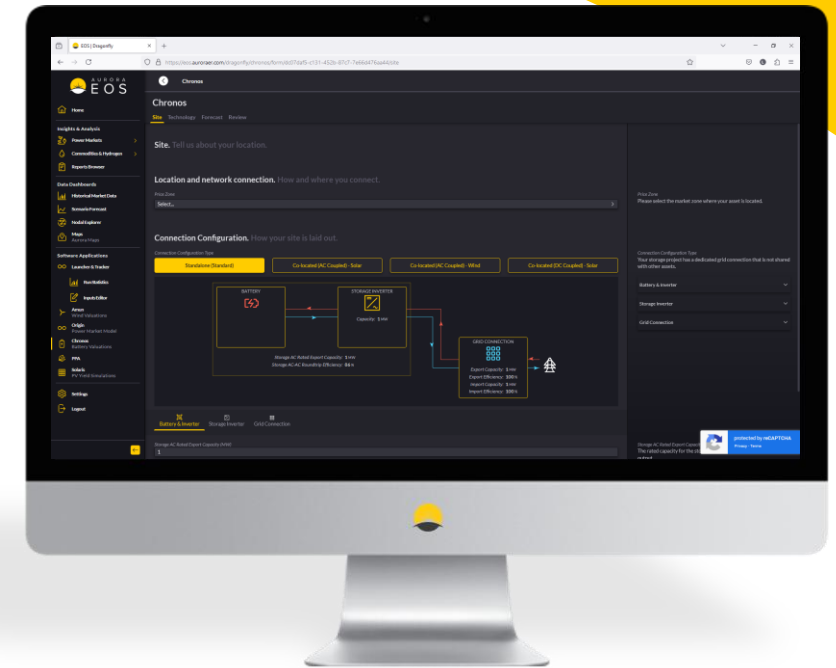
Thorough: Accounts for all site-specific value drivers

Reliable: Backed by Aurora's trusted forecasts and team of experts

Bankable: Methodology recognised by banks and investors, with reliance available

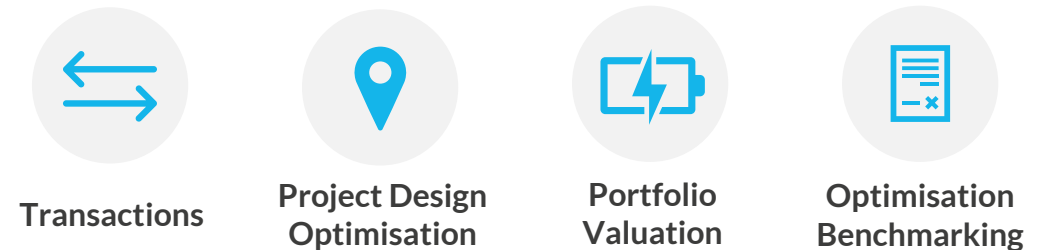
Comprehensive UX: Intuitive interface that empowers user driven analyses

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What can Chronos be used for?

Intuitive 4-step process:



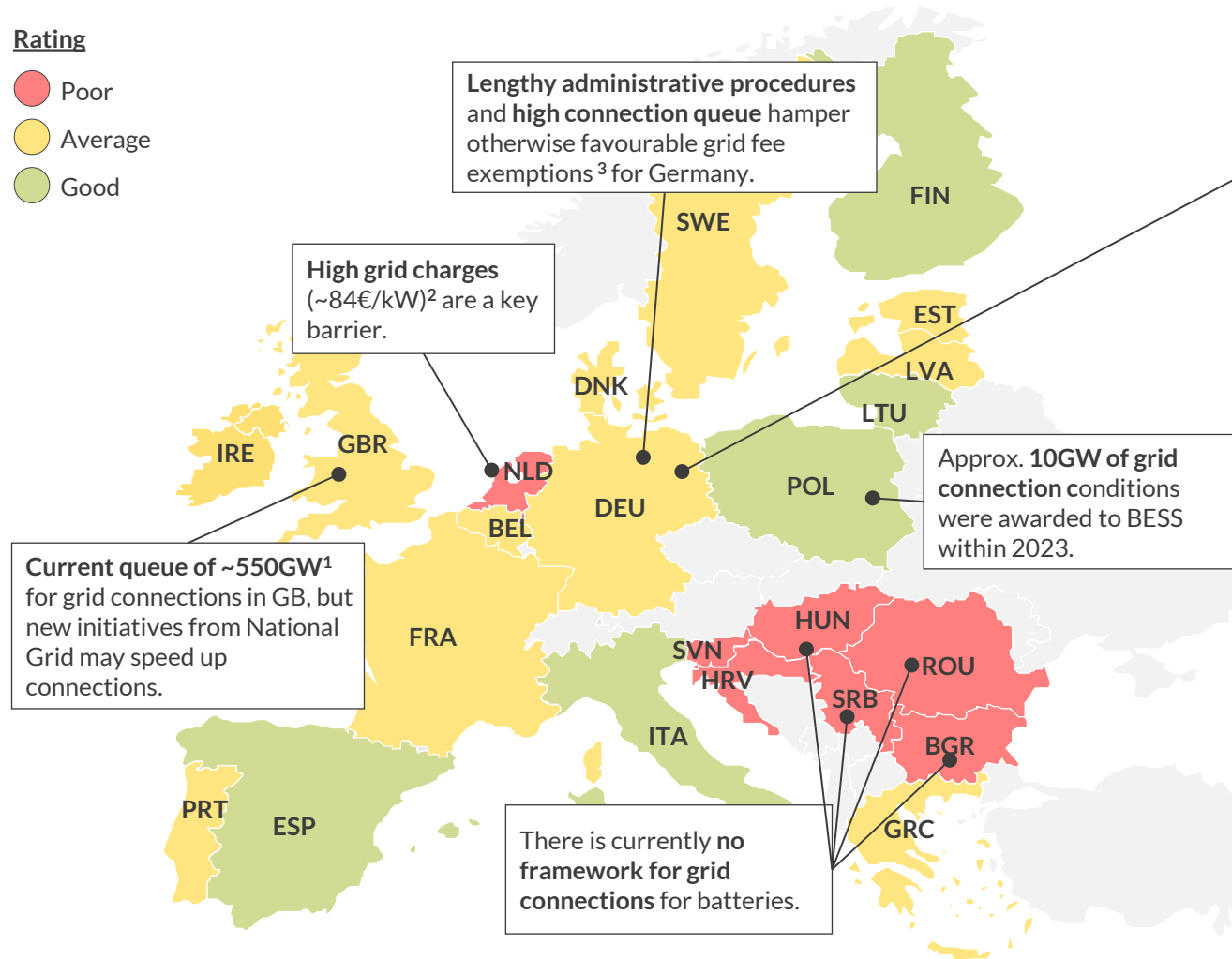
Trusted by industry leaders:



Batteries face grid access hurdles in many European countries, from which Germany is no exception

Rating

- Poor
- Average
- Good



Beschleunigung von Netzanschlüssen bleibt innovationslos

Übertragungsnetzbetreibern liegen zum Jahreswechsel 650 Anschlussanfragen für große Batteriespeicher mit 226 Gigawatt vor

Batteriespeicher-Boom alarmiert Netzbetreiber und Experten

energate messenger

Branche macht erste Erfahrung mit Überbauung

“Battery tsunami:” Projects totalling 226 GW seek grid connection approval in Germany

pv magazine Deutschland

Bayernwerk plant Ausschreibung für netzdienliche Speicher

1) Grid connection queue for storage assets. 2) Including annual fixed charges (EUR/MW) and grid usage fees or tariffs (EUR/MWh). 3) Assets commissioned between 04/08/2011 and 04/08/2029 are exempt from taxes and grid fees for 20 years.

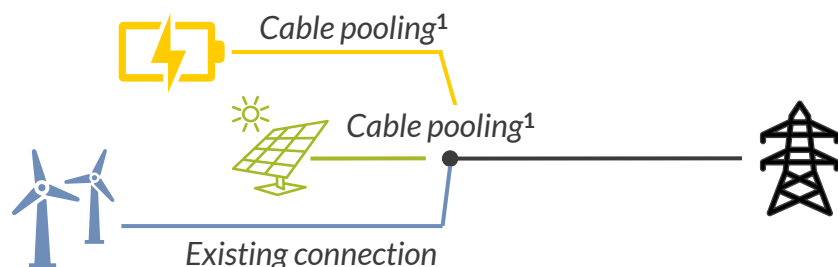
The revision of Germany energy law (EEG, EnWG) enables flexible grid connection agreements and cable pooling

Background

- High costs and delays for grid connections are becoming a significant barrier to the energy transition.
- Previously, grid connection capacity for renewables and storage assets has been awarded as firm connection capacity.
- A recent amendment to the EnWG and EEG, passed on January 25, 2025, introduces more options for grid connection agreements. They aim to reduce costs and delays for grid integration by introducing the following concepts:

Cable pooling - §8 (2) EEG

- The new regulation allows operators to **choose a grid connection point already used by an existing asset**, supporting the practice of "cable pooling."
- This can result in "**overbuilding**", where the total installed capacity exceeds the available capacity at the connection point.
- The regulation supports the right to "cable pooling" as long as there are **no grid-related concerns** from the grid operator.



Flexible grid connections - §8a EEG, §17 2b EnWG

- The EnWG novella introduced the possibility of flexible grid connection agreements.
- For asset owners, this could **reduce the price and the time** to get connected to the grid. Furthermore, it can help reduce pressure on the grid, caused by many grid connection requests.
- The agreements must include **technical requirements and liability provisions** to ensure grid stability.
- The specific implementation of flexible grid connection agreements can vary depending on the type of installation and grid situation.

Flexible grid connections and cable pooling can unlock significant grid capacity, offering faster and more cost-effective grid access—especially for flexible assets such as batteries. However, the specific limitations imposed could worsen the overall business case.

1) Cable pooling is defined as a single grid connection being able to accommodate multiple power generating sources.

Timing is everything: the impact of flexible connections strongly depends on time periods affected, the lead time and the remuneration

Flexible grid connection agreements can vary significantly in scope, lead times, and remuneration, resulting in widely different impacts on battery business cases.

Scope of flexible connection



The limitation of grid connection capacity can have different extents:



Constant static limitation



Time-dependent limitation



Event-based limitation

Lead-time



It refers to the period between the notification of a grid limitation to the BESS operator and its implementation



Lead time before gate-closure time of ancillary markets



Lead time after gate-closure time of ancillary markets

Remuneration



There are different compensation schemes for flexible grid connection agreements:



No compensation



Reduction of *Baukostenzuschuss*



Compensation for supporting grid stability

We analyse three exemplary constraining patterns, focusing on discharging and charging restrictions as well as on the impact of lead times

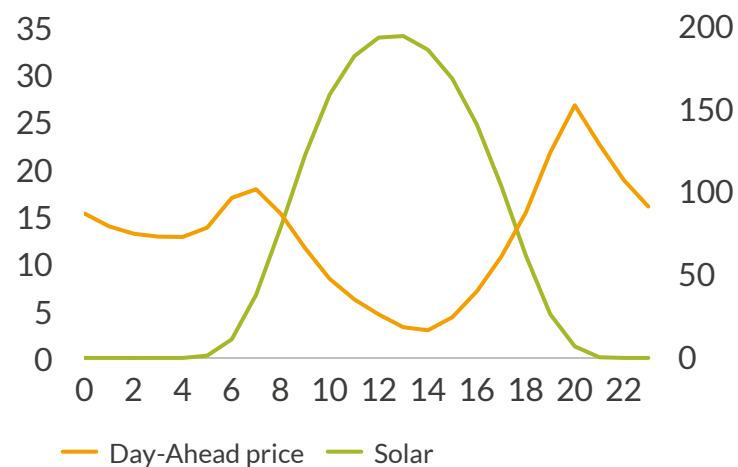
A

Dynamic discharging restriction

- Discharging restriction in the 500 or 1000 hours with the highest solar generation.
- Lead time before the gate closure times of any relevant market, enabling participation in all markets in non-restricted hours.
- The grid charging is not restricted.

Solar generation¹
GWh

Day-Ahead price¹
€/MWh

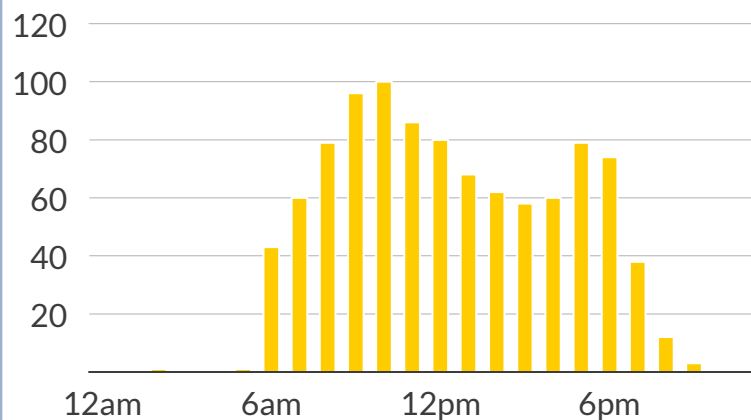


B

Dynamic charging restriction

- Charging restriction in the 500 or 1000 hours with the highest total demand.
- Lead time before the gate closure times of any relevant market, enabling participation in all markets in non-restricted hours.
- The grid discharging is not restricted.

Daily shape of hours with charging restriction
of restricted hours



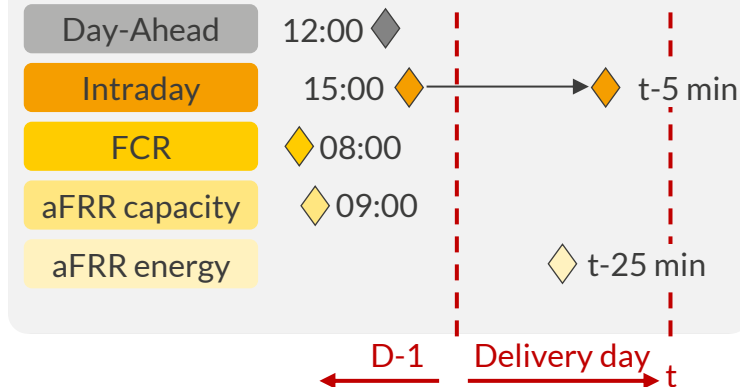
C

Low lead time restriction

- Low lead time restriction, making it impossible to participate in the FCR or aFRR capacity market.
- Worst-case scenario, showcasing the impact of lead time on the business case.
- No grid charging/ discharging restriction is applied to focus purely on the lead time.

Gate closure times

Gate closure times



1) Illustrative

Sources: Aurora Energy Research, ENTSO-E

Solar-based discharging restriction usually impacts the schedule in hours with low Day-Ahead prices but high ancillary market prices

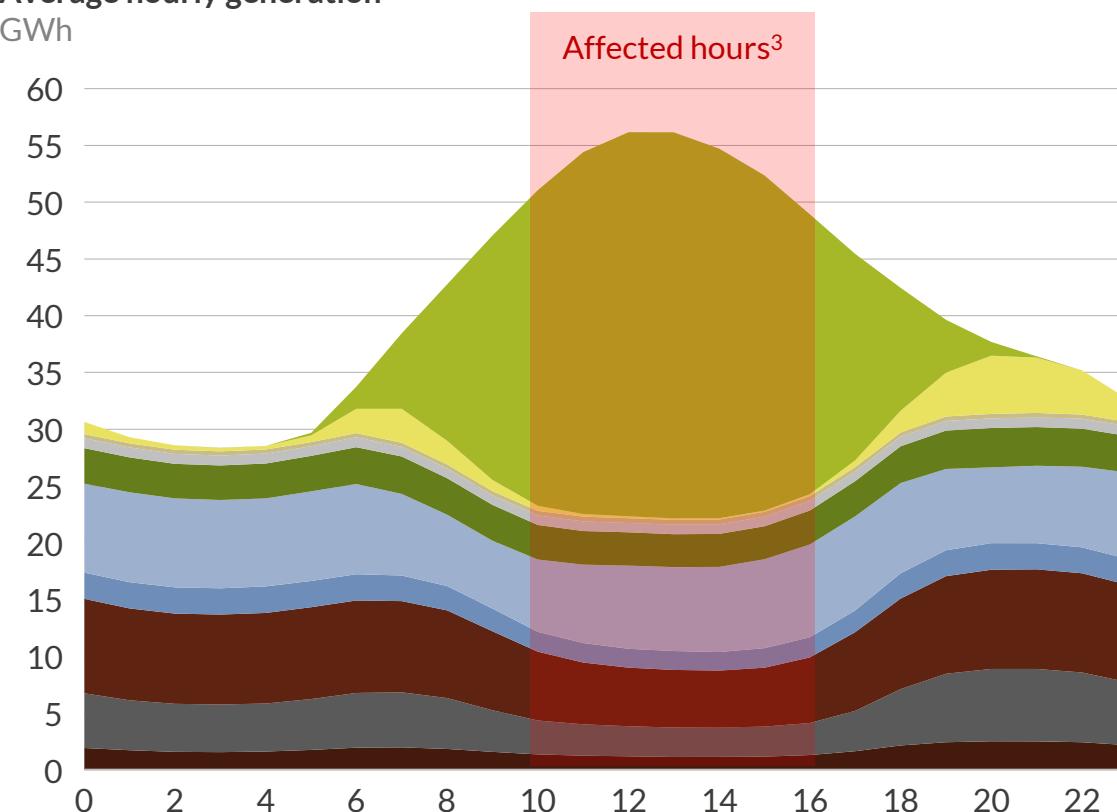
A U R  R A

A Discharging restriction

A dynamic grid feed-in restriction can prevent batteries from intensifying grid congestions in hours of high solar generation.

Average hourly generation^{1,2}

GWh



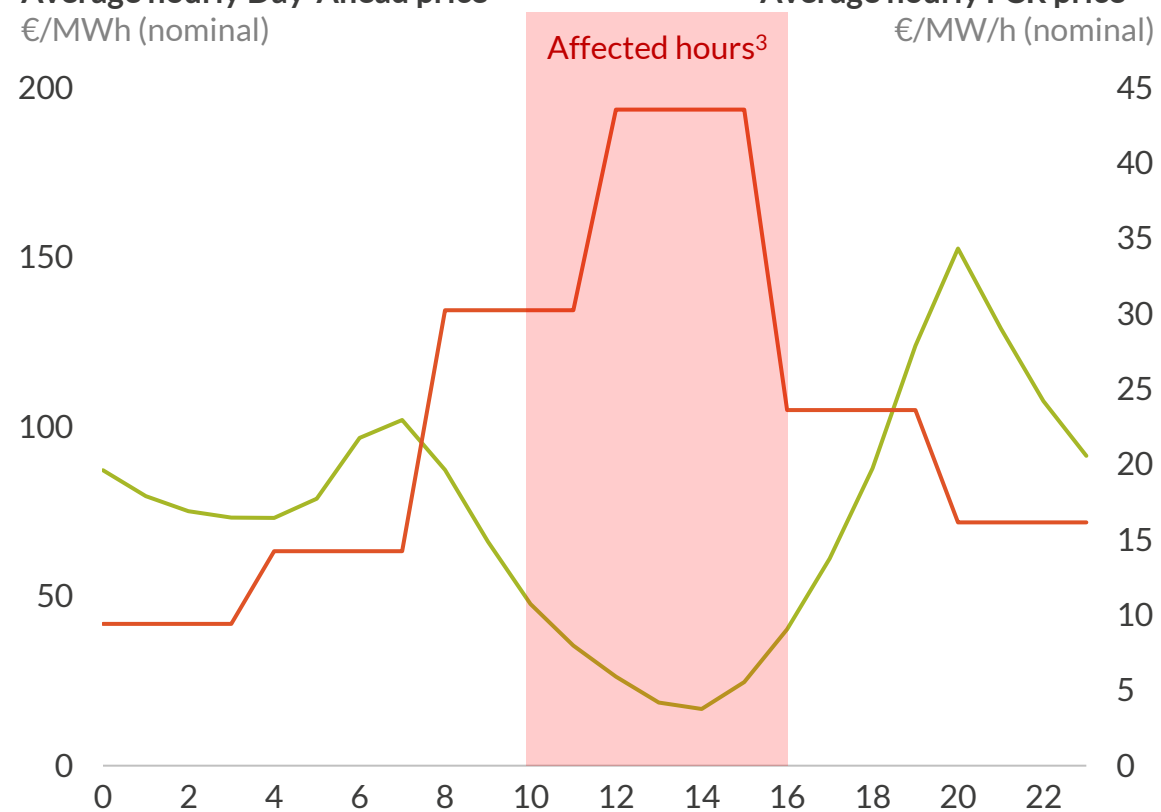
In hours of restricted discharging, batteries can usually charge at low costs, limiting the impact of the flexible grid connection on energy arbitrage.

Average hourly Day-Ahead price^{1,2}

€/MWh (nominal)

Average hourly FCR price^{1,2}

€/MW/h (nominal)



Coal Lignite Onshore wind Other thermal Pumped storage
Gas Offshore wind Other RES Peaking Solar

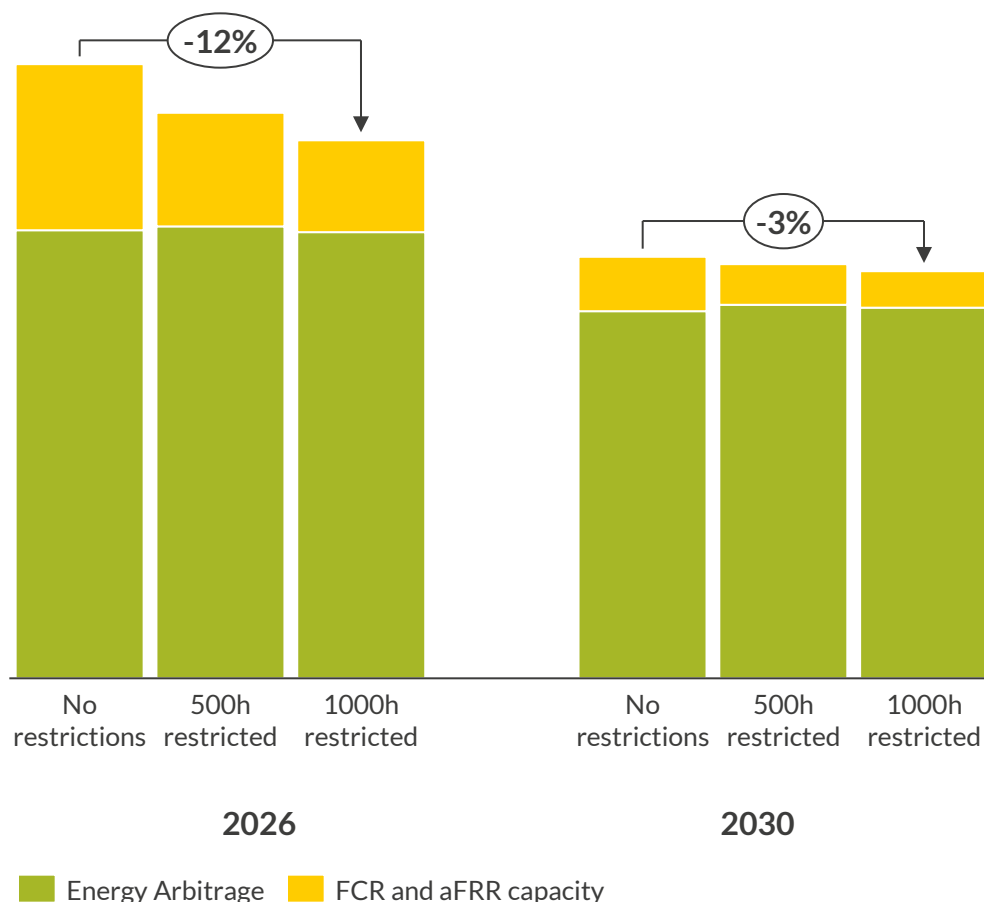
Day-Ahead price FCR price

1) Time Zone used for the above charts is CEST (Central European Summer Time). 2) Average generation between August and October 2024. 3) Illustrative.

If BESS output is limited in the 1000 hours with the highest PV generation, revenues would reduce by 12% in 2026, but only by 3% in 2030

A Discharging restriction

Gross margins for a 2h battery system with 1.5 cycles, COD 2026
€/kW, (real 2023)



Whereas energy arbitrage revenues are barely impacted by a flexible grid connection, ancillary service revenues reduce strongly.

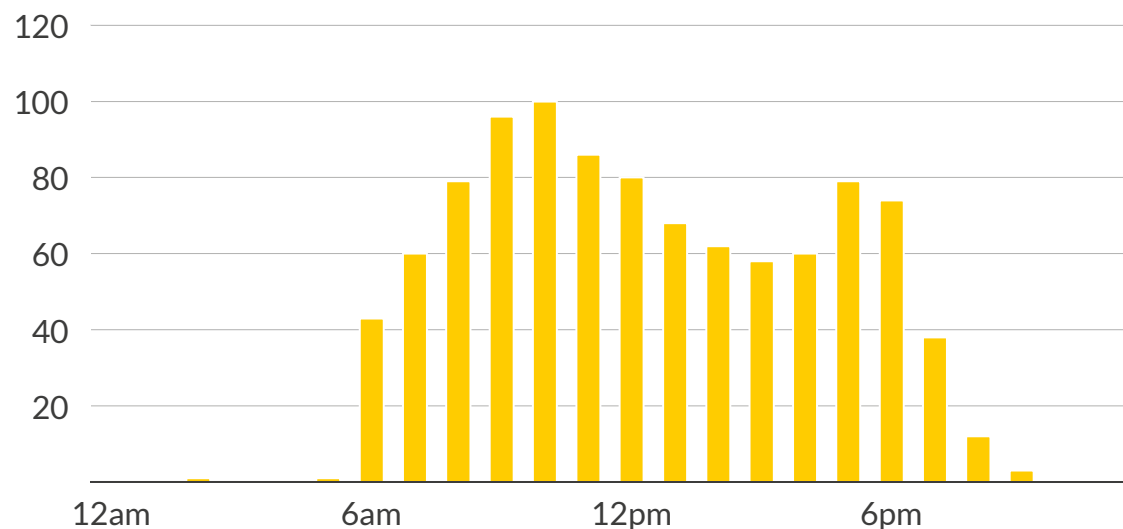
- A flexible grid connection, with feed-in restriction in the 1000 hours with the highest solar generation, reduces the gross margins by 12% in 2026.
- The reduction is only caused by **less revenues on the FCR and aFRR capacity** markets, as we usually see very high prices on these markets in hours of high solar generation.
- In contrast, **energy arbitrage revenues are barely impacted**, as batteries usually charge on these markets in hours of high solar generation.
- In 2030, the impact of the flexible grid connection is **only 3%**.
- Similarly to 2026, only the FCR and aFRR capacity market revenues are negatively impacted by the grid limitation.
- However, as these markets are **more saturated** in 2030, their share of the total revenues will have declined strongly and therefore, reduced revenues on these markets have less impact on the overall business case.

Demand-based charging restrictions are more evenly distributed over the year and day and therefore, all markets are impacted by the grid limitation

Highest demand hours are usually between 6 am and 8 pm, impacting the battery optimisation on all markets equally. This leads to a revenue reduction of 8-9% in case of a charging restriction of 1000h.

Daily shape of hours with charging restriction

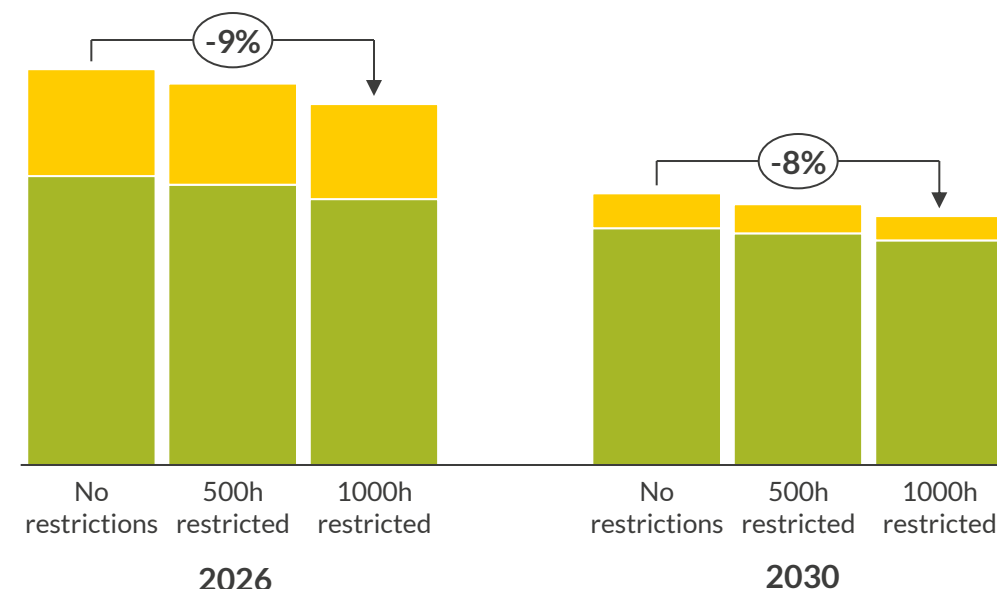
of restricted hours over the year



- We assume a flexible grid connection, where the grid feed-in is limited during the hours of highest demand, so that the battery does not add to the peak demand.
- This leads to restrictions during day, especially in the morning and early evening hours.

Gross margins for a 2h battery system with 1.5 cycles, COD 2026

€/kW, (real 2023)



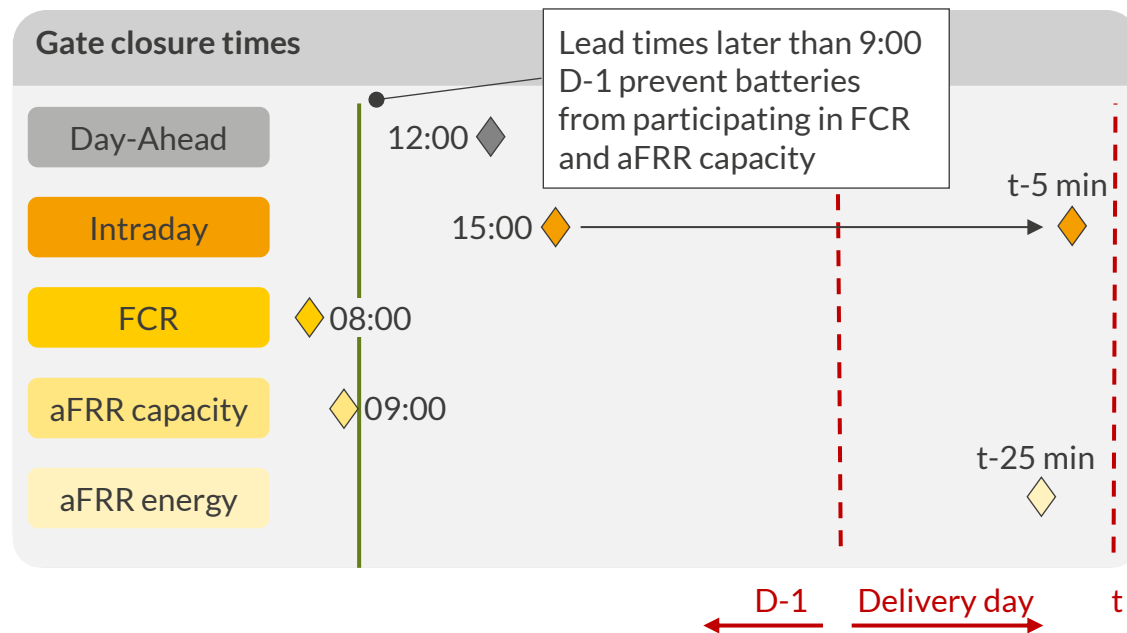
- Charge restrictions based on the peak demand hours impact energy arbitrage and ancillary market revenues equally.
- While the impact reduces slightly between 2026 and 2030, the effect is minor and in both years storage revenues are reduced significantly.

■ Energy Arbitrage ■ FCR and aFRR capacity

1) Time Zone used for the above charts is CEST (Central European Summer Time).

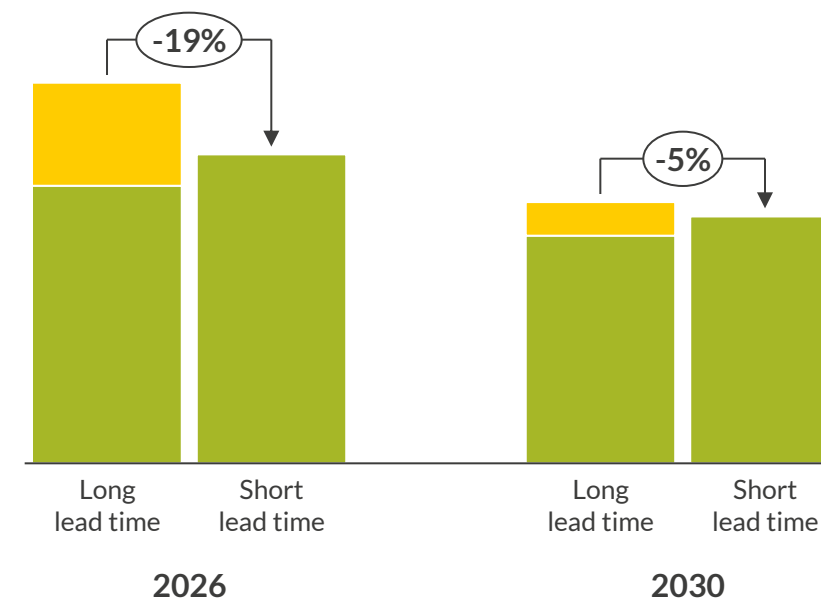
Short lead times prevent batteries from participating in the FCR and aFRR capacity markets, leading to strong revenue reductions of up to 19%

Short lead times can lead to missed FCR and aFRR capacity auctions, reducing the markets in which the battery can optimise.



- A short lead time for flexible grid connection could prevent batteries from participating in the FCR and aFRR capacity markets, significantly impacting their business case.
- To assess this impact, we optimised the battery exclusively on the Day-Ahead, Intraday and aFRR energy markets.
- However, we did not consider any actual restriction to focus solely on the impact of the shorter lead time.

Gross margins for a 2h battery system with 1.5 cycles, COD 2026
€/kW, (real 2023)



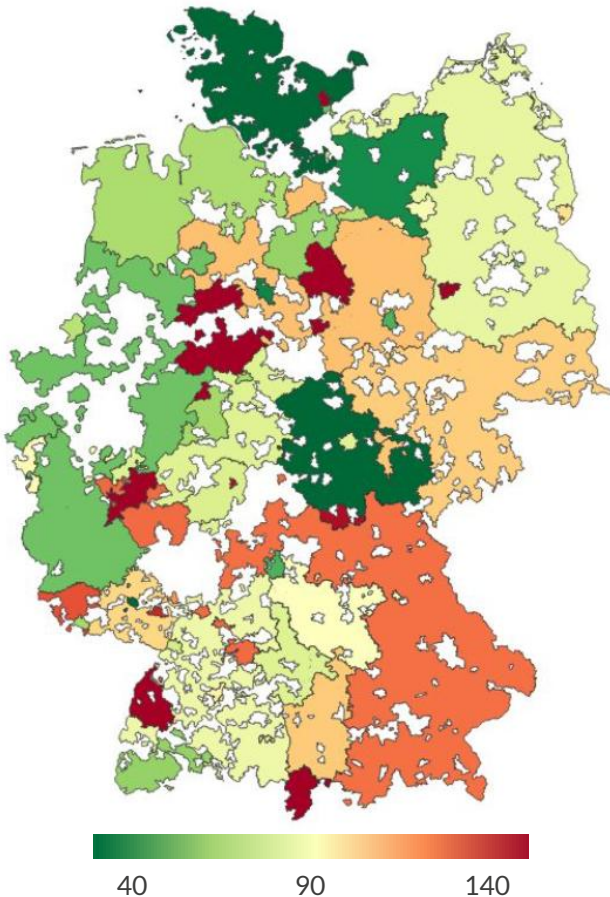
- Lead-time restrictions have **opposing effects on energy arbitrage and ancillary market revenues**. While there are no longer revenues from the latter, energy arbitrage revenues partially compensate with a moderate increase, as the optimising strategy focusses on arbitrage trading.
- The impact decreases strongly between 2026 and 2030, with total revenues only slightly reduced as ancillary markets are more saturated in 2030.

Energy Arbitrage FCR and aFRR capacity

Baukostenzuschuss reduction between 28 and 74€/kW would be needed to compensate the revenue losses due to flexible connections

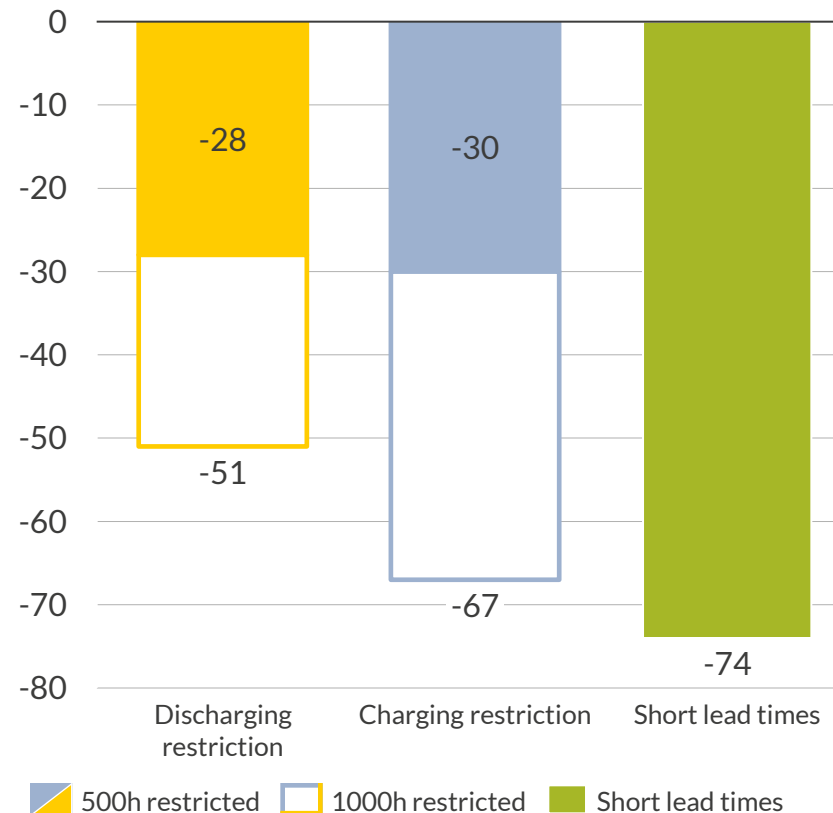
The Baukostenzuschuss (BKZ) varies strongly in Germany between 0 and 140€/kW.

Overview of Baukostenzuschuss level in Germany¹
€/kW



A BKZ reduction of 28 to 74€/kW would be needed to compensate for revenue losses due to a flexible grid connection.

Needed BKZ reduction to compensate for revenue losses
that are induced by the flexible grid connection
€/kW, (real 2023)



The Baukostenzuschuss

- The “Baukostenzuschuss” (BKZ) is a fee to be paid to the grid operator.
- It is meant to compensate for the construction or the reinforcement of distribution facilities, not the grid connection itself.
- This fee varies strongly between DSOs and can reach up to 140€/kW.
- Some DSOs reduce the Baukostenzuschuss for assets with a flexible grid connection.
- A reduction between 28 and 74€/kW would be needed to compensate for the revenue losses.

1) Source: dvp.energy

Key take aways

1

Grid connections are becoming increasingly scarce in Germany. The latest energy law update is expected to drive the adoption of non-firm grid connections and cable pooling across all regions.

2

Flexible connection agreements can differ strongly - depending on the level of restriction, lead times and remuneration models, the impact on the business case could vary substantially.

3

Solar-based discharging restrictions have little effect on battery wholesale trading but significantly limit ancillary service provision, leading to a revenue reduction of 12% in 2026 when ancillary revenues are still high. However, this impact is expected to decline to around 3% by 2030 as FCR and aFRR markets saturate.

4

Demand-based charging restrictions impact the battery throughout the day, leading to reduced revenues of 8-9% across all markets and years.

5

Flexible grid connections can justify a reduction of the Baukostenzuschuss. Depending on the design of the connection agreement, a reduction of 28 to 74€/kW would be required to offset revenue losses for asset owners.



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E N E R G Y R E S E A R C H

Details and disclaimer

Flexible grid connection agreements in
Germany
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