

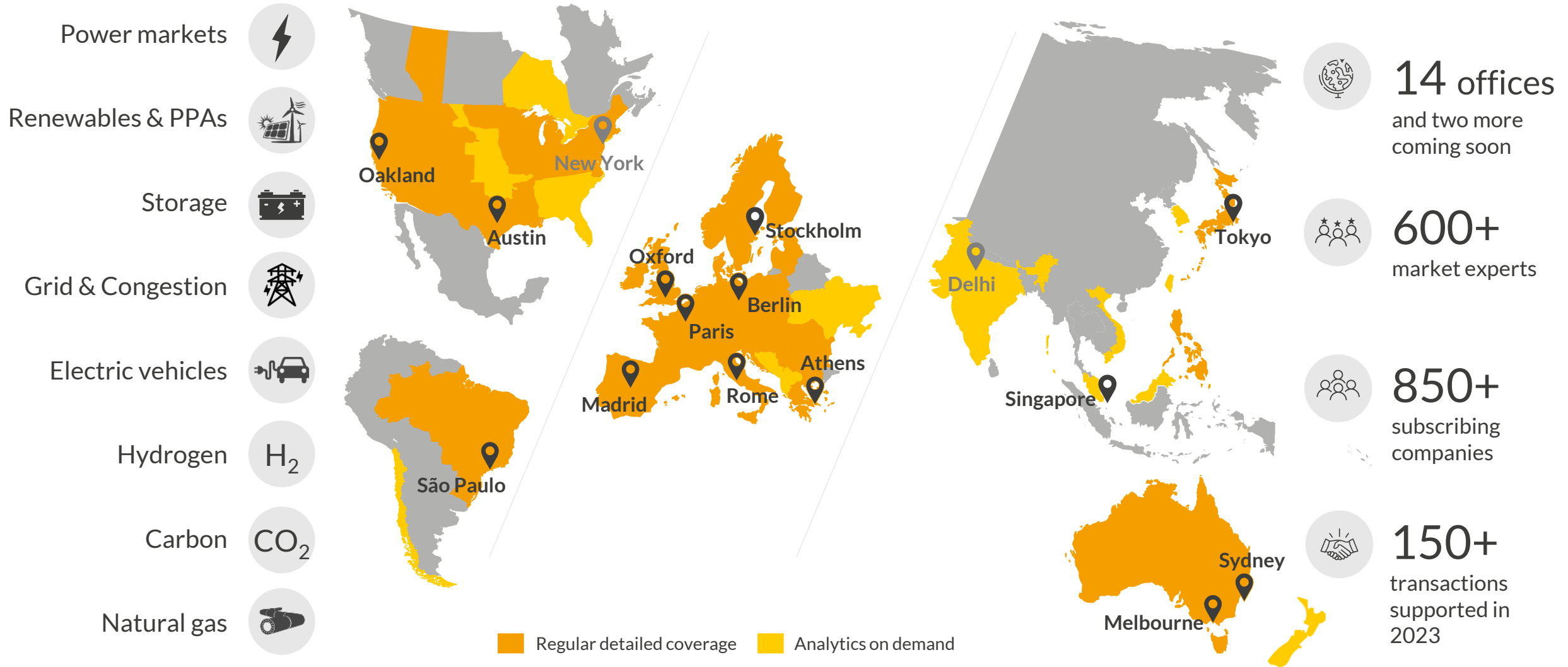
# Financing Batteries in Germany: Challenges and Opportunities

Virtual banking roundtable

20 November 2024

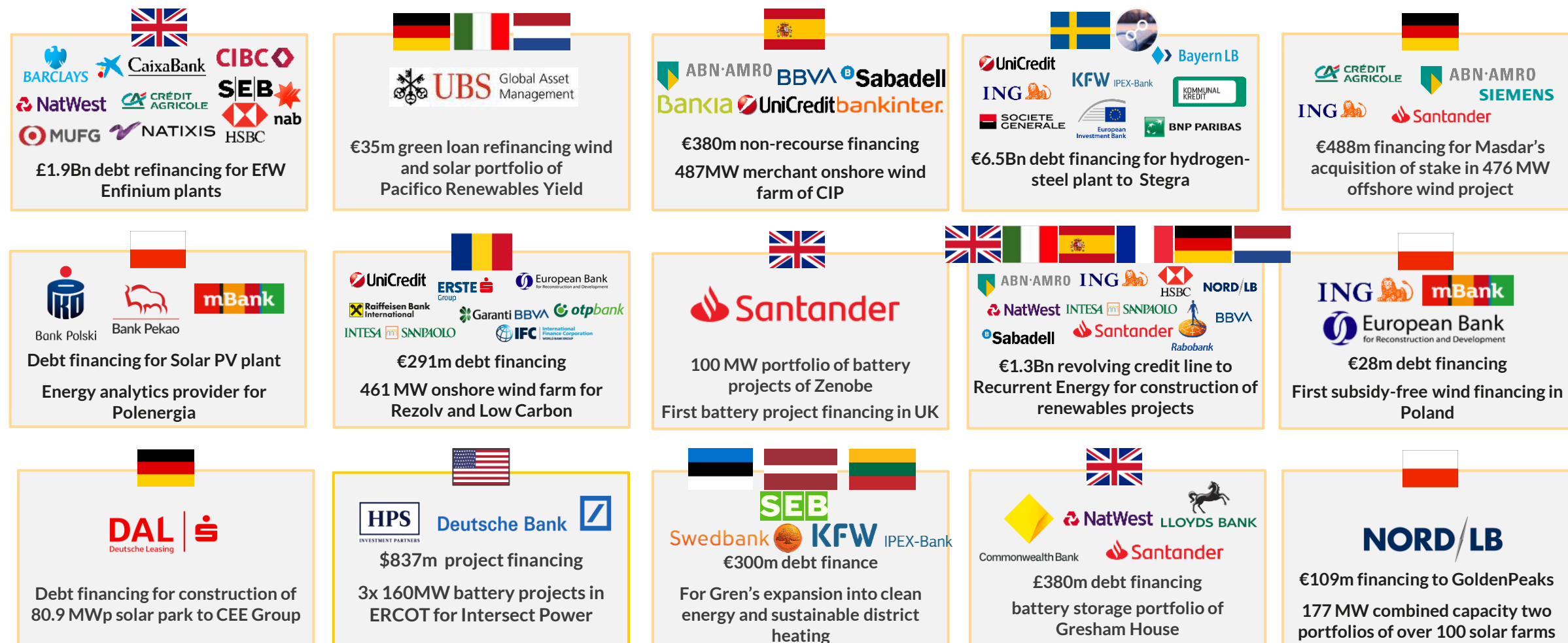


# Aurora provides market leading forecasts & data-driven intelligence for the global energy transition

A U R  R A

# Aurora has a strong track record of acting as a market lending advisor

Aurora's price forecasts have been relied upon by lenders in recently completed transactions:



# Debt providers in our network agreed to act as a reference on Aurora's bankability

References from lenders (contact details available on request)



▪ Paul Batelle, Director Infrastructure and Energy Finance



▪ Dominik Franz, Head of Energy and Infrastructure  
▪ Antje Gruber, Senior Project Manager



▪ Tim Koenemann, Managing Director, Global Head of Coverage Renewable Energies



▪ Bastian Schachtner, Head of Renewable Energy Finance



▪ Katharina Stahl, Vice President Infrastructure and Energy



▪ Christoph Tomas, Head of Project & Infrastructure Finance



▪ Markus Schröder, Head of Structured Finance for EMEA, Germany



▪ Caroline Lytton, Managing Director, Head of EMEA Sustainability Solutions

# Introducing today's speakers

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**Claudia Günther**

**Research Lead  
Northwestern Europe**



**Thaddäus Kreisig**

**Project Leader Advisory**



**Lars Jerrentrup**

**Lead Expert  
DACH Research**



**Steffen Schülzchen**

**CEO  
EntriX**

- I. Power market outlook and battery business cases in Germany
- II. Specifics of battery business cases
- III. Key aspects for financing batteries
- IV. Guest presentation: “Commercial structures” (Steffen Schülzchen, CEO Entrix)
- V. Concluding discussion and key take-aways



# Decarbonisation and renewable deployment require an increasing amount of flexibility in the system



The phase-out of conventional thermal generation together with the rising peak demand increases the demand for flexibility

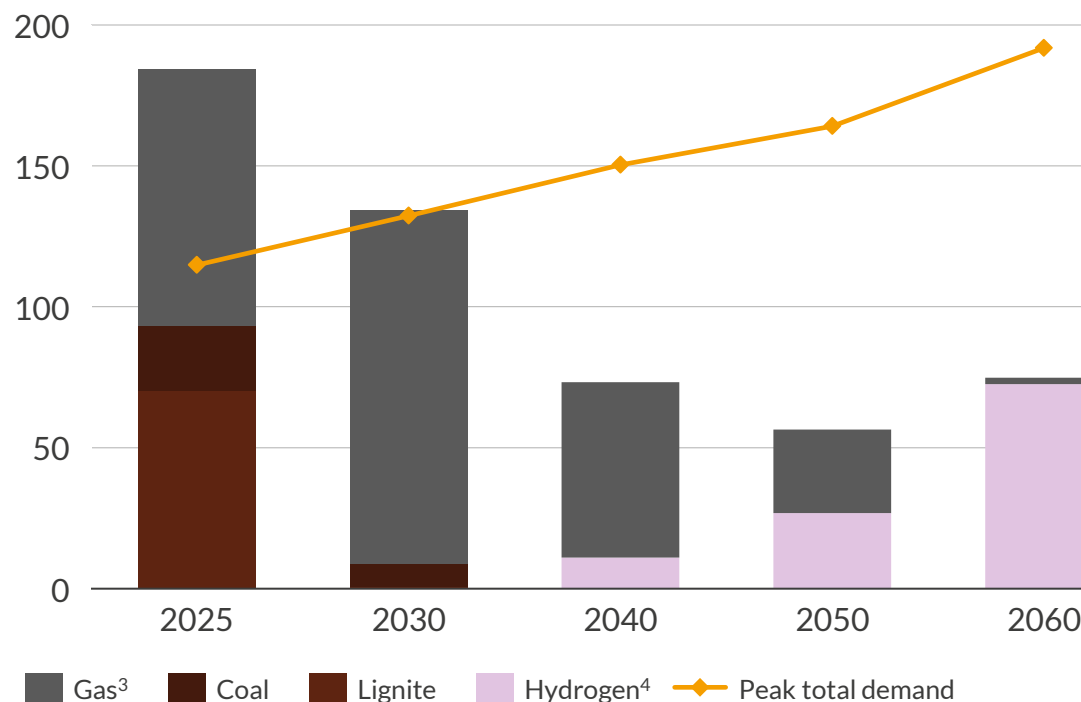


Flexibility is needed to integrate the increasing renewable capacities into the system and bridge the supply-demand gap

Thermal generation in Germany<sup>1</sup>

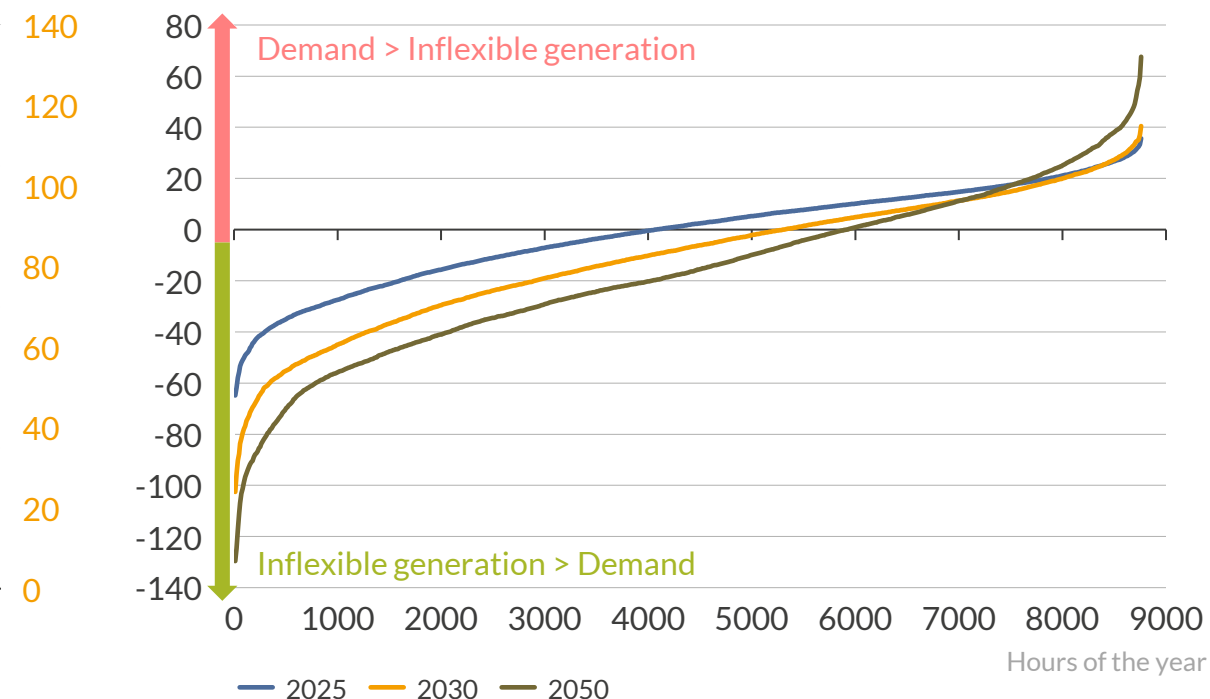
TWh

Peak inflexible demand  
GW



Residual demand curves for Germany<sup>1,2</sup>

GW



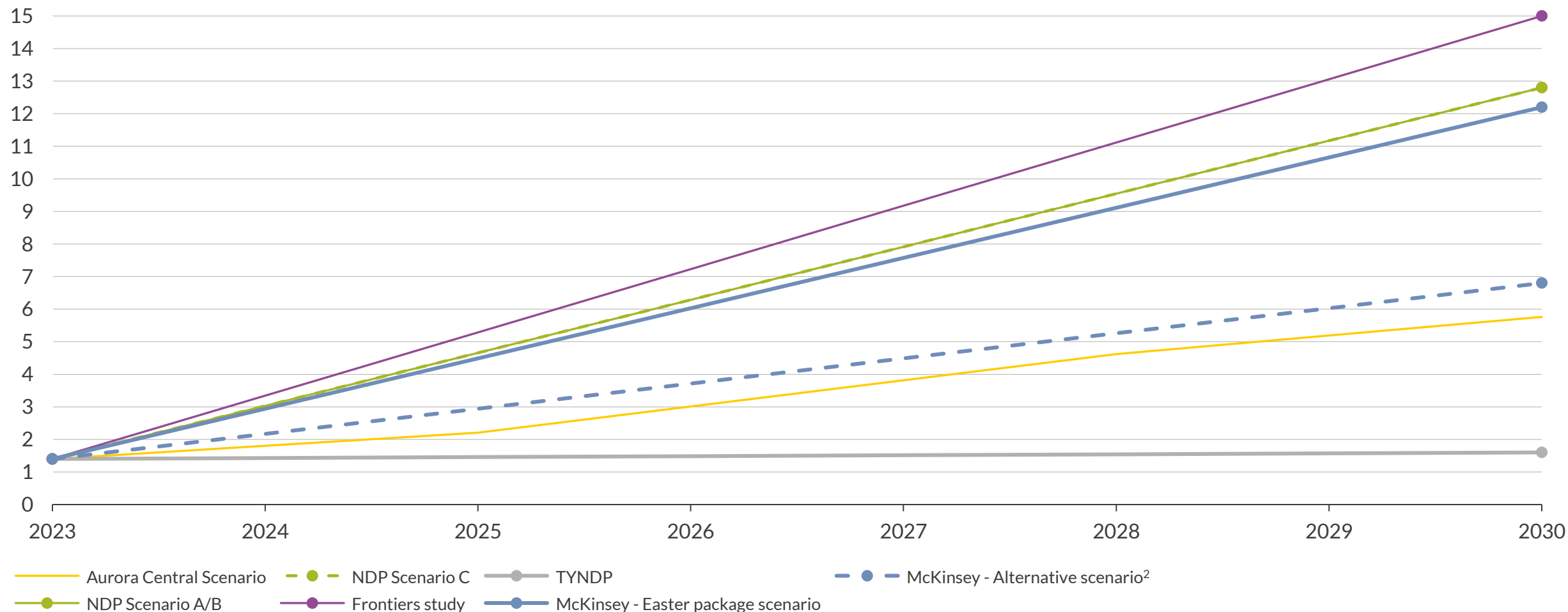
In the ambition to decarbonise the system, conventional thermal generation will be phased out and renewable energy deployment will accelerate. This introduces challenges to the security of supply and grid stability. Flexibility solutions can help to mitigate these risks and to reduce the total system costs.

1) Based on the Aurora Central Scenario from April 2024. 2) Residual demand is the demand, subtracted by solar generation, wind generation and inflexible thermal generation. 3) Includes gas CCGTs, OCGTs and peakers. 4) Includes hydrogen CCGTs and peakers.

# The German utility battery market is expected to grow quickly – however, the extent of growth varies strongly between studies

Utility-scale battery capacity in Germany in different market outlooks<sup>1</sup>

GW



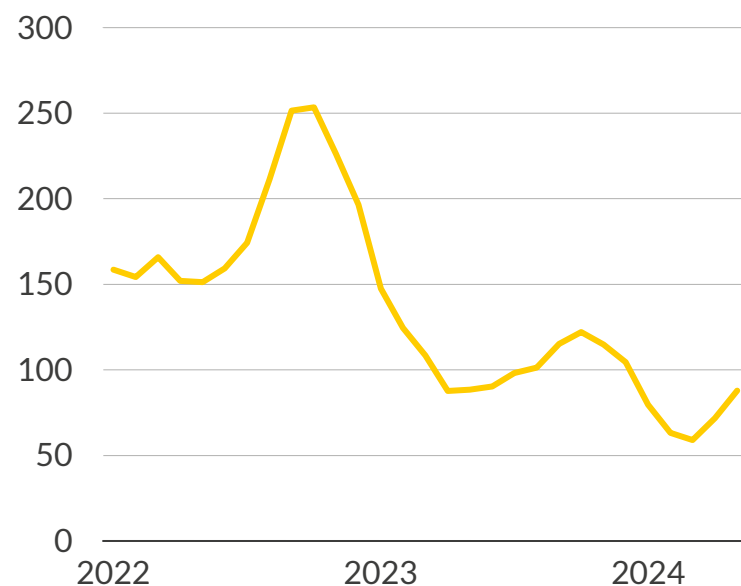
1) Capacities are linearly interpolated in years without data. 2) Mc Kinsey does not distinguish between utility and home storages in their alternative scenario. Therefore, the same capacity ratio than in their easter package scenario was assumed.



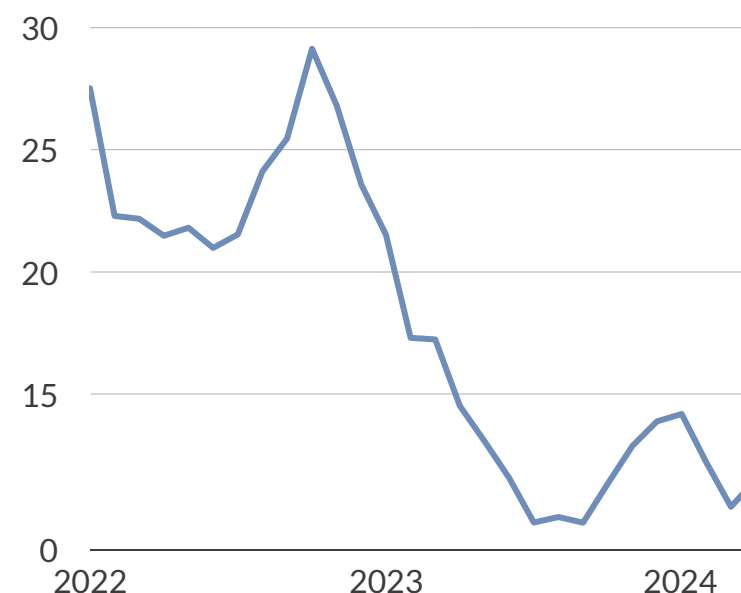
# Despite prices on wholesale and ancillary markets dropping sharply, we expect a good revenue outlook for batteries in the years to come

After peaking price levels during the energy crisis, the market prices on the wholesale and flexibility markets decreased quickly as commodity markets recovered.

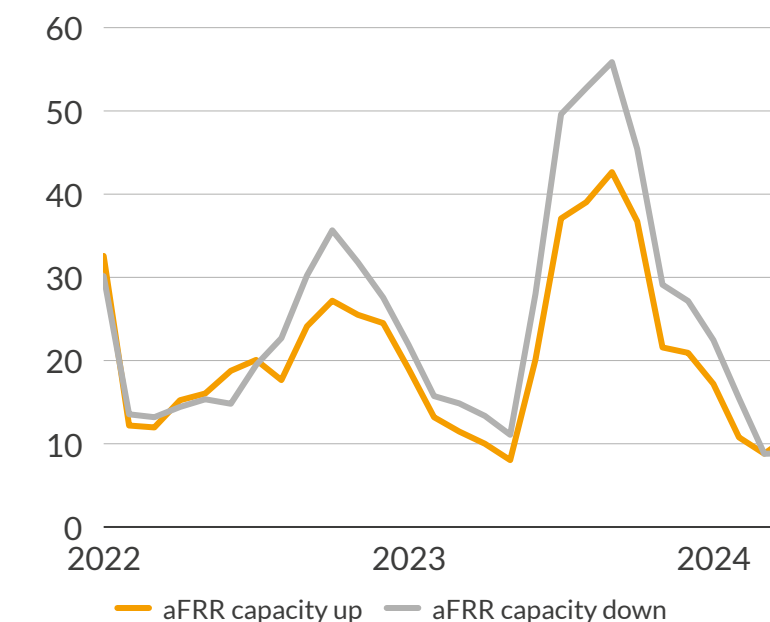
Four-month rolling average daily spreads in the Day-Ahead market<sup>1</sup> €/MWh, nominal



Four-month rolling average FCR prices<sup>2</sup> €/MW/h, nominal



Four-month rolling average aFRR capacity prices<sup>3</sup> €/MW/h, nominal



Outlook to 2030  
in Aurora Central

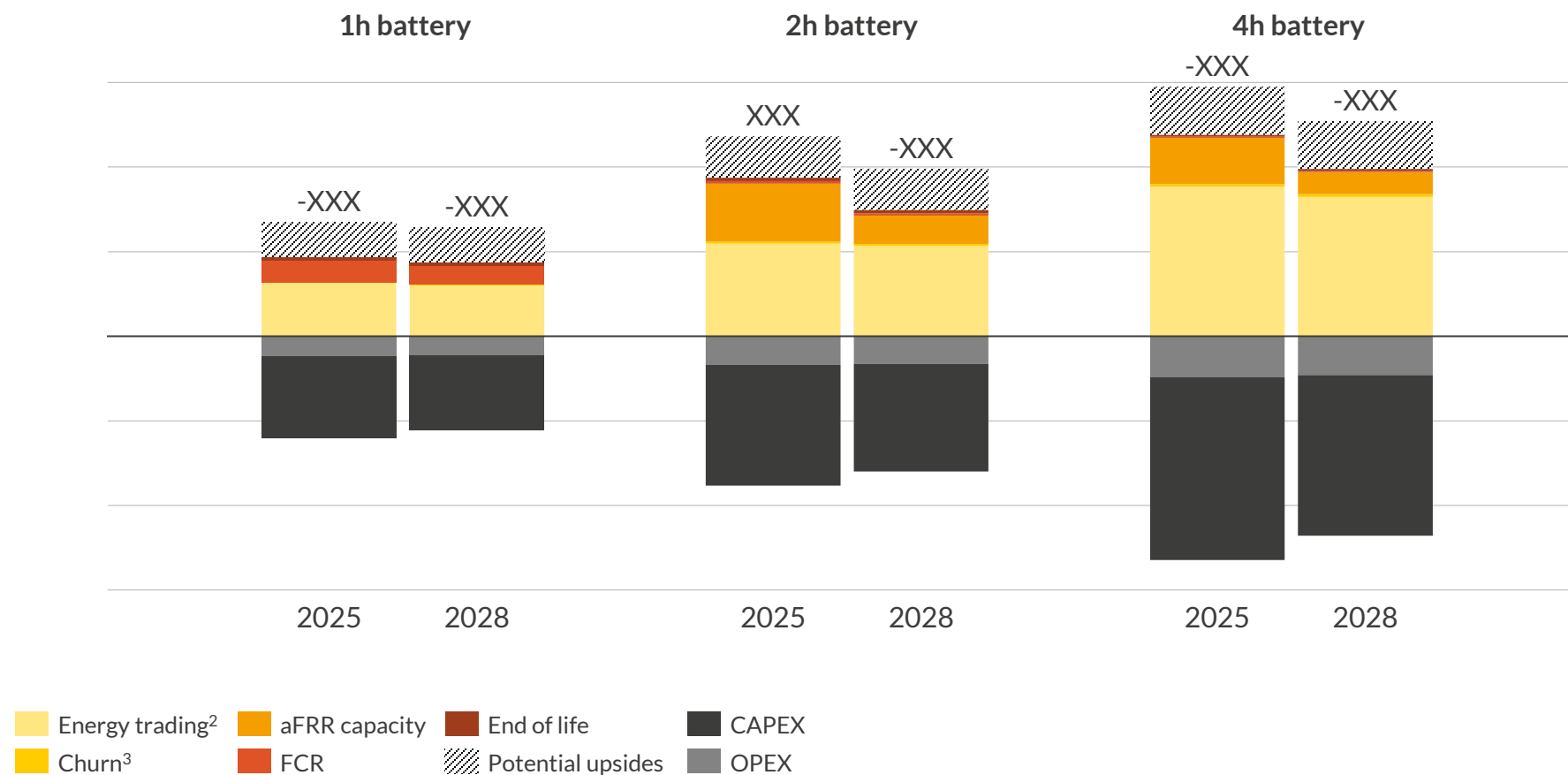


1) Data up to and including 22 May 2024. The rolling average includes the shown month and the previous 3 months. 2) Data up to and including 21 May 2024. The rolling average includes the shown month and the previous 3 months. 3) Data up to and including 25 May 2024. The rolling average includes the shown month and the previous 3 months.

# We analyse 1h, 2h and 4h batteries for the entry years 2025 and 2028 with the 2h battery promising the best business case

Present Value in Aurora Central for batteries with 1, 2 and 4h duration and the entry year 2025 and 2028

€/kW (real 2023)

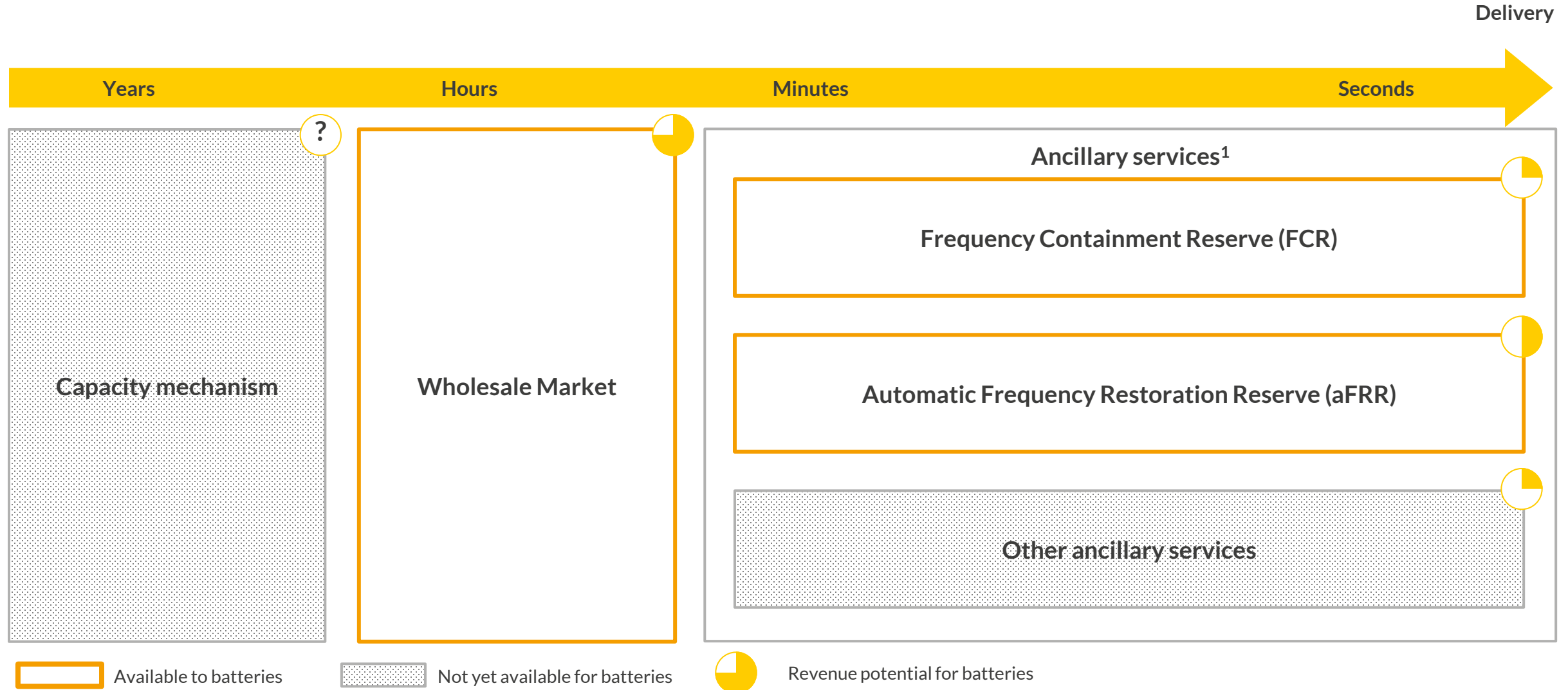


- In our Central scenario, the business cases reach two IRRs
- Whereas the 4h battery generates the highest revenues, the 2h battery achieves the highest IRRs.
- As the wholesale markets have a high market depth and do not saturate, energy arbitrage is the main revenue source for all battery durations.
- Potential revenue upsides can improve the business case, e.g.:
  - Repowering the battery cells and extending the project's lifetime
  - Advanced trading strategy on the Intraday market
  - Additional revenue streams such as inertia or black start.

1) Real IRR, Pre-tax. Discount rate used is 11.5% 2) Energy trading includes margins on the Day-Ahead, Intraday and aFRR energy markets. Churn is excluded from this category on this chart. 3) Non-physical trading. Churn here does not include the advanced trading strategy presented later in the report.

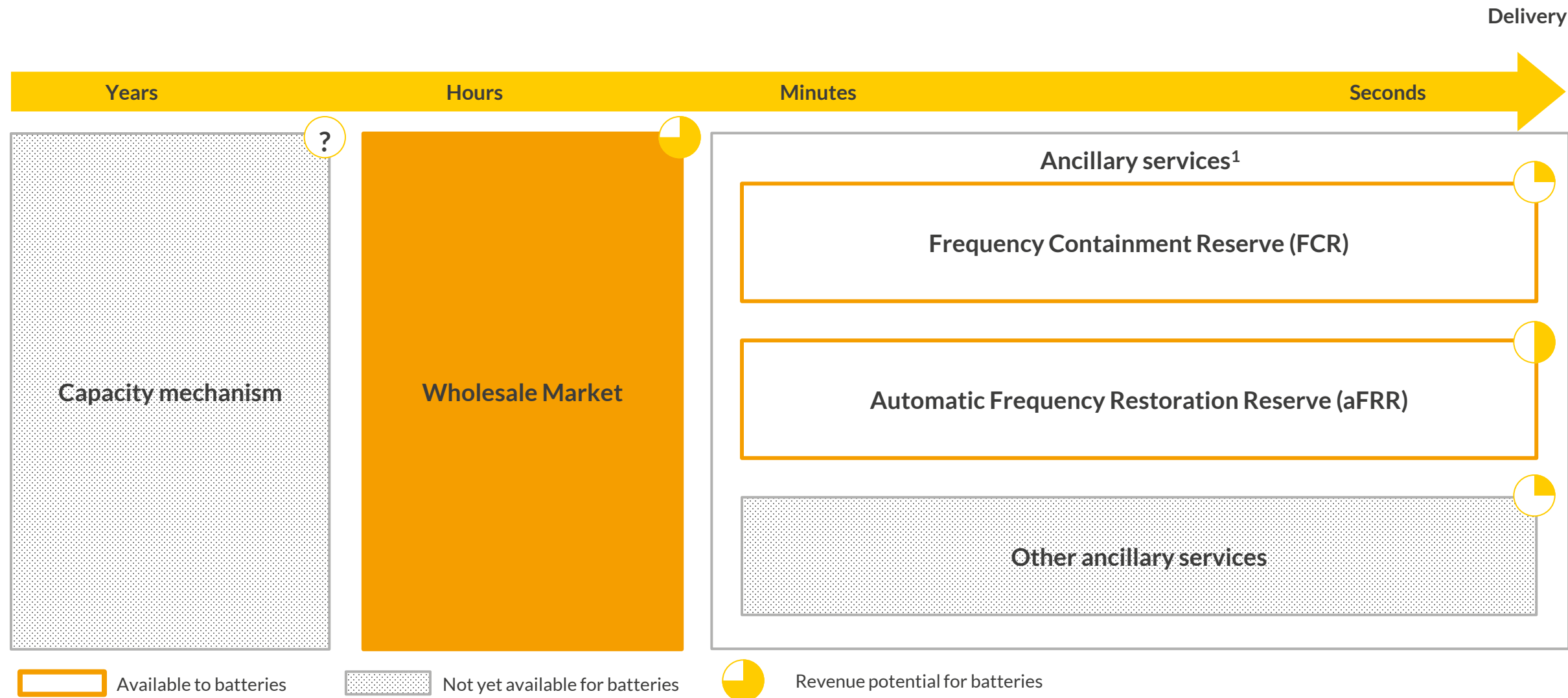
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# Batteries in Germany need to optimise across all existing revenue streams to be profitable, while new markets are currently being set up



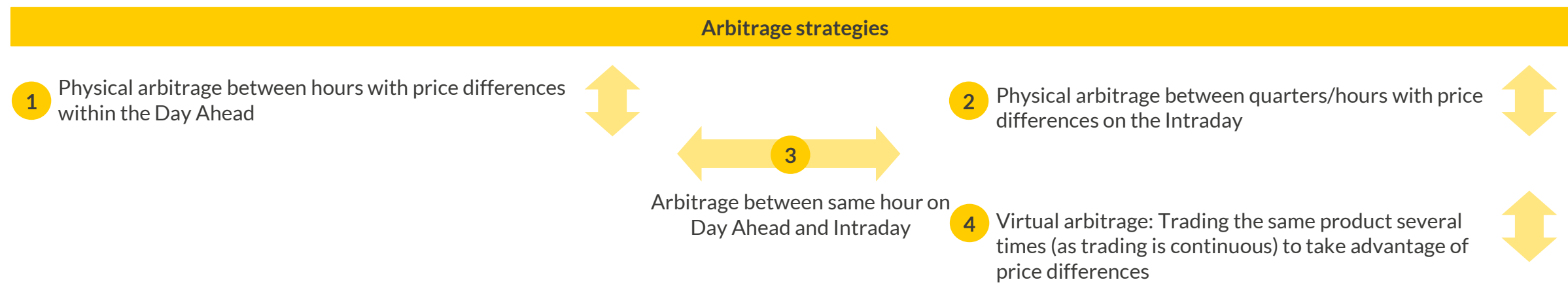
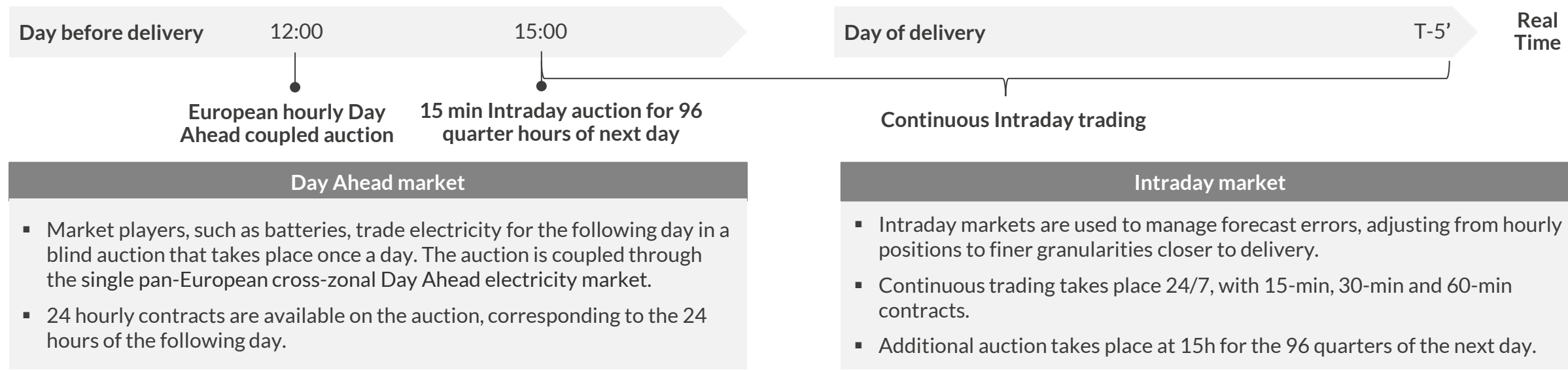
1) Next to the mentioned ancillary services, there is also mFRR, which is not relevant for batteries and black start capability, which is only relevant for large batteries >150MW.

# Wholesale market arbitrage offers a stable pillow for battery revenues due to a big market size and stable, predictable spreads



1) Next to the mentioned ancillary services, there is also mFRR, which is not relevant for batteries and black start capability, which is only relevant for large batteries >150MW.

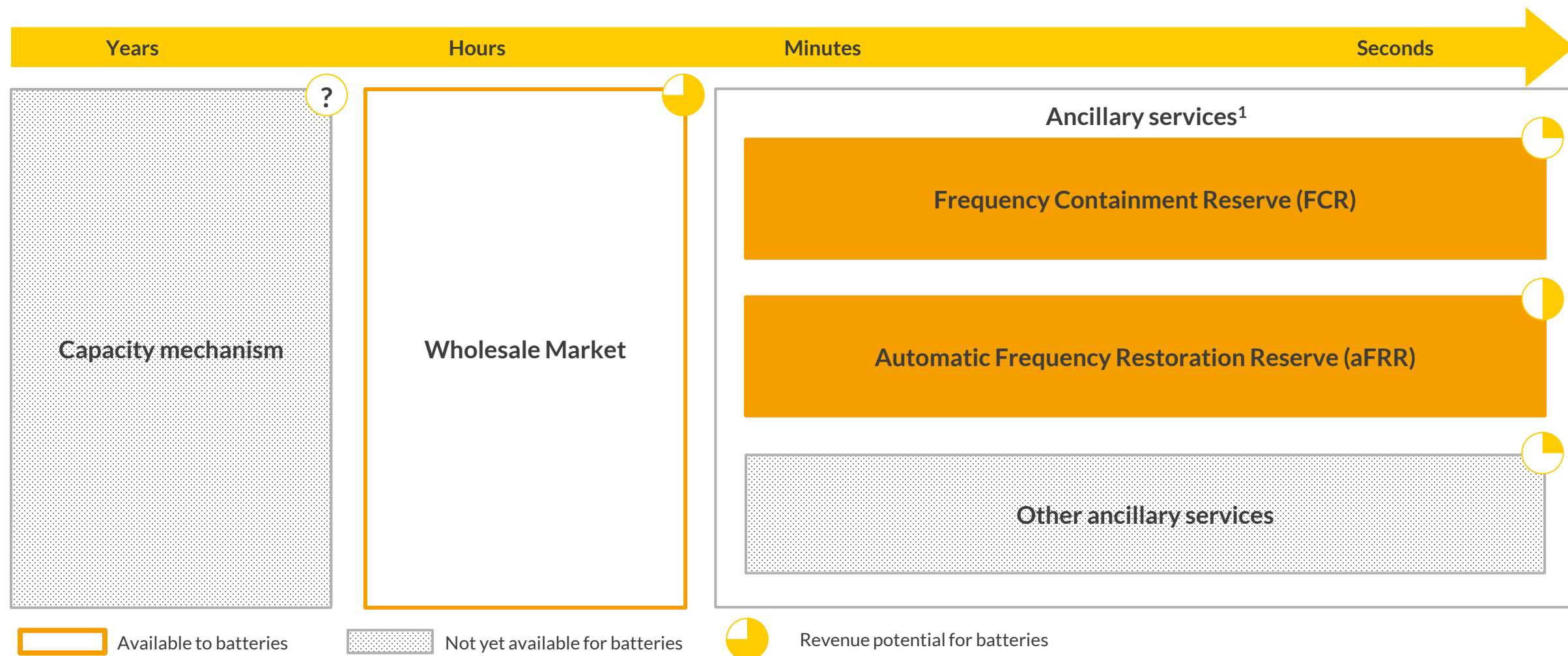
# Arbitrage can be done within, but also between the Day Ahead and the Intraday market



# Ancillary services add and additional revenue potential, but are limited in size and therefore prone to cannibalization

Response time

Delivery



1) Next to the mentioned ancillary services, there is also mFRR, which is not relevant for batteries and black start capability, which is only relevant for large batteries >150MW.



# While we expect increasing demand in capacity-based ancillary services, their market size will remain small

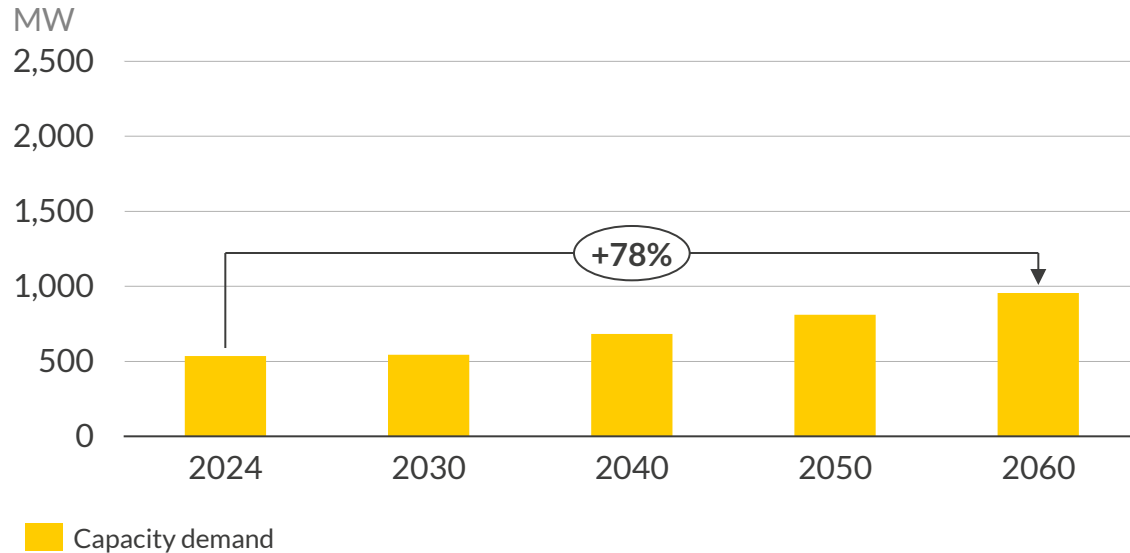
FCR market design parameters

Procurement	Daily auction for next delivery day
Duration of product delivery	4 hours
Pricing principle	Pay-as-cleared in €/MWh
Minimum bid size	1MW
Maximum bid size	25MW (indivisible)

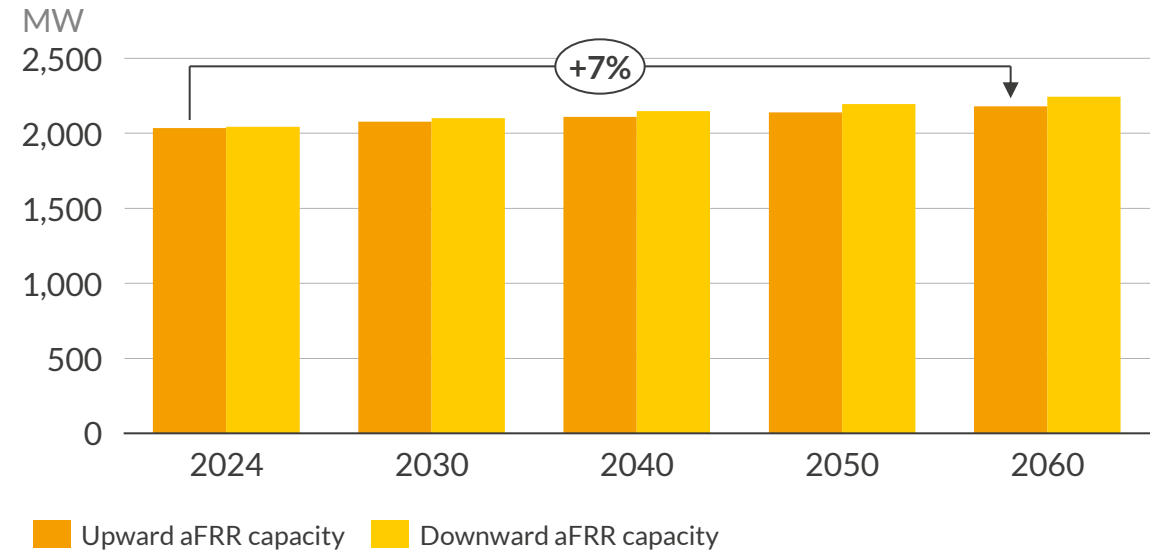
aFRR market design parameters for capacity

Procurement	Capacity in D-1, energy auctions in D
Duration of product delivery	4-hour blocks for capacity, 15min for energy
Pricing principle	Pay-as-bid in €/MW for capacity, pay-as-cleared in €/MWh for energy
Minimum bid size	5MW (smaller bid size possible if only one bid per BSP and delivery period)
Maximum bid size	25MW (indivisible)

Projected FCR capacity demand in Germany

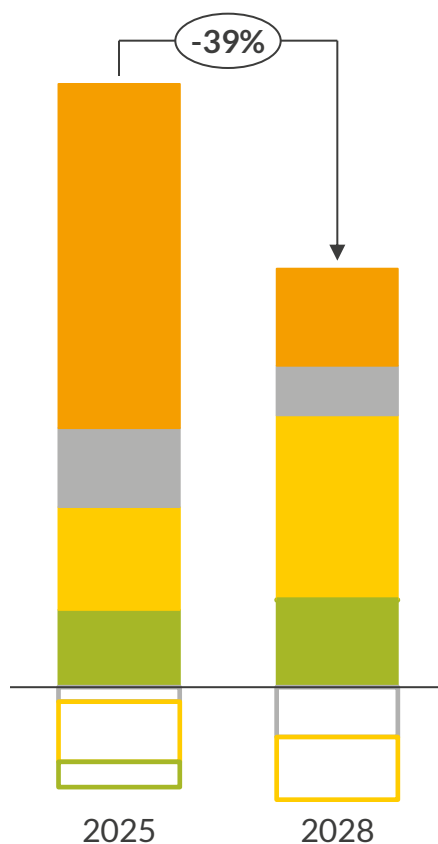


Projected aFRR capacity in Germany (yearly average)



# However, ancillary markets will saturate rather quickly with increasing battery capacity in the German market

Revenues and costs for a 2h battery system with 1.5 cycles, undegraded  
€/kW (real 2023)



## Comments

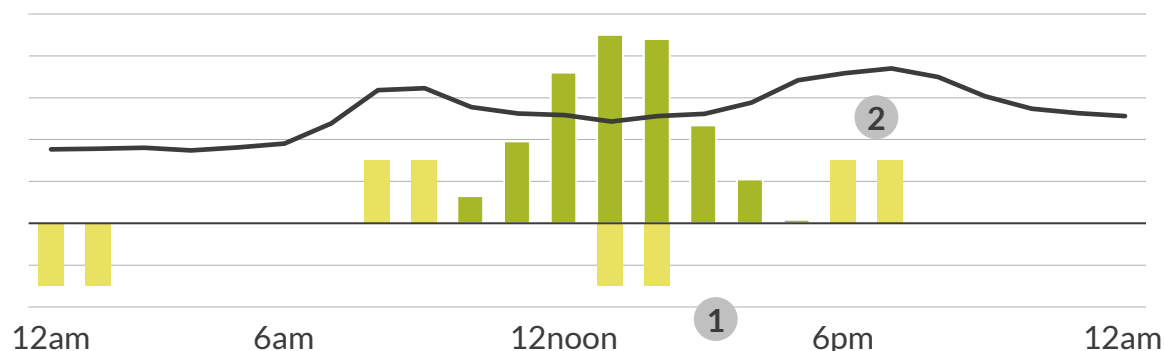
- While batteries that enter the market in 2025 can still profit from high prices in the aFRR market, this market will saturate with increasing battery capacity in 2028, leading to lower total gross margins below 110 €/kW.
- Lower revenue potential on the ancillary services markets will incentivise batteries to participate more on the wholesale markets (day-ahead and intraday), and thus, they will cycle more.
- Even with lower gross margins in the future years, battery business cases are set to be profitable. Projects with earlier commissioning years will have earned higher margins in the first years, while projects with later commissioning years can profit from decreasing CAPEX.

■ Day-Ahead discharge cashflow   
 ■ Intraday discharge cashflow   
 ■ aFRR energy discharge cashflow   
 ■ FCR+ aFRR capacity cashflow  
■ Day-Ahead charge cashflow   
 ■ Intraday charge cashflow   
 ■ aFRR energy charge cashflow   
 ■ FCR+ aFRR capacity cashflow

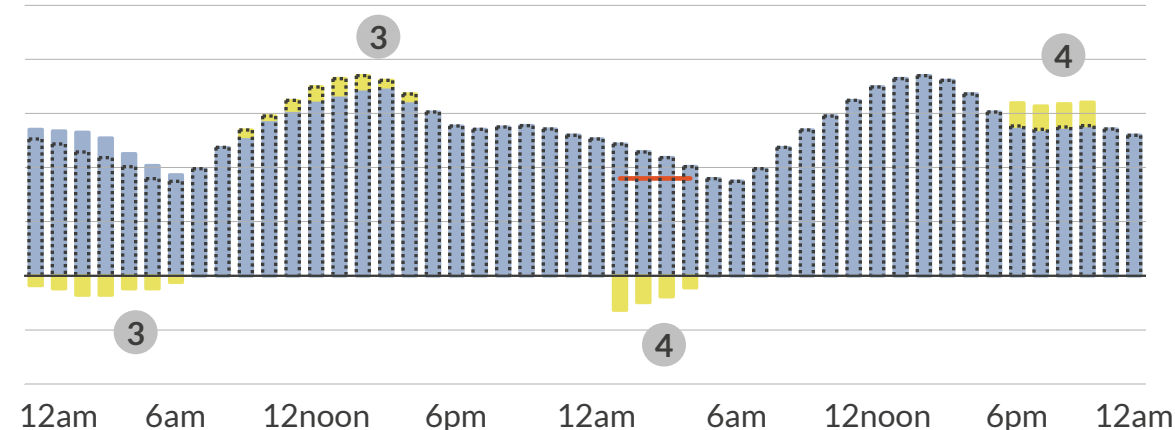
# By time-shifting RES generation, co-located batteries can increase RES capture prices and mitigate for curtailment and imbalance risks

Illustrative output of co-located solar + battery  
MW

Wholesale price  
€/MWh



Illustrative output of co-located onshore wind + battery  
MW



■ Solar generation 
 ■ Battery charge/discharge 
 — Wholesale electricity price 
 ■ Actual wind generation 
 □ Forecasted wind generation 
 — Curtailment threshold

## 1 Increasing capture prices

- A co-located battery can increase RES capture prices by shifting the production of renewables from lower price hours to higher price hours, via:
  - Charging from the asset when its energy output is high and prices are low
  - Discharging to the grid when RES energy output is low and prices are high

## 2 Reducing imbalance volumes and costs

- RES imbalance costs, resulting from deviations in actual generation versus forecasted generation, can be mitigated by a co-located battery through:
  - Charging/discharging in case RES production deviates from the forecast

## 3 Mitigating curtailment

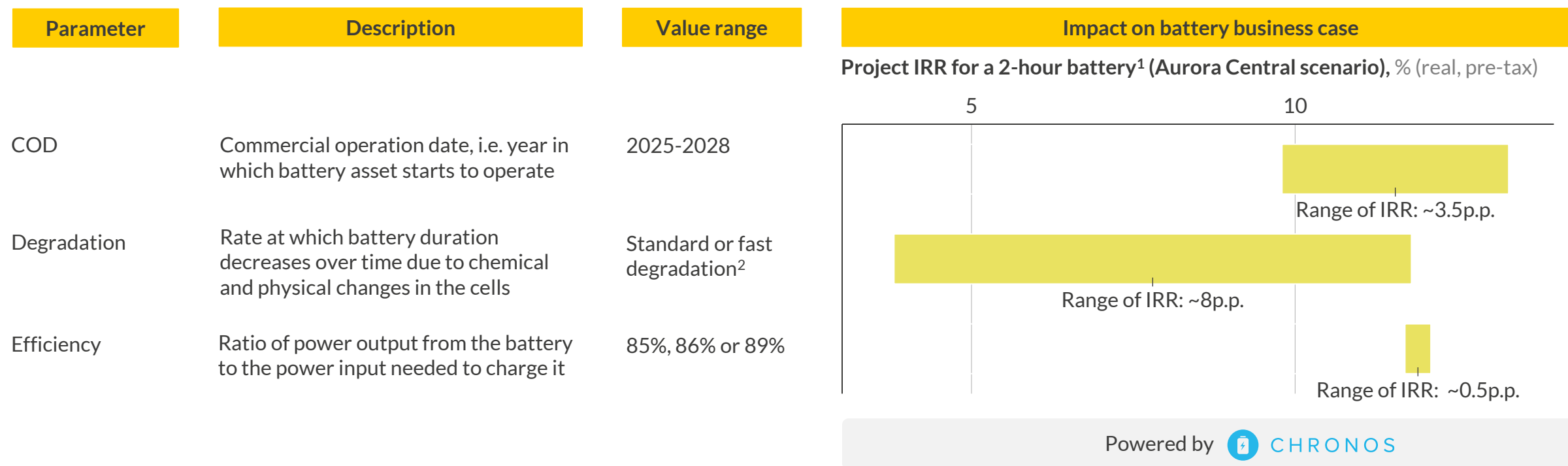
- Co-located BESS can also mitigate against risk of curtailment by:
  - Charging curtailed generation (e.g. due to negative prices, turn-down by grid operator, inverter clipping if RES is oversized, etc) from the RES asset, benefiting from 'free' charging, discharging at a later time.

## 4 Cost savings

- Co-locating assets can help spread CAPEX and OPEX across assets, minimizing costs per individual asset

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# Asset-specific parameters, such as COD and degradation, can significantly affect the economics of a battery asset



- Later **commissioning of a battery** asset leads to lower (but still high) profitability, due to high foregone profits especially from capacity-based ancillary service markets (such as FCR and aFRR capacity) in the coming years.
- The **speed of battery degradation**, especially in the early years of a battery's lifetime, can be a key determinant for its business case. In the (more unlikely) event of rather quick degradation, IRRs could reduce significantly due to lower duration and resulting revenue opportunities.
- **Variations in efficiency** only impact battery asset profitability to a moderate degree, as most Lithium-Ion batteries feature similar efficiency levels.

1) COD 2026 and 86% efficiency, unless stated otherwise. 2) While standard degradation leads to ~55% of initial duration remaining after a 15-year lifetime, fast degradation makes duration decrease to only ~35% over the same period.

# Key items to look out for when receiving a revenue forecast

1

Are the fundamental power market scenarios used to generate the revenue forecast bankable?

- ✓ Aurora provides bankable power market scenario forecasts for most European countries, while country teams are actively following the regulatory debate, which is highly impactful for batteries
- ✗ Other players might focus one specific country and extrapolate their findings to the German market.

2

Is saturation of the ancillary markets through cannibalization properly reflected in the revenue forecast? ➡ Deep-dive

- ✓ Fundamental prices curves for ancillary services markets modelled, which reflect substantial BESS buildout
- ✗ Statistical approaches used or extrapolation of historical ancillary services upside

3

Are the potential upsides in the revenue forecast transparently documented?

- ✓ Clear view on share of revenues that stems from advanced continuous intraday trading or future capacity market payments
- ✗ Revenues from advanced continuous intraday trading implicitly contained in wholesale market revenues

4

Are asset-specific technical parameters properly reflected in the revenue forecast? ➡ Deep-dive

- ✓ Manufacturer degradation curve and efficiency used to calculate the forecast
- ✗ Generic assumptions on degradations and efficiency

# Statistical modelling can be suitable for short-term forecasts, however, long-term developments are captured better by our fundamental models

There are two approaches that are commonly used to forecast prices: fundamental and statistical modelling.

## Statistical modelling

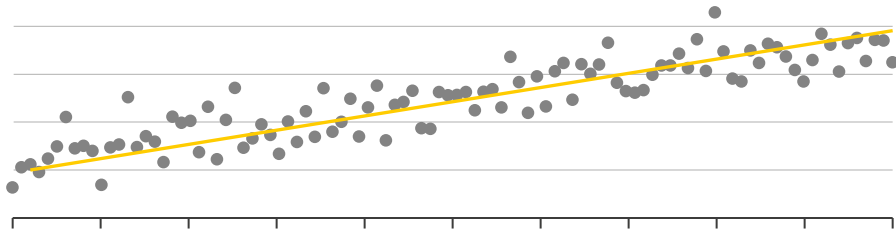
### Advantages:

- Efficient approach
- Scalable, as it can be applied to large amounts of data
- Suitable for short-term forecasts

### Disadvantages:

- Not able to capture fundamental market changes
- Depends on the quality of the historical data used
- Prone to overfitting

### Illustrative price formation in a statistical model (regression)



## Fundamental modelling – Aurora's approach

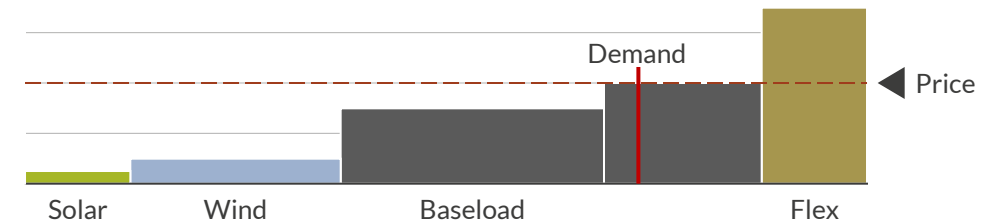
### Advantages:

- Able to model fundamental system changes
- Provides insights about mechanisms that are driving system behaviour
- Suitable for long-term projections

### Disadvantages:

- Strongly driven by input assumptions
- Time-consuming to calibrate and maintain

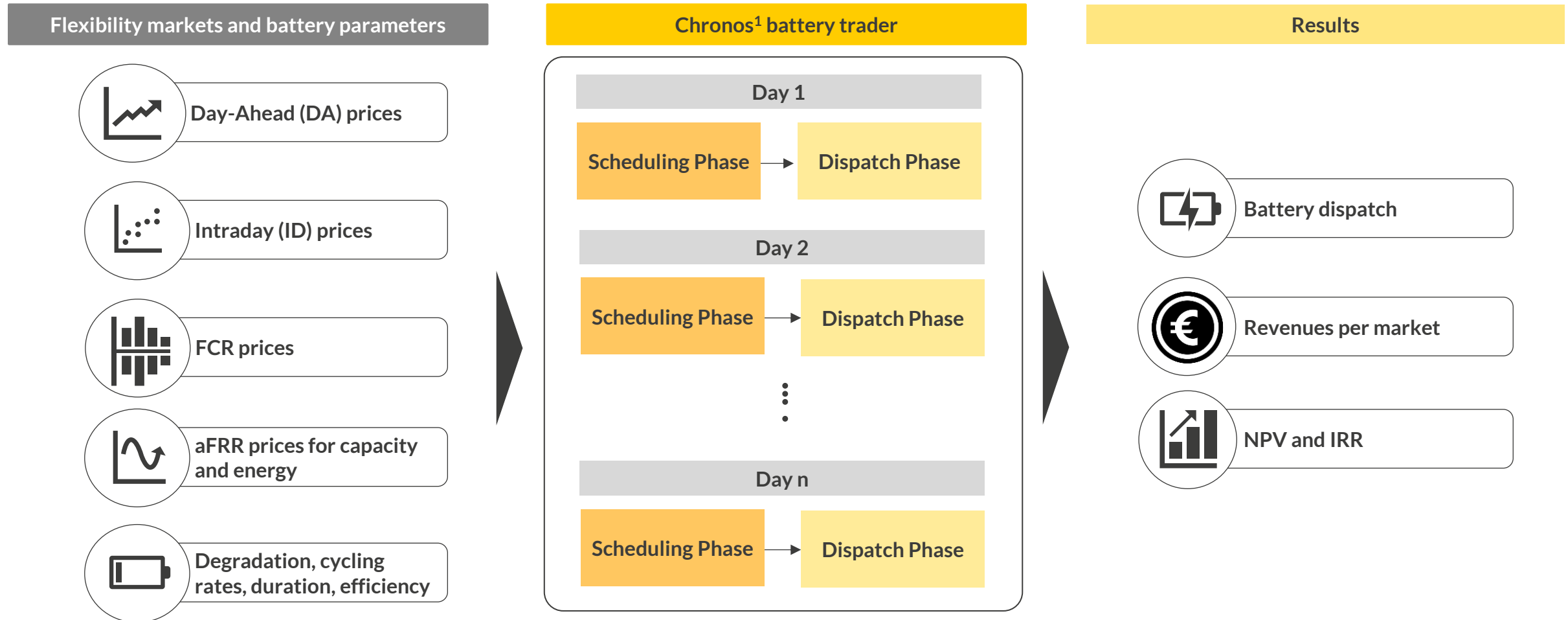
### Illustrative price formation in a fundamental model (merit order)



While **statistical modelling** can be suitable for forecasting prices in the short term or in systems with no major changes expected, **fundamental modelling** is the better option for modelling long-term developments in systems that change fundamentally, like power markets. Therefore, Aurora has chosen the fundamental modelling approach for long-term price forecasts.



# Aurora models battery business cases in two stages based on our in-house market forecasts and Chronos, our battery dispatch software



1) Includes intermarket optimization such as **buying back** commitments on the ID to fulfill a DA commitment if the price is more attractive, **adding cycles** by selling earlier than committed on the DA market if an ID spread is observed, and **optimising** between the aFRR energy & ID markets depending on the more attractive price, does not include intra-market optimisation through asset backed trading such as continuous trading of 15-minute products on the ID and trading the same quarter hour multiple times.

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# Capturing the maximum value from flexibility

*Aurora Roundtable*

November 2024

[entrixenergy.com](https://entrixenergy.com)

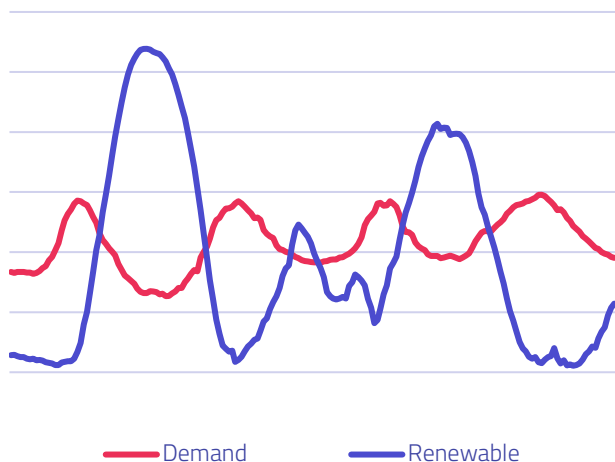




## About Entrix

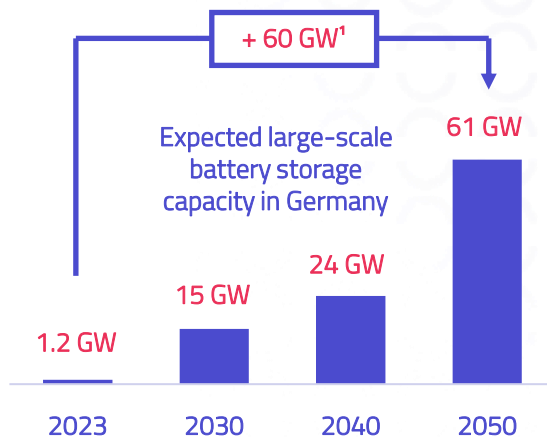
# Flexibility is defining the next phase of the energy transition – we at Entrix capture the maximum value from batteries and VPPs

Volatile green electricity will power the world



8x more renewables until 2050 needed

Flexibility will fill the gaps but requires substantial CAPEX



€50bn CAPEX needed for grid-scale storage in Germany

Our mission: capturing the full value from flexibility

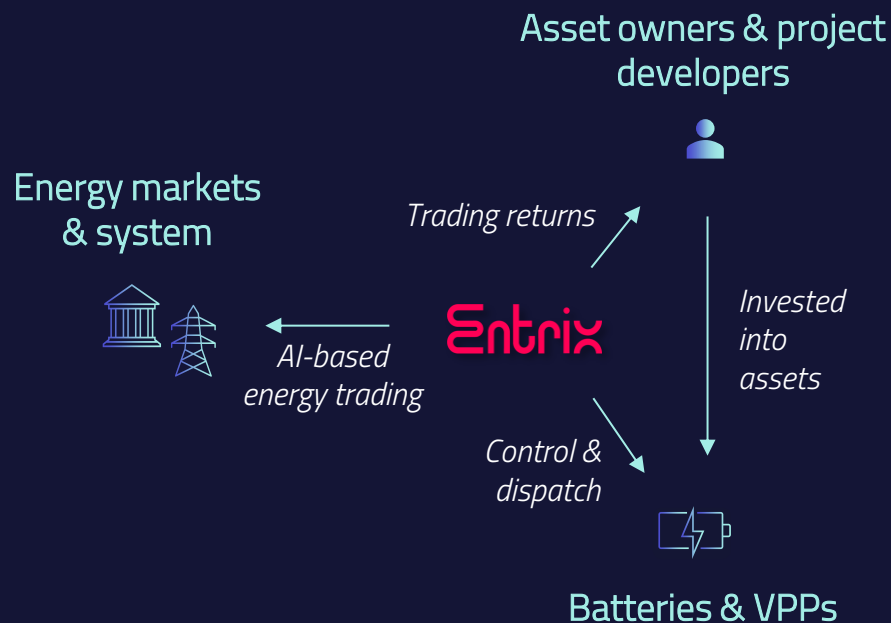
Up to 6%p IRR uplift

generated by Entrix for grid-scale batteries according to Aurora Energy Research<sup>2</sup>

Market-leading AI-based trading & optimization solution

1) Source: Frontier Economics  
2) %p = percentage points, based on the business case for a 2h asset in Germany

AI-based algo trading is just one of our strengths  
– we're the one-stop-shop for owners of batteries and VPPs



## WHAT SETS US APART FROM CONVENTIONAL TRADERS



**We cover all wholesale & ancillary services revenue streams**

Best trading performance by ideal combination of all revenue streams



**Batteries are unique and we treat them as such**

Hardware specifics deeply embedded into the algorithm



**We cover the value chain end-to-end**

Energy market operations, trading, asset dispatch, O&M integration

We have invested €25m+ to build Germany's leading optimizer  
– developed by a Silicon Valley tech organization



We have the right people to advance the solution in the future ...

In the past, you needed the best energy traders  
- today and tomorrow, you need the best tech team

Our team covers the entire flexibility value chain and brings experience from the world's leading tech companies



... and are backed by family offices & institutionals

Allianz

ARVANTIS  
GROUP

ABACON  
CAPITAL

AENU

Enpal.



# Leading infrastructure investors use our solution to trade their batteries and VPPs

## Customer spotlights



Aquila works with us on their **first two storage projects in Germany** (>100MW)



For Encavis, we optimize **batteries together with renewables**



We're the exclusive partner for **Europe's largest residential VPP**

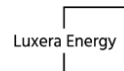
First project live since

**2022**

**>700 MW**

under contract

## Further project references



**400 MW**

going live in 12  
projects in 2025

## Our Services



Our offering: Market-leading AI-based algo-trading

# Excellent algos are just one of our strengths – we're the one-stop-shop and long-term partner for our customers

## The building blocks of our service



Market leading AI-based algo trading

With our algorithms, we can make the best trading decisions in real-time. We monetise flexible assets across all revenue streams – fully integrated and every day anew



End-to-end value chain coverage

Decision-making is not enough – we also execute the trades on energy markets and integrate directly with the hardware to control the dispatch



"Co-owning" the business case

Optimising the asset value starts much earlier than trading operations commence – we help our customers to make the right design choices and obtain financing

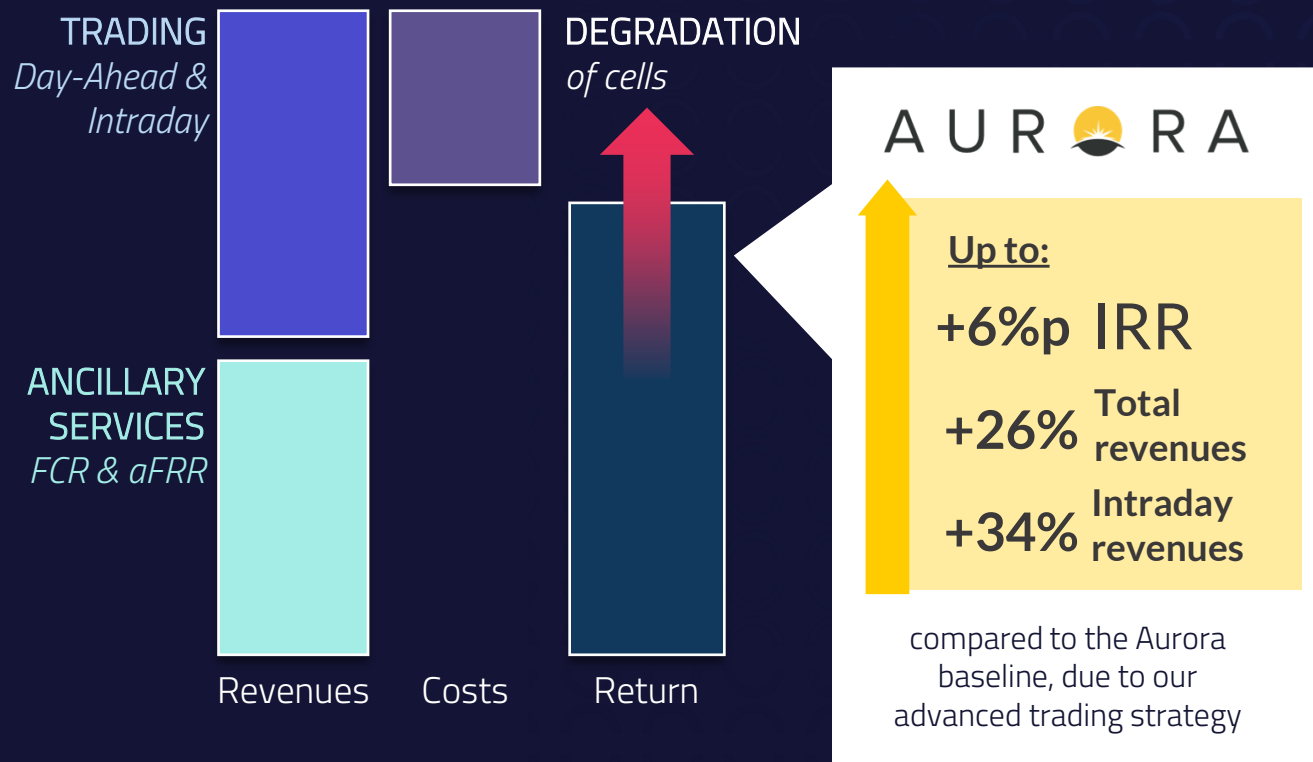


Strategic partner to co-shape BESS market of tomorrow

In the future, storage systems will provide additional value in various applications – we're already collaborating on this with you today

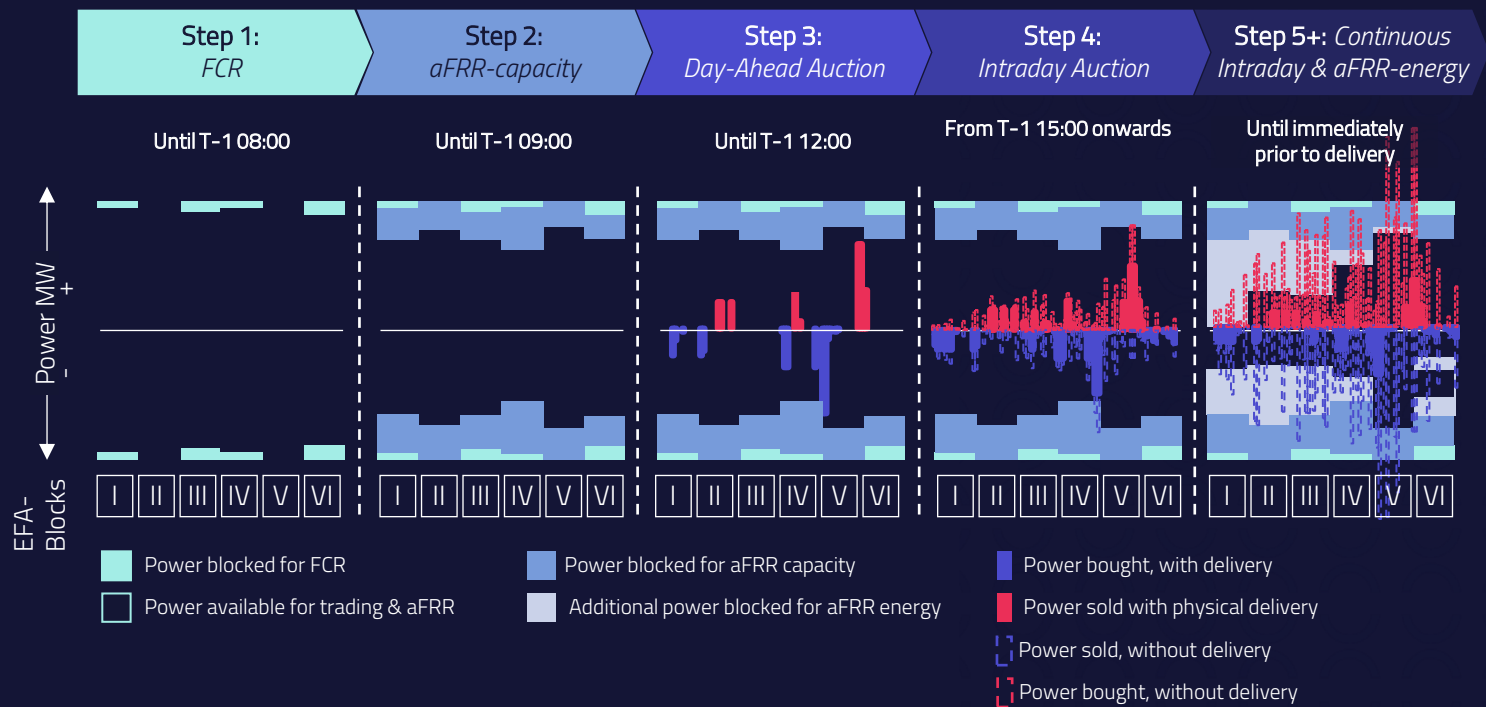
# We optimize batteries across the full value stack and achieve superior performance

## WHAT WE OPTIMIZE FOR



# With AI-based algorithms, we find the best way to trade a battery every day anew

## WHAT OUR ALGOS DO EVERY DAY



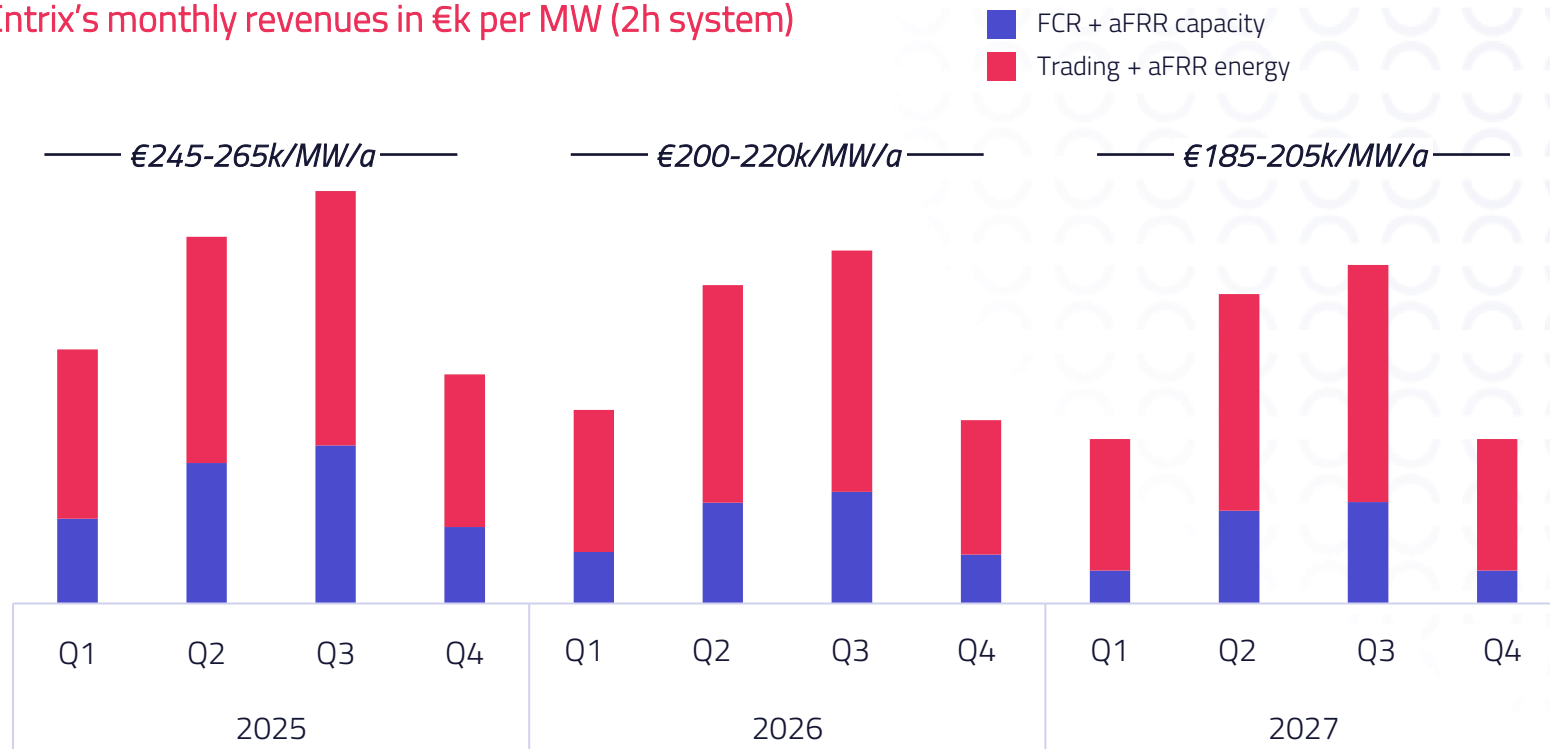
AI helps us to **distribute flexibility perfectly** across the various **revenue streams**

We **re-optimize in real-time** based on the latest market data

**95% of our trades are virtual:** we generate revenue without degrading the battery

In short/medium term we expect storage revenues to range between €200-250k/MW/a. Seasonal variation creates financing challenges

Entrix's monthly revenues in €k per MW (2h system)



### Commentary

#### Seasonal shape:

- Q1 & Q4: Lower volatility: Less trading revenues, higher FCR share
- Q2 & Q3: Higher volatility, higher trading revenues, high aFRR capacity revenues

#### Slight downward long-term trend:

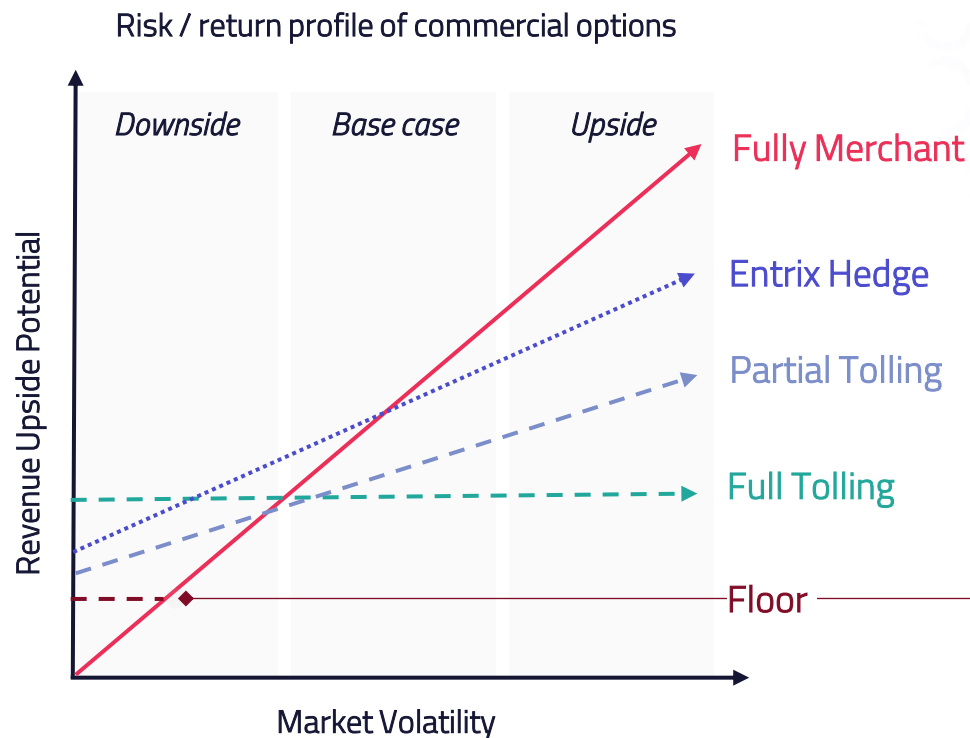
- Saturation in MW driven markets, both aFRR capacity and FCR
- Rather stable trading and aFRR energy revenues

Seasonal volatility of returns creates cash flow variability during the year. Financing structures including cash sweeps can address this challenge. The Entrix Hedge serves as an additional protection against seasonal volatility

# Commercial Structures



# Tailored revenue models exist to match risk-return-profile and ensure best financing options for BESS projects



## Fully Merchant

Full exposure to market volatility → high risk, high return

## Entrix Hedge

Base case equal to fully merchant paired with downside protection → medium risk, medium-high return

## Partial Tolling

Combination of fully merchant and tolling, typically strictly lower return and downside protection than Entrix Hedge → medium risk, medium-low return

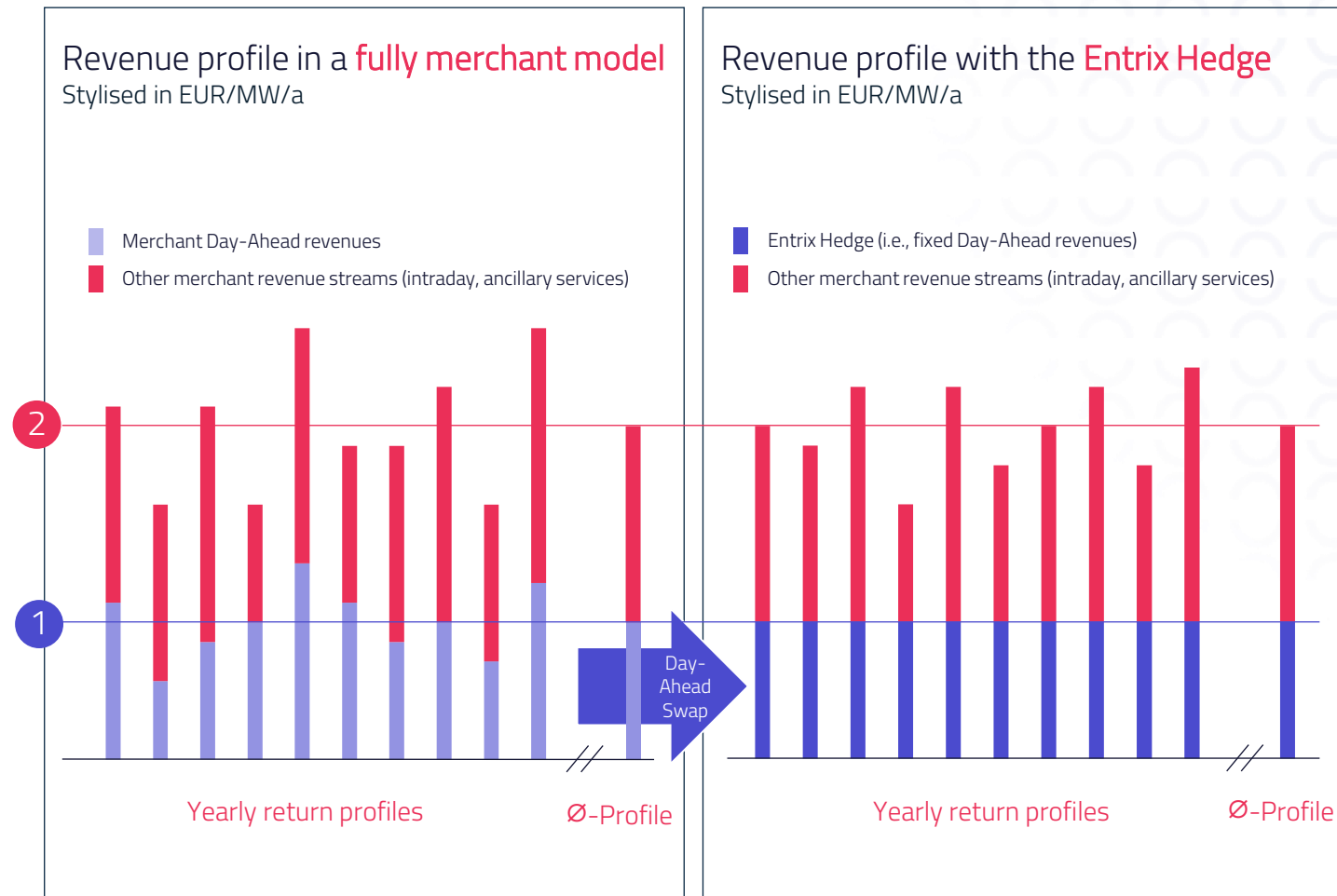
## Full Tolling

All revenues pre-contracted and full handover of asset to third party → low risk, low return, low visibility on asset operations

## Floor

Minimum revenues guaranteed and merchant beyond this. Typically, rather expensive and/or with low level of guaranteed revenues → high risk, medium-high return

# The functioning of the Entrix Hedge: We reduce the exposure to volatility through a so-called "Day-Ahead Swap"



1 Through the Entrix Hedge, changing Day-Ahead returns in a fully merchant model are replaced by a guaranteed fixed payment ("Day-Ahead Swap")

2 The other revenue streams maintain their merchant profile in both models

Overall, both models yield the same return<sup>1</sup>. With the Entrix Hedge, the return profile is less volatile over time

## Terms

Tenor of up to 10 years  
Guaranteed revenues: €60-70k/MW/a  
Counterparty w/ investment grade rating



# We look forward to hearing from you!



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- I. Power market outlook and battery business cases in Germany
- II. Specifics of battery business cases
- III. Key aspects for financing batteries
- IV. Guest presentation: “Commercial structures” (Steffen Schülzchen, CEO Entrix)
- V. Concluding discussion and key take-aways

## We are interested in your views!

- How large is the interest in financing you are experiencing? Any insights you can share on your experience?
- Batteries are completely different compared to renewables in how they make their money. Which challenges does this pose for project financing? (How) Do they differ between investments in stand-alone and co-located assets?
- Why do you think many banks are still hesitant about battery investments, and what key changes could encourage more participation?
- What role do route-to-market contracts play in risk assessments for battery investments, and how would you price in revenue guarantees (e.g., floor pricing, tolling agreements) against merchant revenue exposure?
- With market saturation potentially on the horizon, how do you address this risk?

## Key take aways

1

Due to the phaseout of dispatchable capacity, an increase in peak demand and the rise of renewable generation, a capacity gap emerges. This opens up great potential for battery storage in Germany.

2

Batteries in Germany need to optimise across all available revenue streams to be profitable in the future. This adds complexity to the optimisation, but is necessary as markets saturate slowly.

3

Even though the share of different revenue sources changes, batteries will be able to keep a sufficiently high revenue due to deep wholesale markets.

4

Besides fundamental market developments, asset-specific parameters such as COD, degradation and efficiency can significantly impact the economics of a battery and need to be considered in project financing.

5

Revenue risks for battery assets depend on the type of “route to market” contract between operators and traders. While floor and tolling agreements guarantee certain minimum revenues, day-ahead swaps limit exposure to volatility.



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## Advisory: Bespoke Consulting Projects for specific questions outside of reports' scope<sup>1</sup>

### Tailor-made storage asset valuations

- Including day-ahead, intraday, balancing and where relevant capacity or grid services market
- For a wide range of storage durations and for stand-alone and co-located storage assets

### Market attractiveness screening for energy storage

- Including both the commercial and regulatory perspectives

### Development of a flexibility strategy and/or a portfolio of flexible assets

- E.g. for utilities, global energy companies, or investors

### Use of energy storage for demand smoothing analysis

- Demand profile optimisation for industrial consumers and electrolyzers



## Subscription Analytics: Market Reports for general market information

### Country-specific Flexible Energy Market Forecast

- Market, policy and regulatory overview
- Model input assumptions
- Balancing markets evaluation
- Exemplary investment cases for short-term batteries

### European Battery Markets - Attractiveness Report

- Introduction to battery storage
- Country-specific market size and outlook
- Policy and regulatory environment
- Value drivers
- Project economics



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### Project design optimisation

- Explore diverse configurations for battery systems

### Optimisation benchmarking

- Compare the performance of various optimization strategies

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- Evaluate the financial and operational value of a battery asset mix

**Please note:** Chronos Germany is not yet released, but already available for other countries.

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# Organisers of this Banking Roundtable and the Point of Contacts



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