

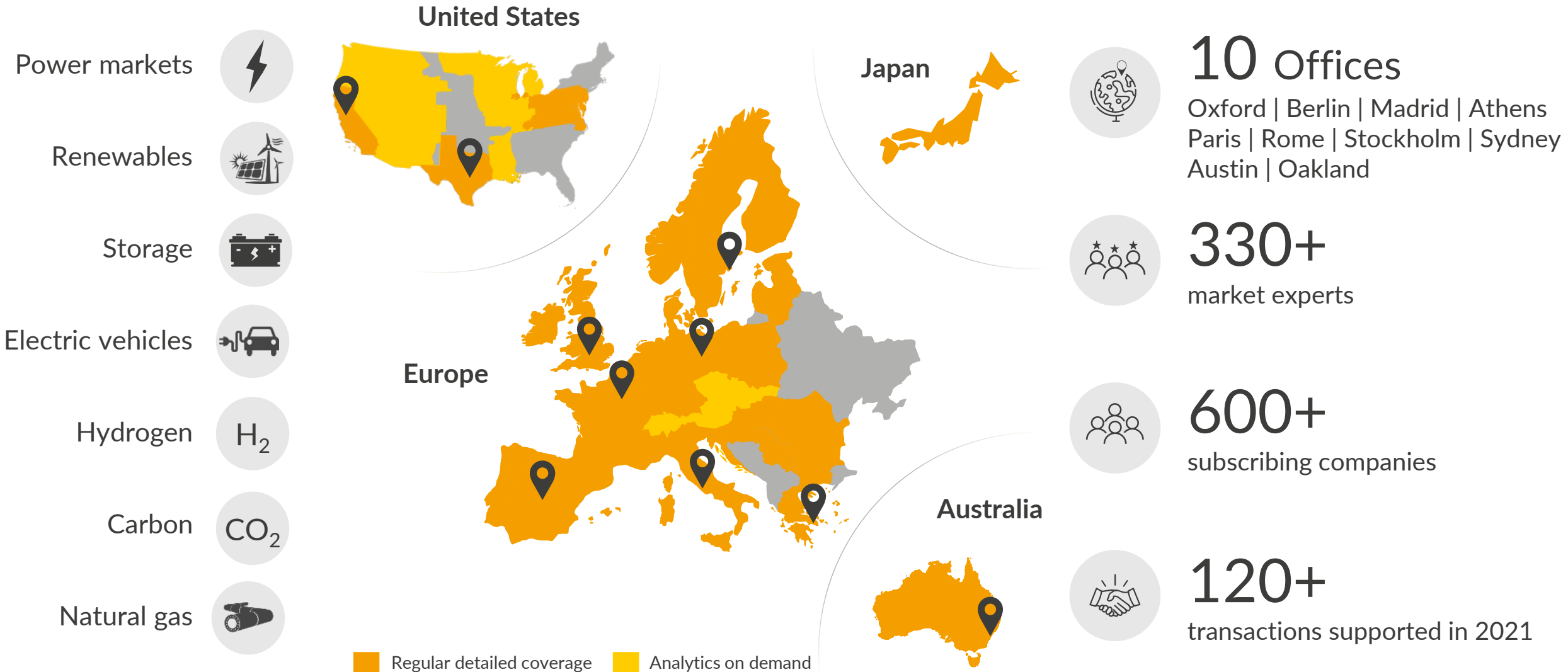
# Battery Investment Cases in Germany, The Netherlands and Belgium

Public Report

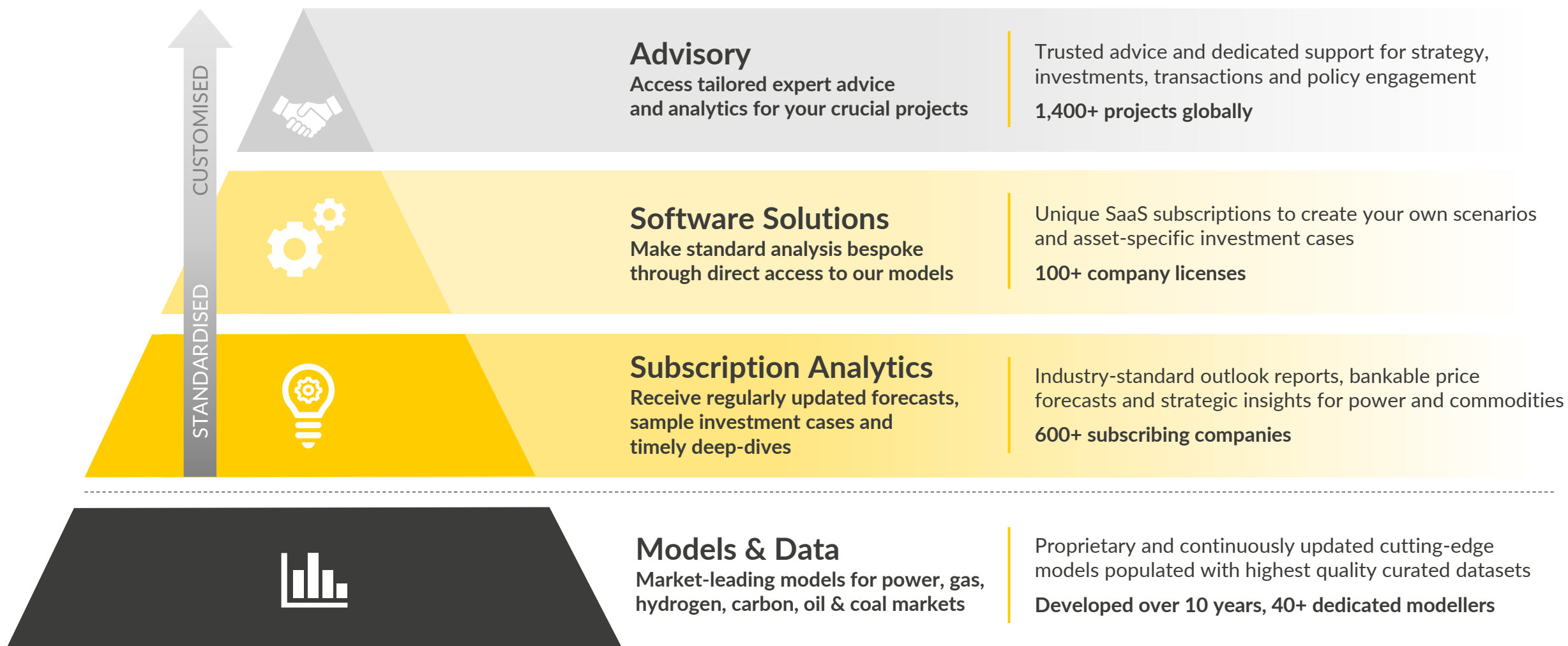


# Aurora provides market leading forecasts & data-driven intelligence for the global energy transition

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# Our market leading models underpin a comprehensive range of seamlessly integrated services to best suit your needs



The insights in this report were developed in a 9 month study in cooperation with key industry players

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Mein Geld macht grün.

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# 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
- Thomas Honig, Director Infrastructure and Energy Finance



- Dominik Franz, Senior Project Manager
- Antje Gruber, Senior Project Manager



- Tim Koenemann, Global Head of Coverage Renewable Energies



- Eckhardt Doose, Vice President Renewable Energy Project Finance



- Jörg Uwe Fischer, Head of Department New Energies



- Thomas Benz, Deputy Head of Department Financing Energy & Infrastructure Financing



- Katharina Stahl, Senior Originator Project Finance



- Dimitris Skordilis, Director Infrastructure & Power Project Finance



- Christoph Tomas, Head of Project & Infrastructure Finance



- Markus Schröder, Deputy Head of Structured Finance for EMEA, Germany



- Peter Schäfer, Director, Team Head Wind Power



- Caroline Lytton, Managing Director, Head of Power & Renewables



- Yuko Misu, Associate at DBJ

*"We consider Aurora to be the most thoughtful and forward thinking of the market advisers across the European power markets we look at. We value their added insight into emerging trends and the work they put into making their message easier to understand and translate to our key stakeholders.*

*Amongst the advisers we work with their market forecasts and scenario are seen as very credible with our internal credit teams and with investors who we work with."*

**Paul Batelle, Deutsche Bank**

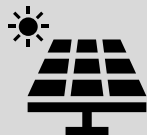
- I. Why flexibility and batteries are important
- II. Auroras methodology for modelling battery business cases
- III. Battery Outlook in Germany, the Netherlands and Belgium

# Rising flexibility needs and corresponding battery storage buildout is primarily driven by decarbonisation and its underlying drivers

## Decarbonisation drivers

1

### Variable renewables (RES) deployment



2

### Thermal generation phase-out



3

### Electrification of other sectors<sup>1</sup>



## Effects on power markets and battery storage requirements

### Energy markets (wholesale)

- Merit order effect: Low marginal cost techs pushing average prices down – capture prices for RES assets increasingly decoupled from commodity prices
- Increases the intermittency of energy generation (increasingly reliant on weather patterns) leading to an increase in price volatility

*Battery storage complements intermittency of renewables and balances baseload prices by charging in periods of high RES production and discharging in peak periods*

### Capacity Markets

- Thermal retirement and non-firm RES contribute to drop in firm capacity
- Increase in peak electricity demand can also increase the need for firm capacity

*Battery storage contributes to availability of firm capacity on the system*

### Balancing and Ancillary Services

- Variable renewables increase need for energy balancing and system services
- Constraint management<sup>2</sup> and the increasing shift from centralised to distributed generation further drives an increased need for these services
- Thermal retirement also drives a need for independent procurement of grid services

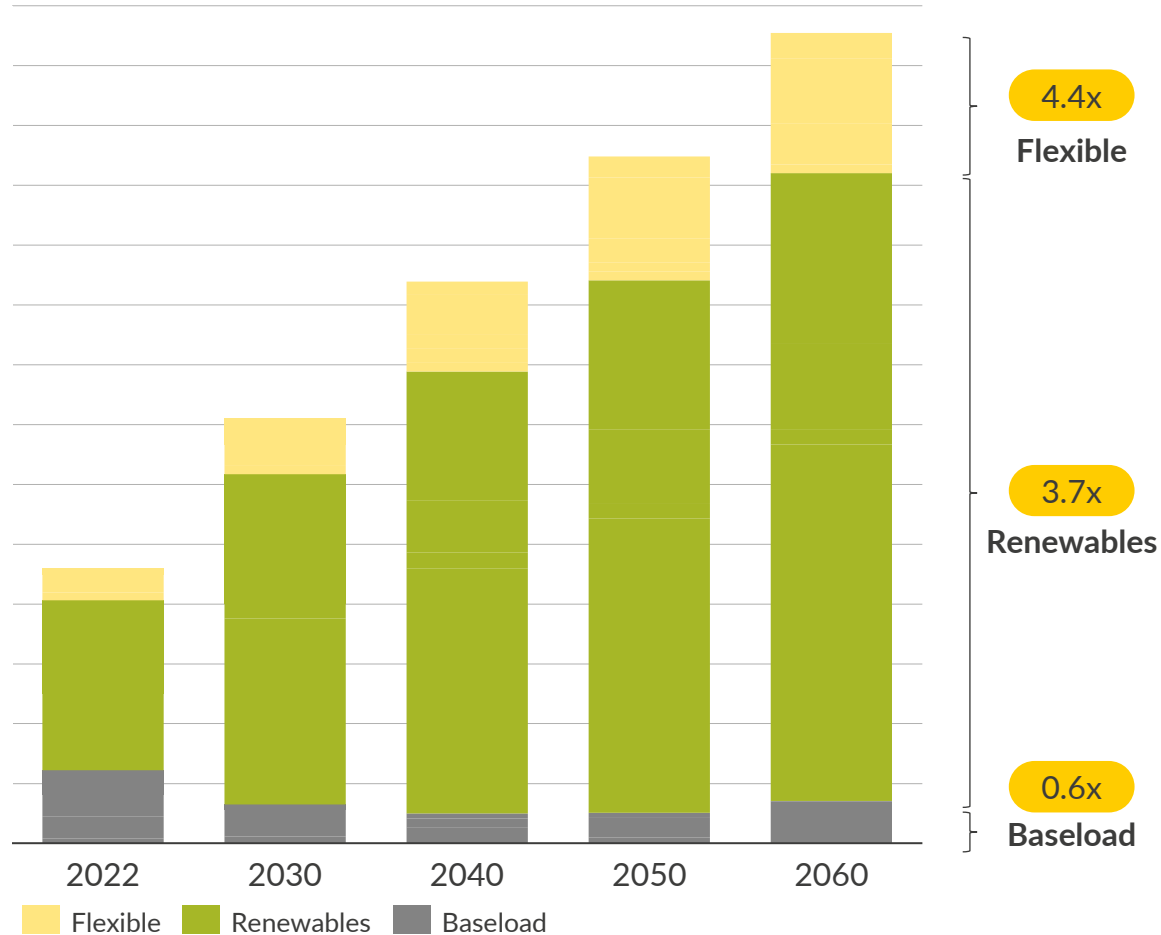
*Battery storage contributes to ensuring operability of the grid*

1) Growing demand could improve business case for storage if it is dumb demand; but if it is smart demand then detracts from business case for grid scale batteries. 2) Increase in constraint management is further driven by RES deployment outpacing grid capacity.

# Due to a 3.7 fold increase in intermittent renewables and 82% more demand, the need for flexibility in the system is rising

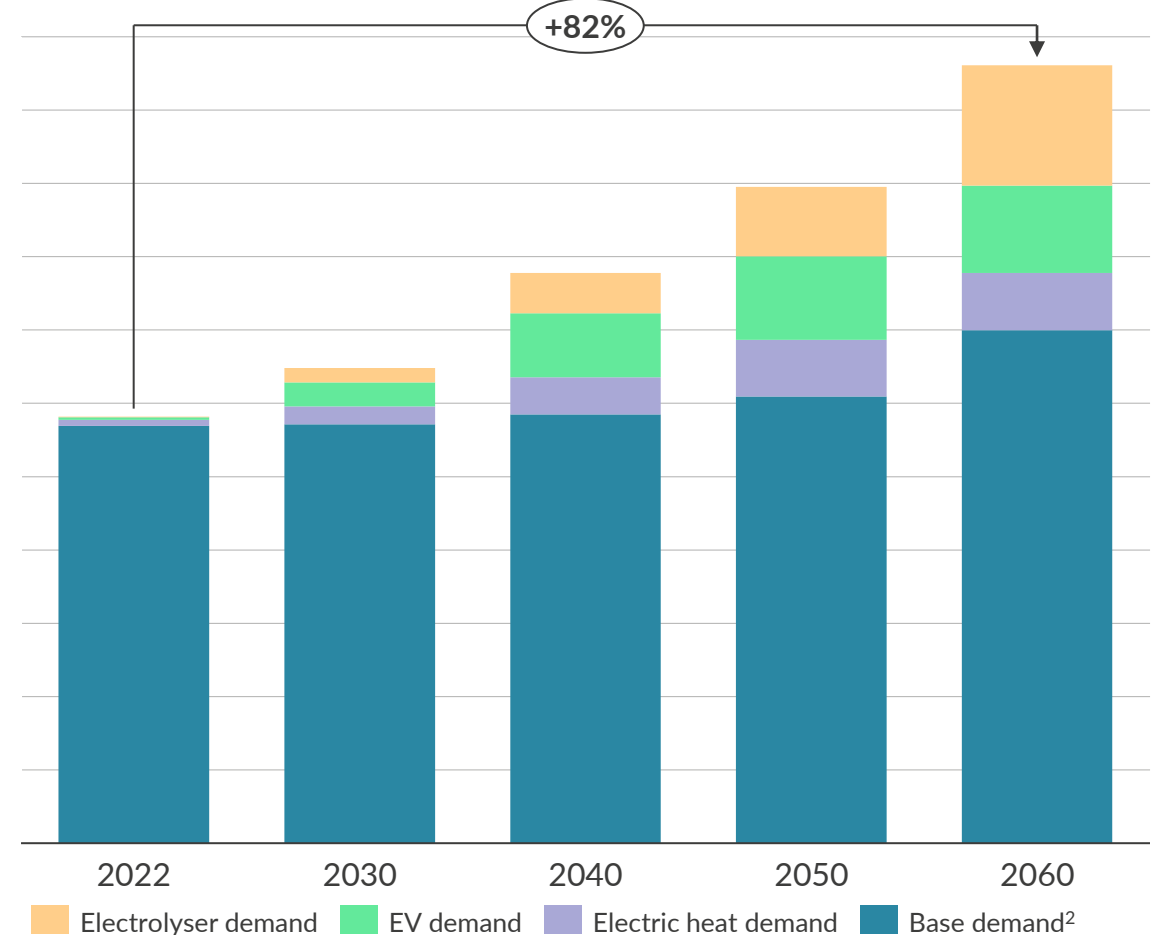
Installed capacity  
GW

1 2



Net annual power demand by type – Central scenario  
TWh

3



1) Total net power demand includes sectoral demand (i.e. industry, commerce, transport and households) as well as transmission losses, but excludes power plant self-consumption and demand from efficiency losses of storage. 2) Underlying base demand excluding heat pumps, EVs and electrolysis.





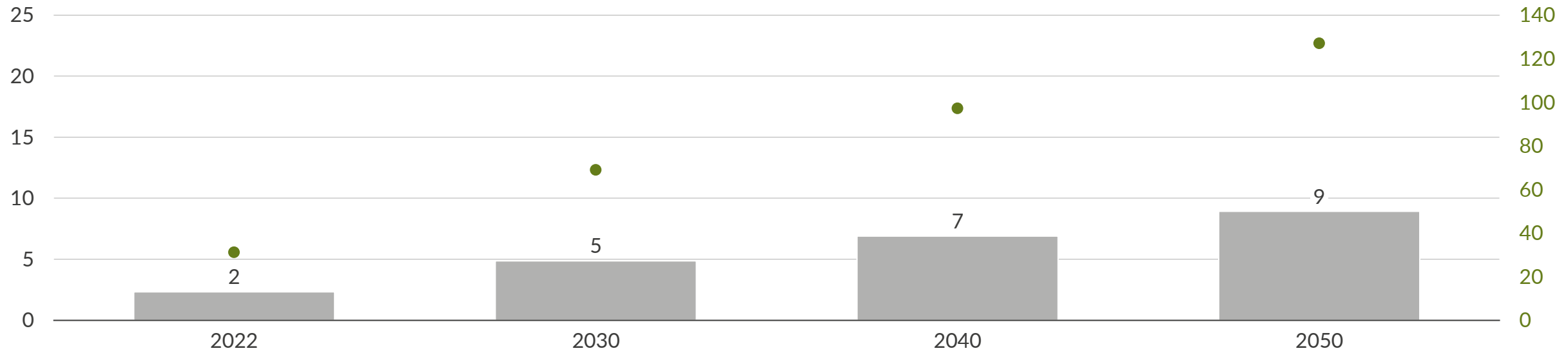
# The increasing share of intermittent renewables leads to a higher need for dispatchable capacity in the system

The increase in intermittent renewables will lead to more sudden changes in output, creating a need for flexible capacities

## Ramping requirements in Germany<sup>2</sup>

average GW/hour

maximum GW/hour



- With increased renewables deployment, more flexibility will be required to tackle increasing imbalances
- This will in turn exacerbate the need for flexibility markets
- Batteries are well suited to provide the needed flexibility

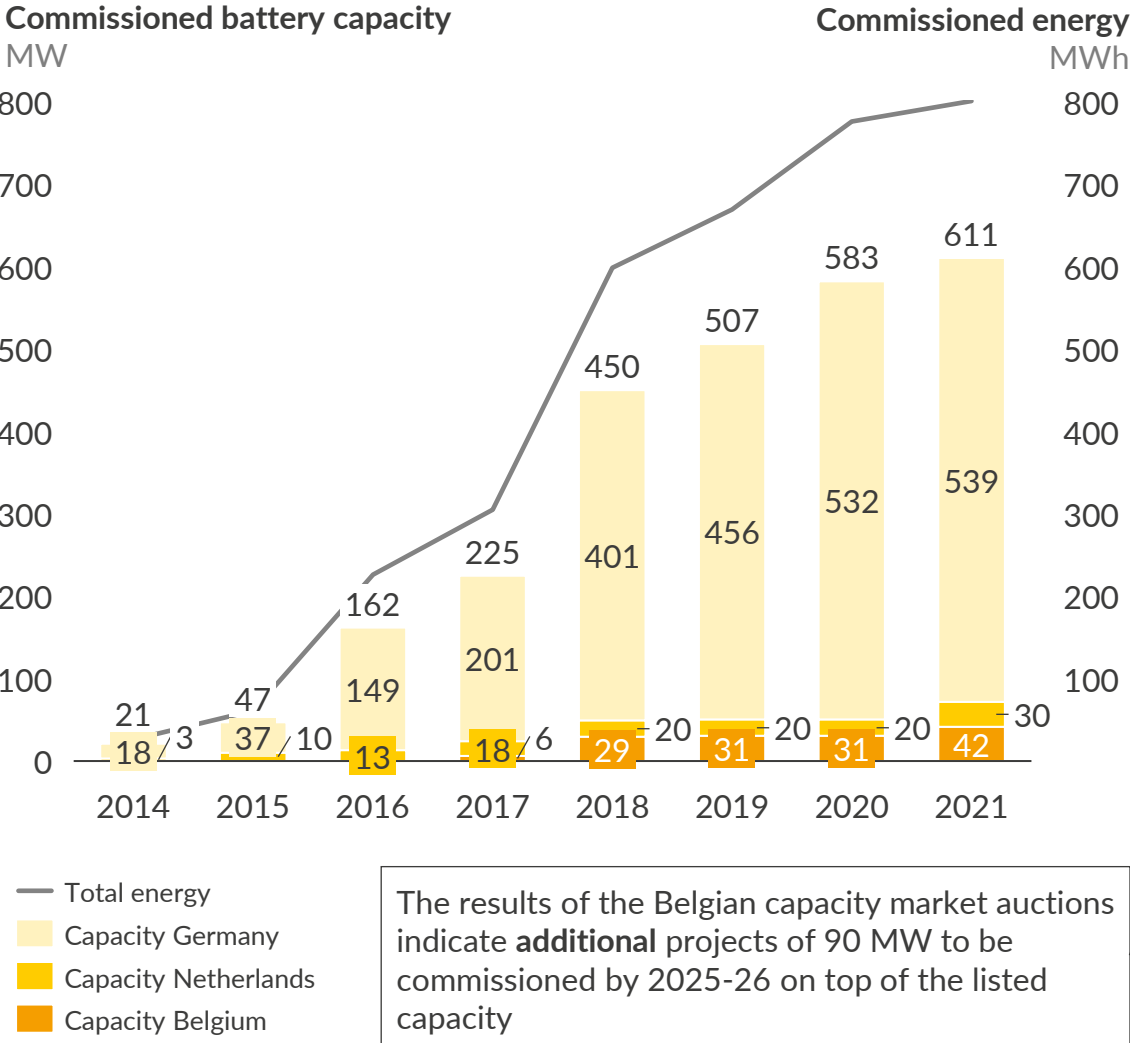
● Maximum ■ Average

For additional information, please contact  
Benjamin La Trobe, Germany Commercial Associate

✉ [benjamin.latrobe@auroraer.com](mailto:benjamin.latrobe@auroraer.com)

1) Aurora April 2022 Central Scenario. 2) Based on the hourly variations difference of non-dispatchable renewable production.

# Battery buildout ramped up strongly in the last 8 years - the project pipeline suggests this trend will continue



Project pipeline expected to go live in 2022/2023

Installation	Capacity (MW)	Energy (MWh)	Owner	Country
Lingen	45	n/a	RWE	DEU
Werne	72	n/a	RWE	DEU
Herdecke	n/a	4.5	RWE	DEU
Wunsiedel	100	200	Siemens <sup>1</sup>	DEU
Freiburg	25	n/a	JT Energy	Freiburg
Saxony	27.6	32	Berenberg	Saxony
Nyrstar's zinc smelting facility Balen	25	100	Nala Renewables	BEL
Wärtsila battery <sup>2</sup>	25	100	n/a	BEL
Ruien Energy Storage	25	100	Yuso	BEL
GIGA Buffalo	25	48	n/a	NLD
unknown	12	7.5	n/a	NLD
Total	>329	>560		

450 MW of grid boosters<sup>3</sup> will be commissioned in the next years and RWE announced severe capacity additions without mentioning single projects. More capacity is expected to be added via the German innovation auctions.

1) Together with Zukunftsenergie Nordostbayern. 2) According to [Battery Industry.tech](#). 3) Grid boosters are battery storages that help to ensure security of supply by relieving the grid.

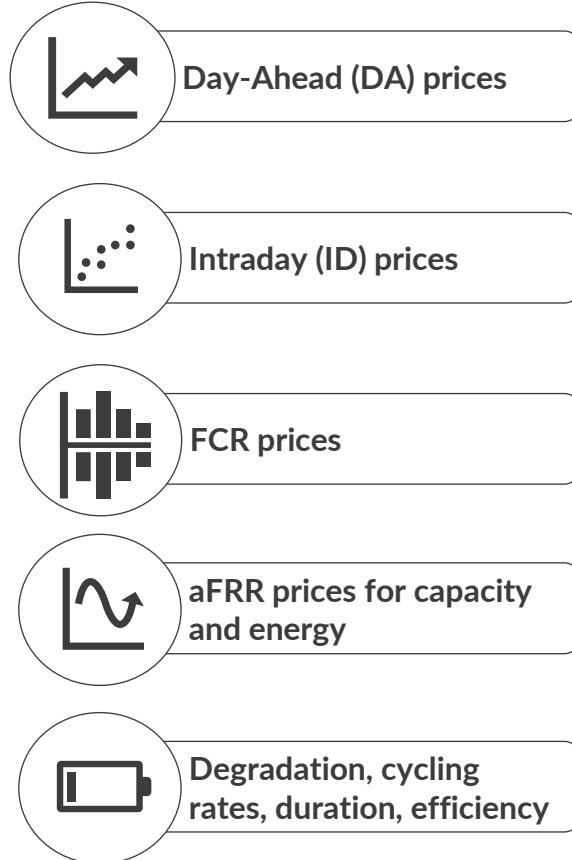
# Agenda

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- I. Why flexibility and batteries are important
- II. Auroras methodology for modelling battery business cases
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# Aurora models battery business cases in two stages based on our in-house market forecasts and imperfect foresight battery dispatch model

## Flexibility markets and battery parameters



## Imperfect foresight battery dispatch model

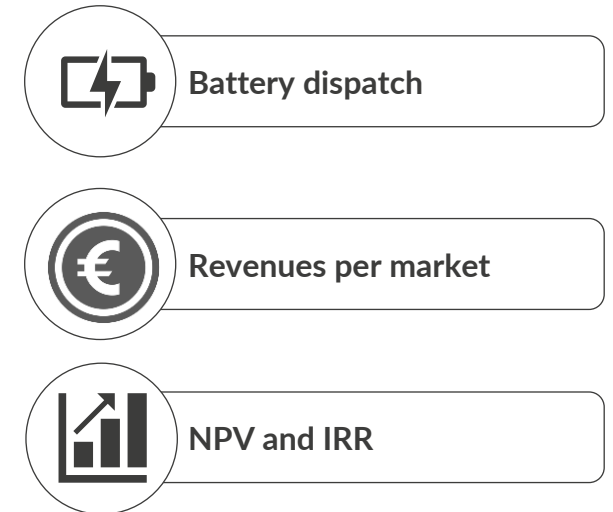
### 1 Optimisation process for day-ahead markets

- Optimisation of markets that take place day-ahead (Day-Ahead, aFRR capacity and FCR markets)
- We assume perfect foresight of two days, but batteries can only take decisions for the next 24h
- The model solves for actions in these markets simultaneously

### 2 Dispatch based on real-time knowledge

- Batteries have limited foresight into Intraday prices (until next committed Day-Ahead trade)<sup>1</sup>
- Battery gains insight into aFRR energy markets in real time
- Based on results of stage 1, battery charges or discharges if within-day market prices are more attractive than planned actions
- Model accounts for upcoming commitments and applies penalties for missed actions

## Results



For more information on our flexibility market offerings, please contact Benjamin La Trobe, Germany Commercial Associate

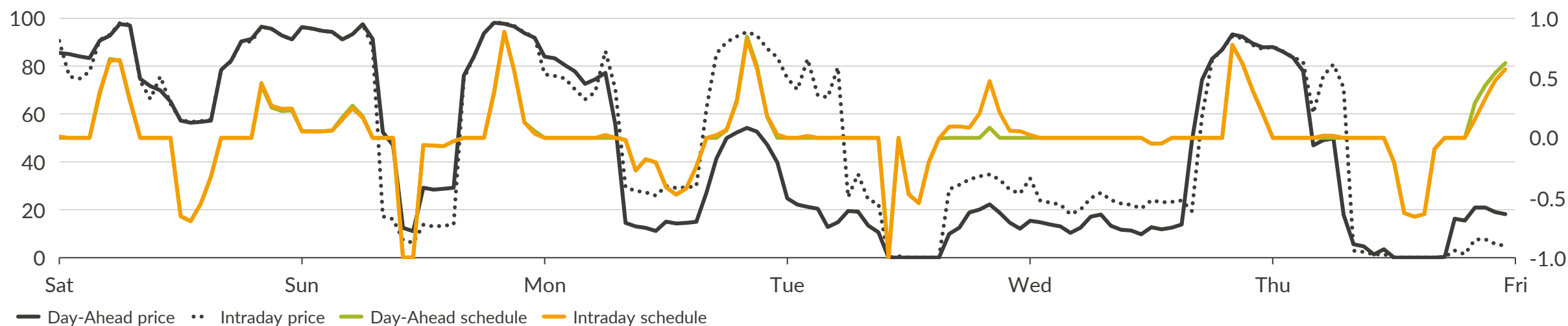
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1) Limited Intraday forecast based on the assumption that battery needs to optimise state of charge with regard to upcoming committed trades, i.e. in the Day-Ahead market.

# Balancing, wholesale and capacity markets are the key sources of revenues for batteries that optimise their dispatch based on prices

Market	Wholesale (Day-Ahead/Intraday)	Primary Reserve (FCR)	Secondary Reserve (aFRR)	Capacity Markets
Description	<ul style="list-style-type: none"> <li>Platform to buy and sell power to meet demand</li> <li>Every hour and is contracted one day before delivery (Day-Ahead) or procured continuously (Intraday)</li> </ul>	<ul style="list-style-type: none"> <li>Measure to secure grid stability</li> <li>Flexibility providers get revenue through capacity payments</li> </ul>	<ul style="list-style-type: none"> <li>Exists to ensure grid stability, gets activated after the FCR</li> <li>Energy will be procured via the European platform PICASSO, TSOs are in charge of procuring capacity</li> </ul>	<ul style="list-style-type: none"> <li>Capacity markets reward capacity to ensure security of supply</li> <li>Batteries are allowed to participate with a derating factor</li> </ul>
Revenue stream	<ul style="list-style-type: none"> <li>Arbitrage</li> </ul>	<ul style="list-style-type: none"> <li>Capacity payment</li> </ul>	<ul style="list-style-type: none"> <li>Capacity and energy payment</li> </ul>	<ul style="list-style-type: none"> <li>Capacity payment</li> </ul>

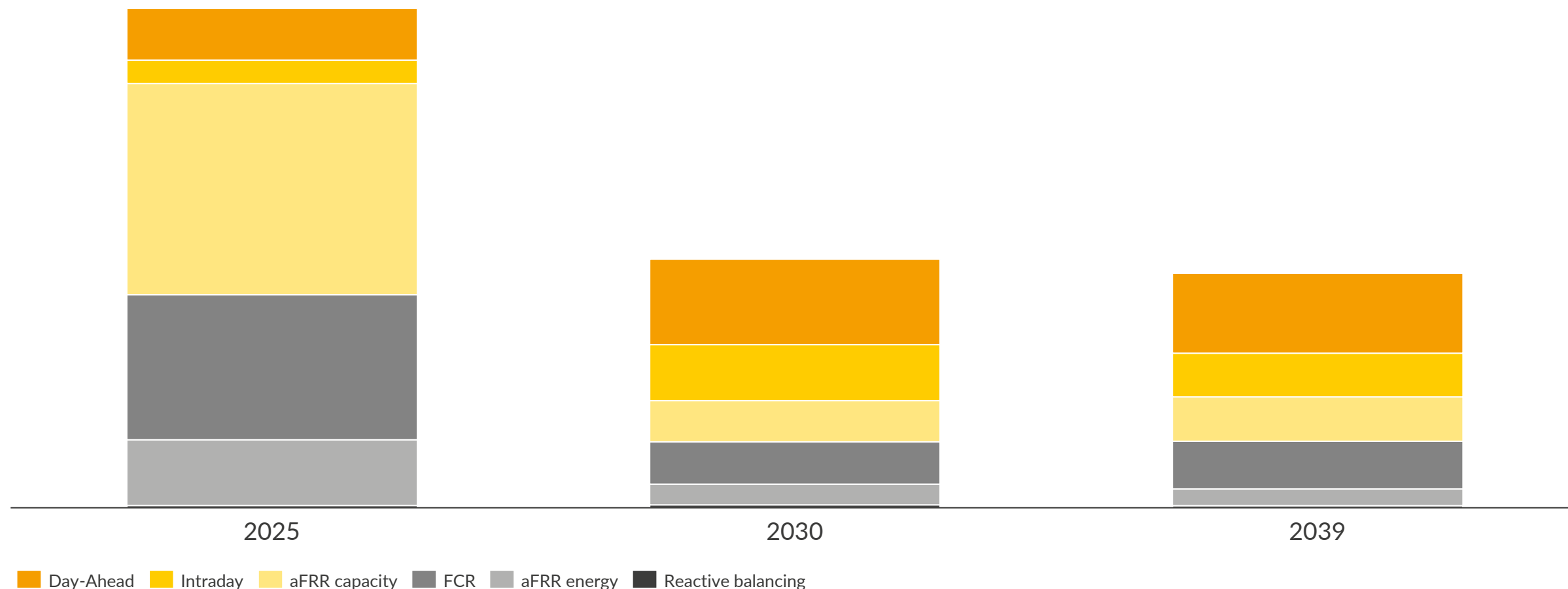
Wholesale price  
EUR/MWh, real 2021



## With capacity-based balancing markets saturating towards 2030, Intraday and Day-Ahead revenues become more important

Revenues of a 2h battery, including degradation

2h battery, 2021 real EUR/kW



1) Assuming 6% WACC, 15y lifetime, 86% efficiency, 2h storage depth and 567 cycles per year.

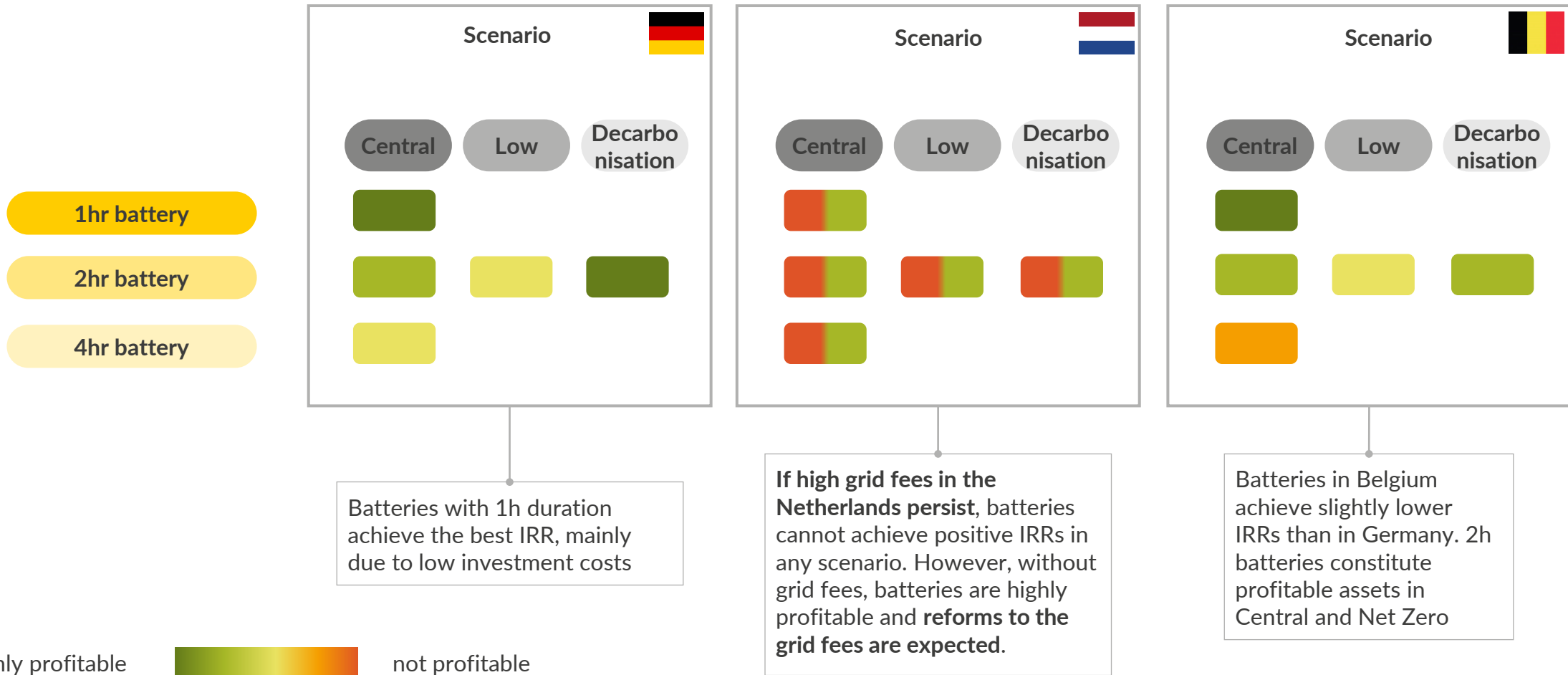
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# Aurora's market forecasts show that batteries are bankable in Germany and Belgium, but depend on changes in grid fees in the Netherlands

Economics for new-build battery entering the market 2025<sup>1</sup>  
real IRR in %



1) Including grid fees.

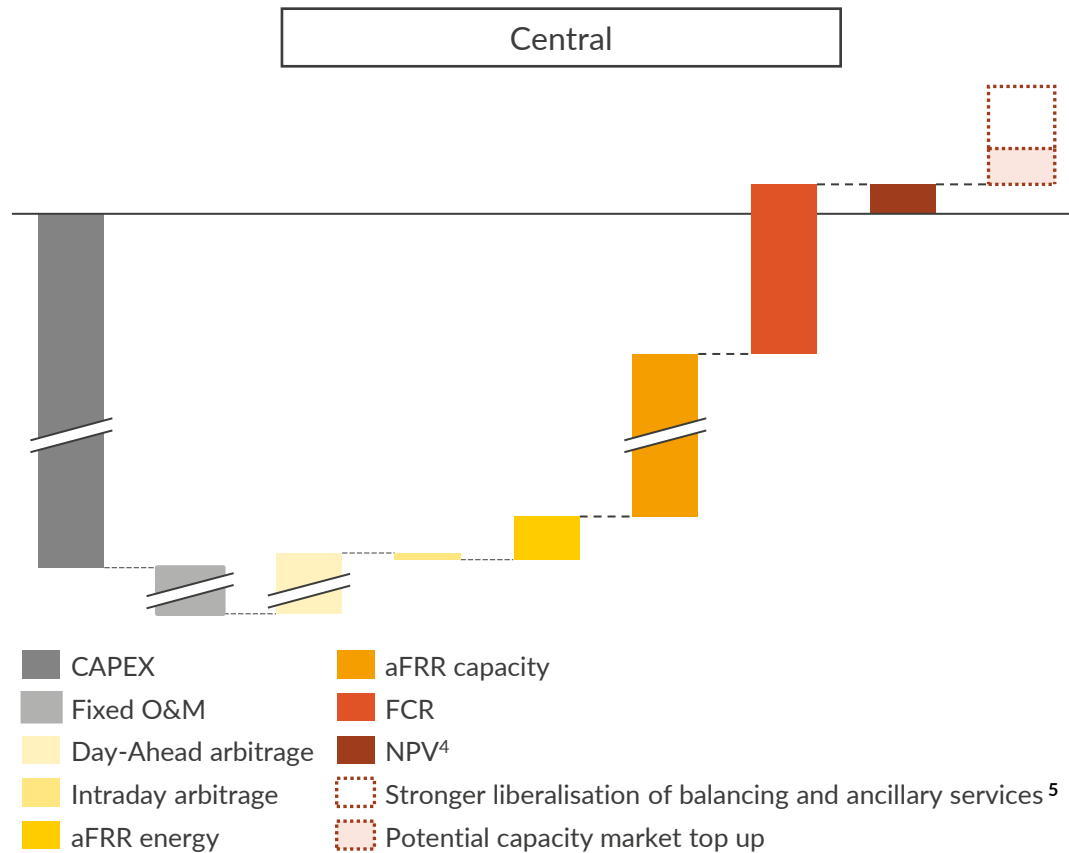




# 2h storage duration batteries are profitable in Aurora Central

Economics for example new-built battery entering 2025 (2h duration, 1 to 2 cycles/day)<sup>1</sup>

Net Present Value EUR/kW, real 2021



NPV<sup>2</sup>

Project IRR<sup>3</sup>

Payback Period

- Only with participating in all possible markets and doing revenue stacking, batteries can recover their investment costs
- Due to high prices on the aFRR capacity and the FCR during the mid 2020s, batteries make most of their profits on these markets
- Several upsides like capacity market payments, locational value or further liberalization of balancing and ancillary services add a premium to the already profitable business case

To learn more about our flexibility market forecasts and analytics, please contact **Benjamin La Trobe, Germany Commercial Associate**

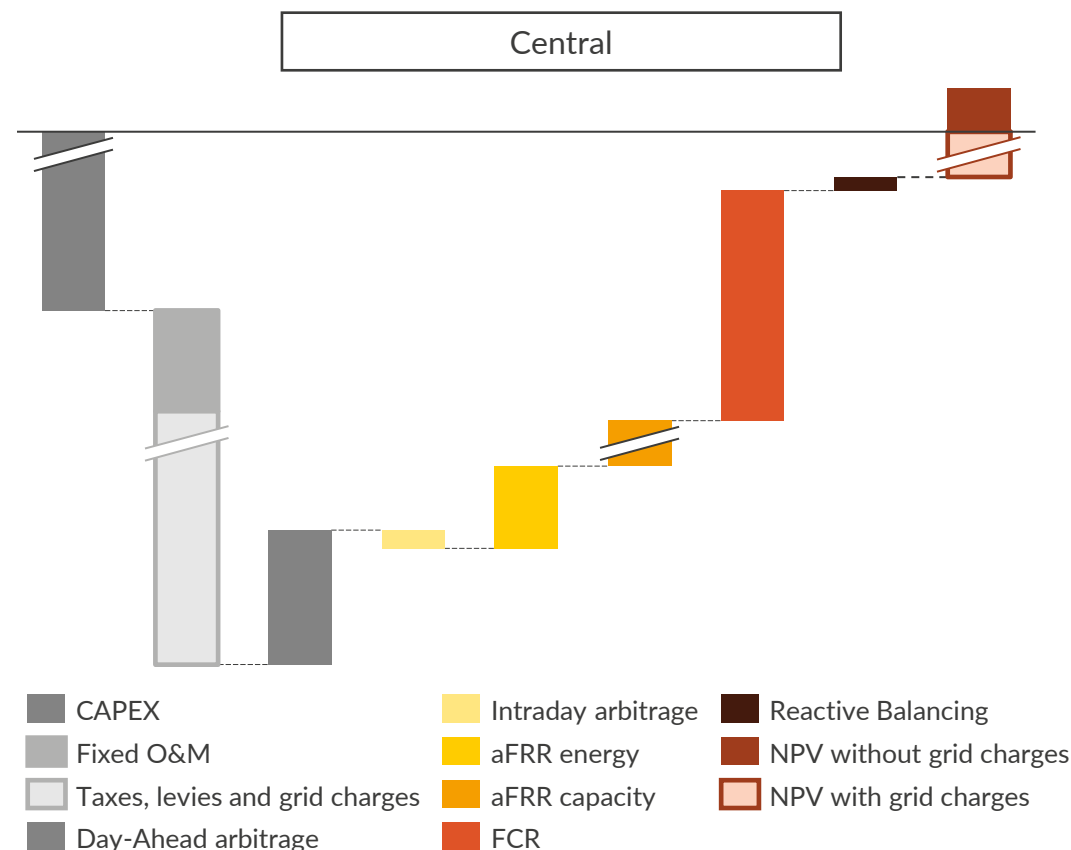
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1) Assuming a lifetime of 15 years or 8,500 cycles. 2) NPV calculated based on discount rate of 9%. 3) IRR in real terms, i.e. to be adjusted for inflation. 4) Due to recent changes in the Energy Industry Act, battery storage is freed from levies, fees and taxes.

5) E.g. market based congestion management

# Batteries can make a positive business case through market segment optimisation, but high grid fees can turn an investment NPV-negative

Economics for average new-build battery entering 2025 (2h duration, 1 to 2 cycles/day)<sup>1</sup>  
Net Present Value EUR/kW, real 2021



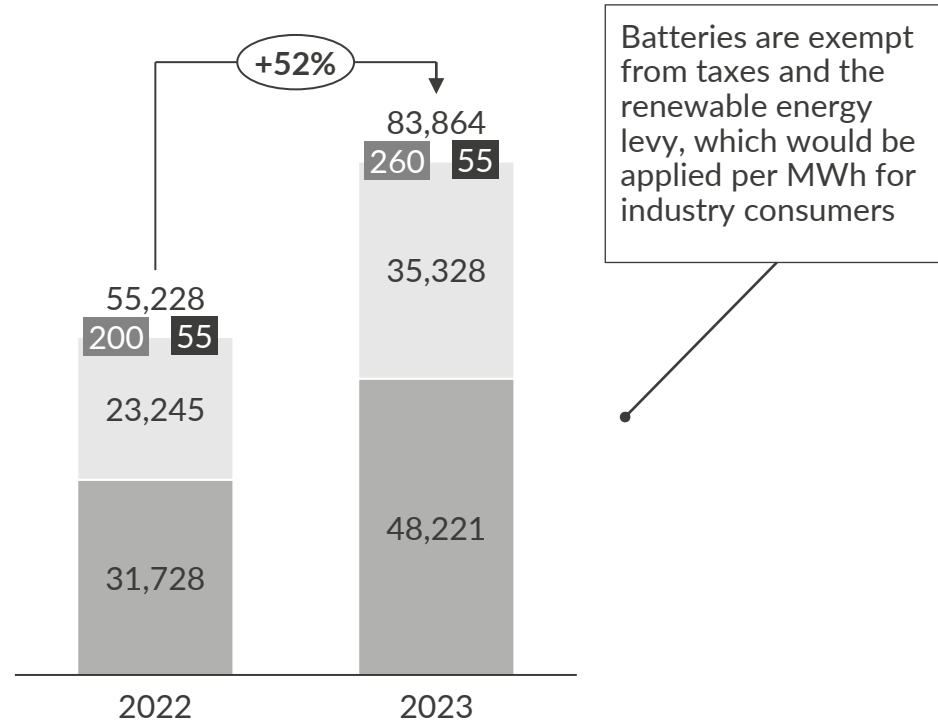
	NPV <sup>2</sup>	Project IRR <sup>3</sup>	Payback Period
Without grid fees			
With grid fees			

- Under the current high grid fee regime for batteries, investment in the Netherlands is not profitable due to the current regulatory framework, despite multiple additional revenue streams available in the Netherlands, such as
  - Locational value via GOPACS
  - Reactive balancing
- Reforms to the height and way grid fees are applied are expected, which would lead investment to be profitable

1) Assuming a lifetime of 15 years or 8500 cycles. 2) NPV calculated based on discount rate of 9%, without grid fees. 3) IRR in real terms, i.e. to be adjusted for inflation. 4) Batteries in the Netherlands pay a fixed grid fee per MW installed and MW peak load per month.

# To finance investments in the grid, grid fees increase from 55k EUR/MW to 84k EUR/MW in 2023

Total grid fees on a per MW basis  
EUR



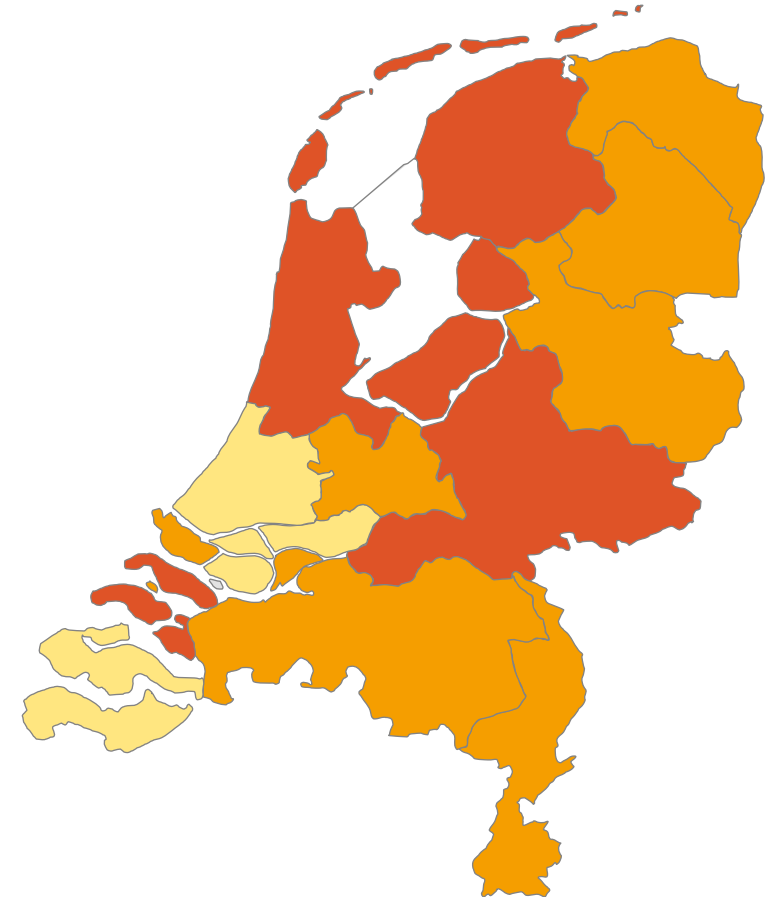
Batteries are exempt from taxes and the renewable energy levy, which would be applied per MWh for industry consumers

Total annual cost for typical<sup>1</sup> battery: 4,193,000 EUR/a

Fixed pay per connection for the typical battery (monthly)
  Per MW installed  
 Fixed pay per connection for the typical battery (yearly)
  Per MW contracted

1) For the typical battery with 50 MW, 4-hour storage, 1.5 cycles per day and total energy consumption of 109.5 GWh per year.

The Dutch Grid is heavily congested  
Congestion for injecting in the Dutch grid

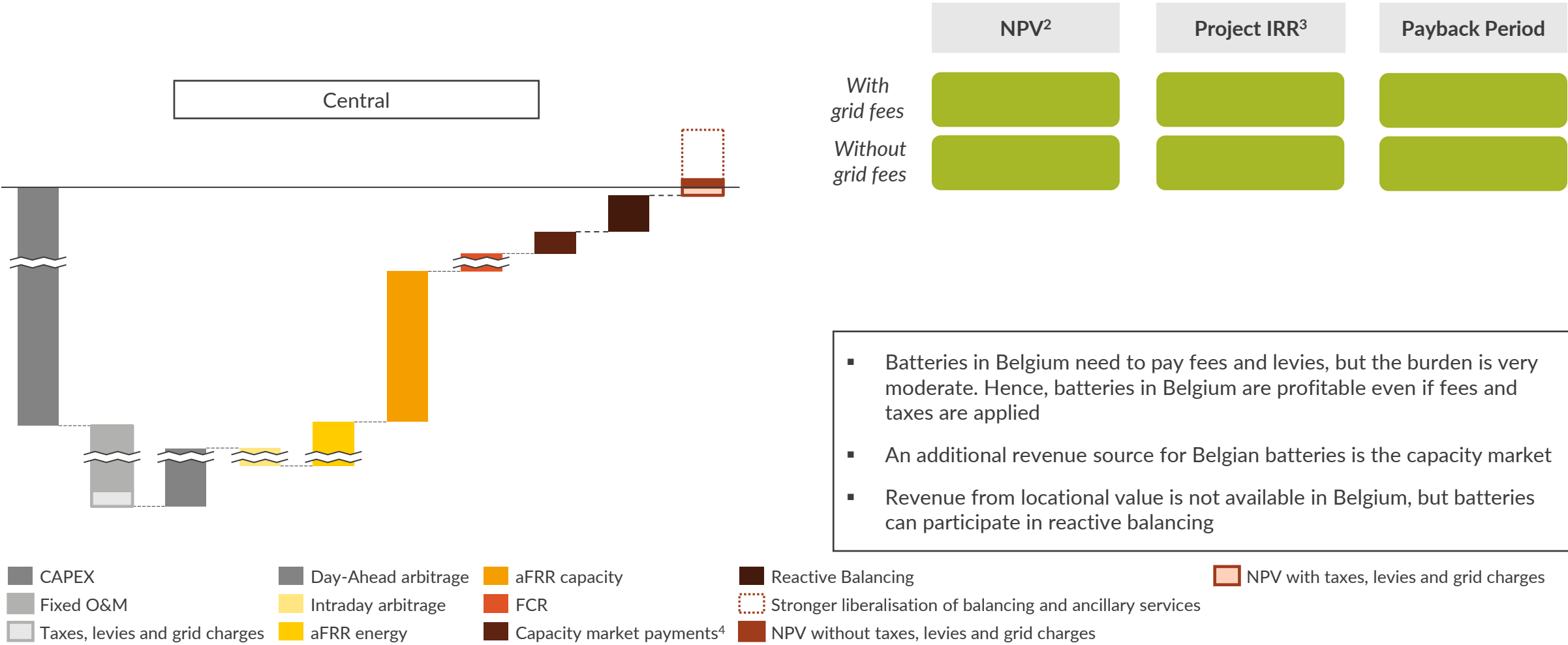


heavy congestion
  moderate congestion
  low congestion



# Batteries can be profitable through market segment optimisation in Belgium

Economics for average new-build battery entering 2025 (2h duration, 1 to 2 cycles/day)<sup>1</sup>  
Net Present Value EUR/kW, real 2021



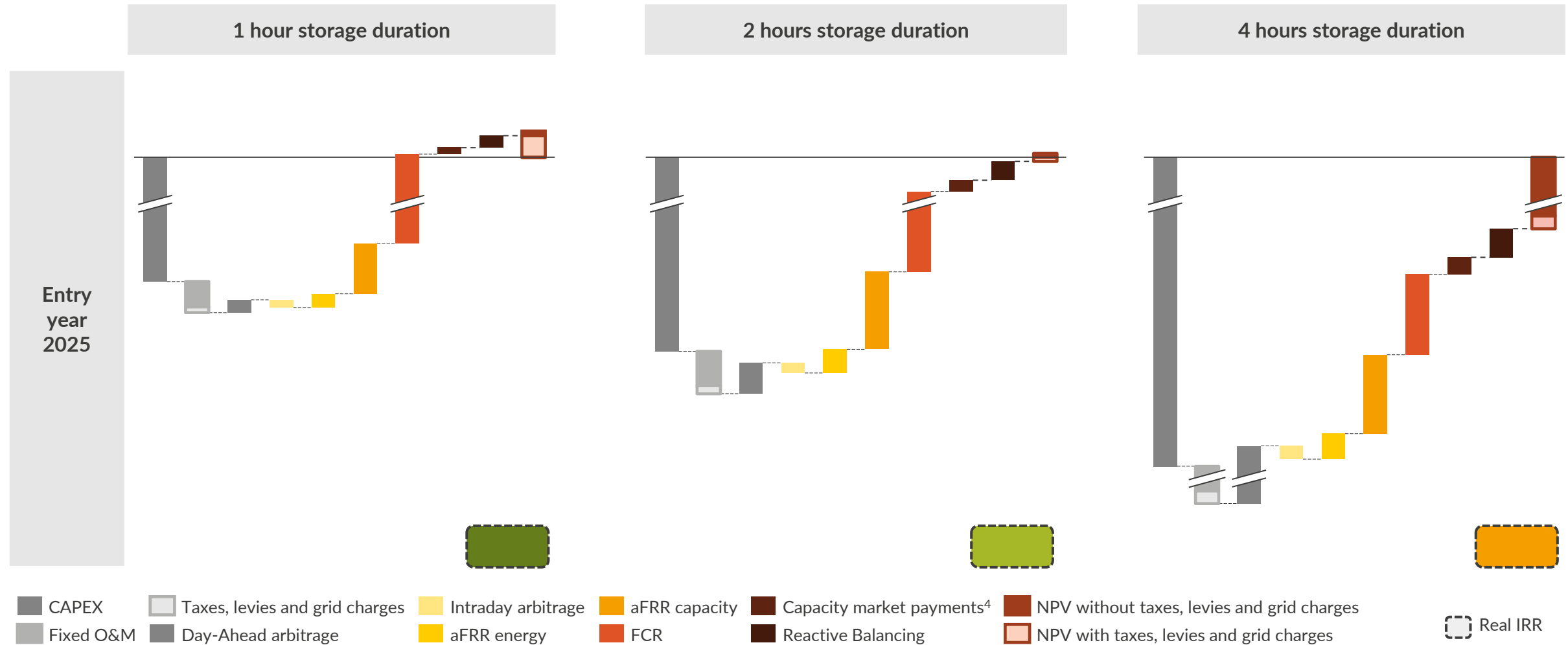
1) Assuming a lifetime of 15 years or 8500 cycles. 2) NPV calculated based on discount rate of 9%. 3) IRR in real terms, i.e. to be adjusted for inflation. 4) Taxes, levies and grid charges are applied per MWh charged. 4) Payback obligation in hours with prices higher than 300 EUR/MWh is not included.



# Batteries with 1 hour storage achieve most revenues due to moderate investment costs and high FCR and aFRR capacity prices

Economics for new-build battery entering 2025 in Aurora Central

Net Present Value<sup>1</sup> EUR/kW (real 2021)



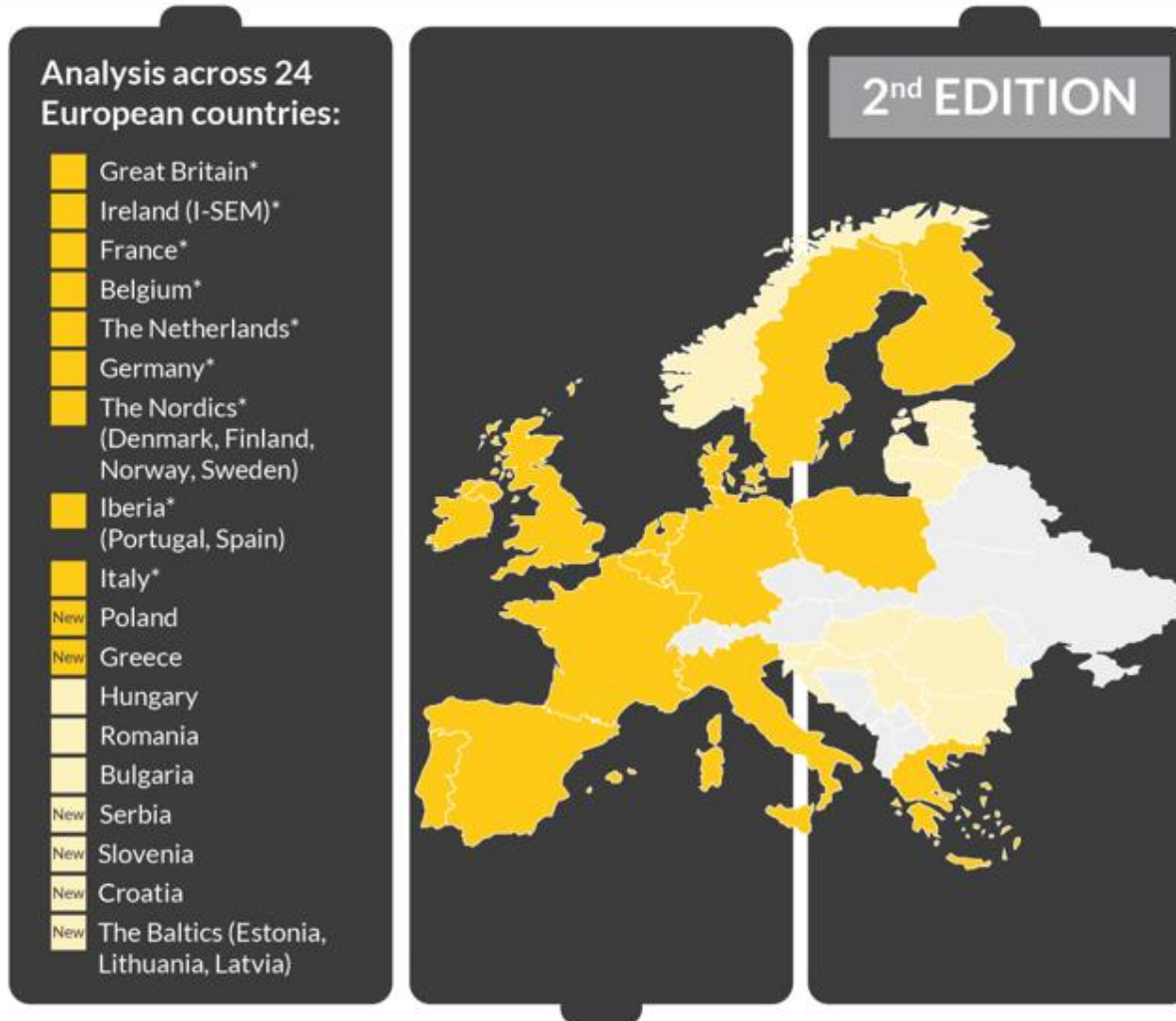
1) Assumed discount rate of 9% for all cash flows and a lifetime of 15 years or 8500 cycles. 2) Payback obligation in hours with prices higher than 300 EUR/MWh is not included.

1. Carbon-free flexibility will be crucial for tomorrow's power system, especially as demand rises and supply becomes increasingly renewable and more intermittent. Batteries can provide the flexibility needed.
2. The flexibility provided by batteries is needed, but to be profitable, batteries need to participate in all markets available and choose on a quarter-hourly basis in which market they should participate to maximise their profits (market segment optimisation).
3. Due to favourable regulation, Germany and Belgium are very attractive markets to invest in batteries. While investments in these markets are already profitable today, additional revenue streams like a capacity market or locational value might add a premium on top of the already profitable business cases.
4. In the Netherlands, grid fees are the major roadblock to batteries' profitability. If the current regulation prevails, batteries will not be profitable. However, the Authority for Consumers and Markets is already aware of the problem. Given the high congestion of the Dutch grid and batteries' potential to help solve this issue, it is likely that grid fees will be reformed.
5. Currently, shorter duration batteries are more profitable as increased investment costs severely affect longer storage duration batteries.

# European Battery Markets Attractiveness Report:

## Discover your next business move in Europe with this comprehensive report

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With over 100 analysts and modellers working across our European Flexibility Energy Market Services, this report provides you with an amalgamation of our credible, reliable, and bankable forecasts.

- European Battery Market Trends – Market Size and Opportunity
  - Installed capacity, battery investment trends, and near-term pipeline
  - Forecast volumes for battery deployment by year and country
- Policy and Regulatory Environment analysis
  - European and national battery strategies, targets and plans
  - Analysis of anticipated regulatory changes impacting battery markets
  - Assessment of policy risks including aggregation of demand side assets, and grid connection
- Battery Storage Business Models and Value Drivers
  - Summary of attainable markets and revenue stacking opportunities
  - Comparison of value drivers across markets including RES penetration and daily wholesale market spreads, balancing services and capacity market auctions
  - Assessment of saturation risk for each country
- Battery Economics and Business Cases. See above plus:
  - Revenue stacking opportunities and gross margins (1, 2 and 4 hours)
  - Investment cases (estimated IRRs) for hybrid business models (optimised between energy arbitrage and ancillary services)

Access this report for:

### New features:

- 6 new regions covered
- Business cases for 2 new markets: Greece and Poland
- Updated BESS cost projections
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# Access detailed power market analysis and investment case data for batteries with our German, Dutch and Belgian **Flexible Energy Market Services**

## Flexible Energy Market Services

### Forecast Reports & Data



#### Technology and Market Development Reports

- Overview of regulatory framework for batteries
- Revenue stacking models for batteries
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#### Forecast Data

- Central case forecast prices provided at hourly granularity until 2050:
  - Wholesale power prices
  - Balancing market prices
  - Intraday, FCR and aFRR market prices

### Investment Cases



#### Standalone battery

- Multiple investment cases per country or zone including:
  - Arbitrage of wholesale market and balancing market
  - Focused participation in frequency control market (if applicable)
- Annual project margins to 2050; IRR and NPV for multiple entry years

Discuss how our Flexible Energy Market Service can help your business with **Benjamin La Trobe, Germany Commercial Associate**

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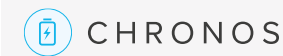
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Putting Aurora's power market model into your hands



Quantifying the true value of your wind project in minutes



The leading battery analytics software



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