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European BESS market: Revenue outlook trends and implications for financing

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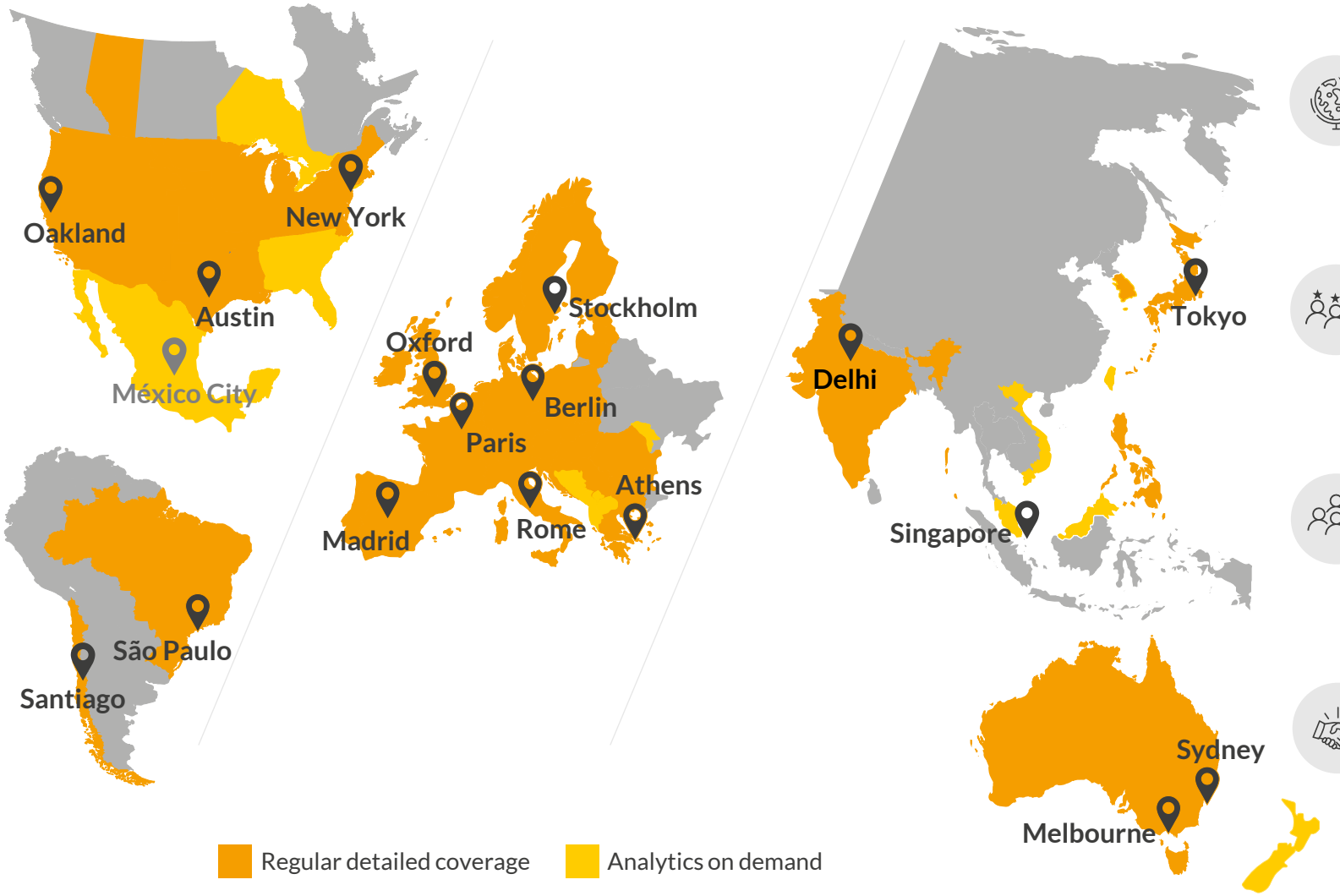


17 offices

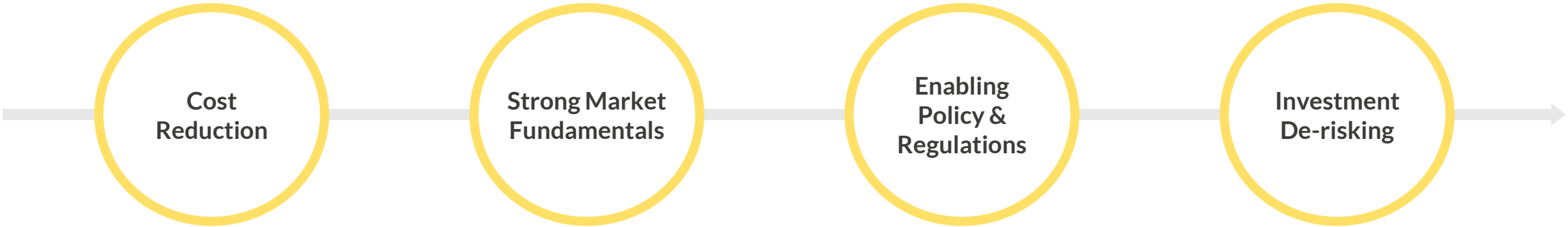
900+ market experts

950+ subscribing companies

150+ transactions supported in 2024

Source: Aurora Energy Research

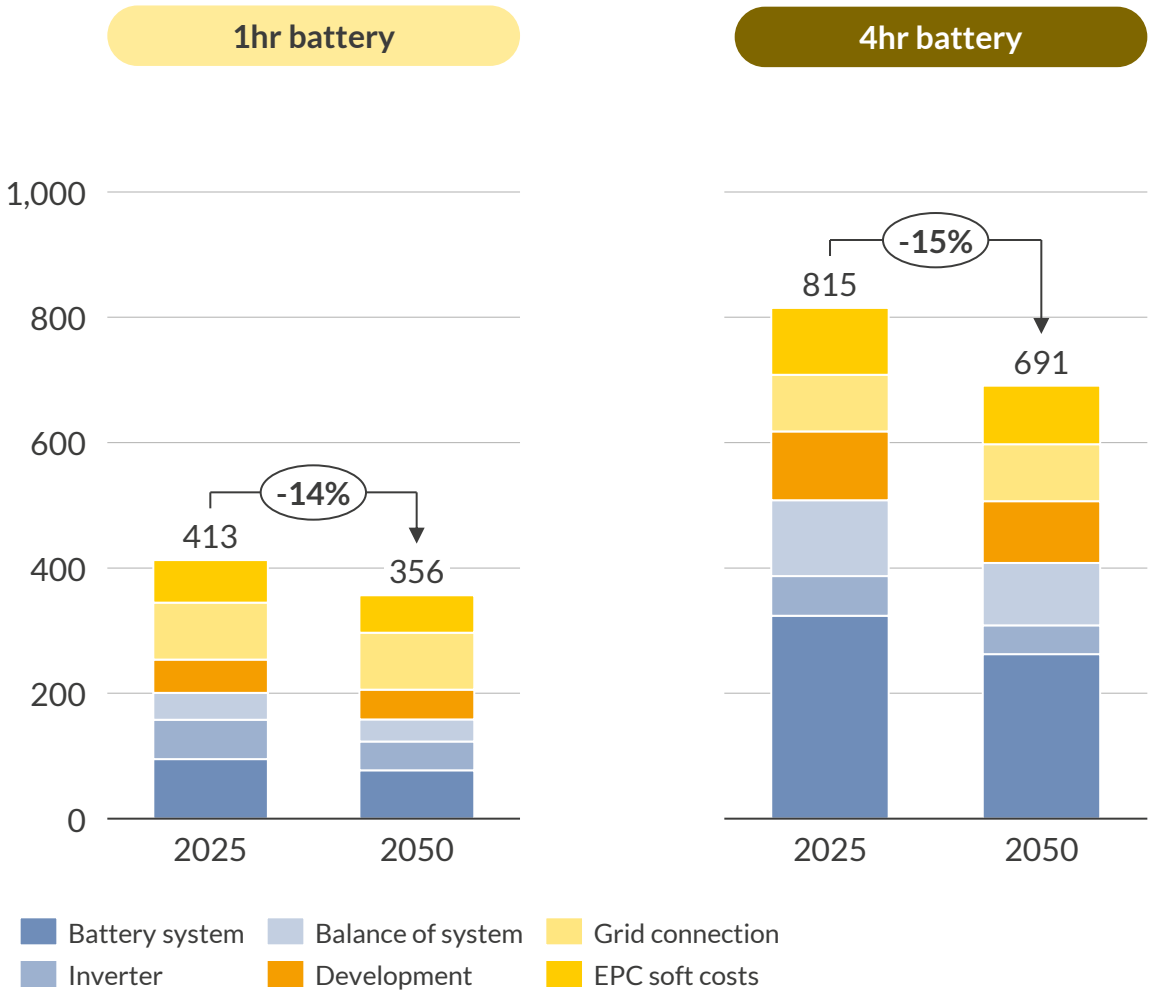
Advancing toward grid-scale BESS market maturity will require overcoming several key challenges



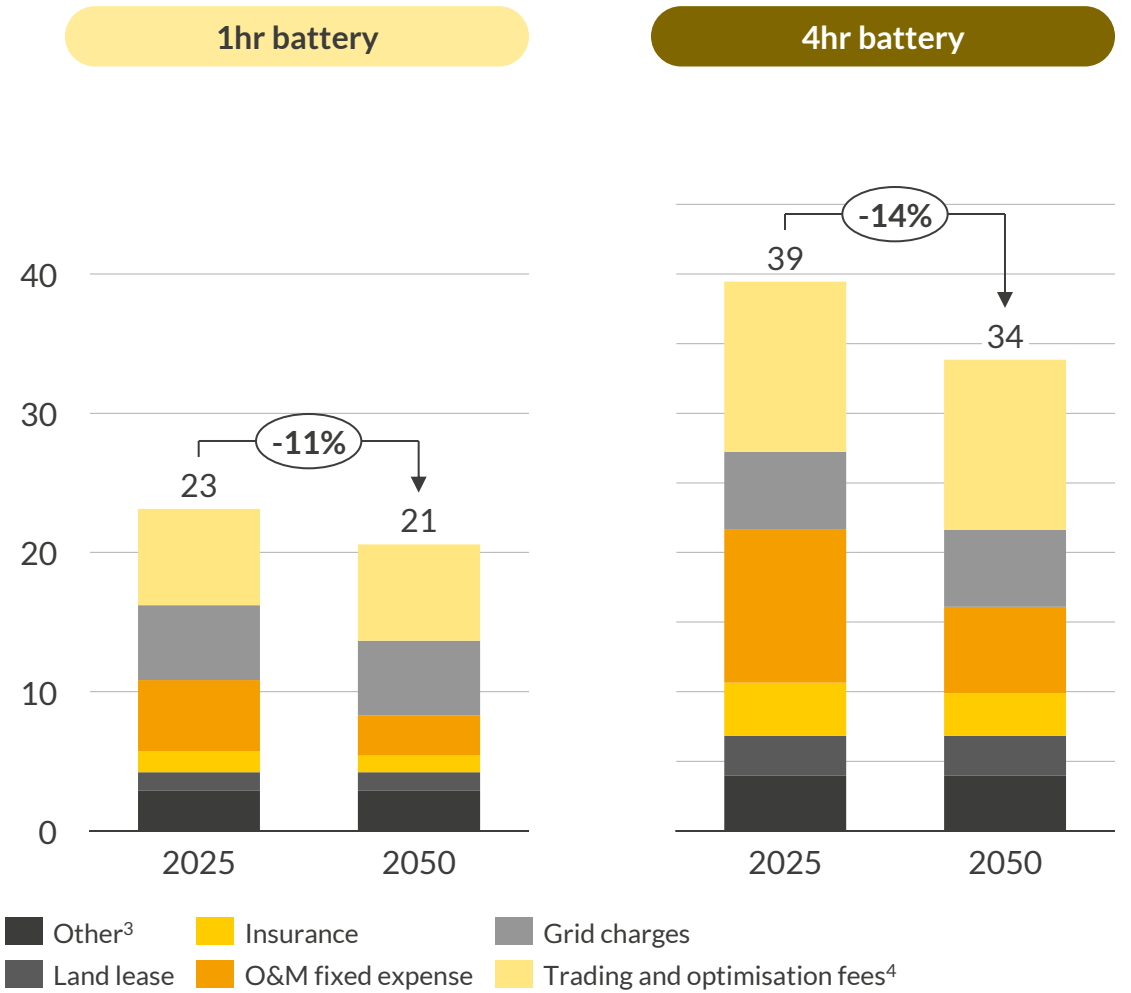
Source: Aurora Energy Research

CAPEX drops by 14–15% by 2050 due to technological progress and scale; efficiency gains and market competition drive OPEX declines of 11–14%

BESS CAPEX, by duration[1]
€/kW, real 2024



Fixed costs breakdown by duration[2]—Central assumption
€/kW/year, real 2024

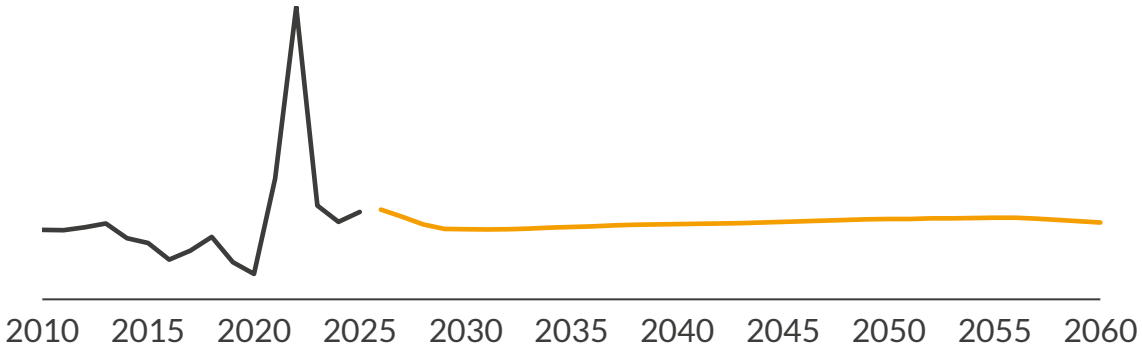


1) Representative average grid-scale stationary battery cost for a 50MW size for Europe; 2) OPEX shown exclude property taxes. The reason is that we calculate pre-tax IRR for better comparability across markets; 3) Includes auxiliary loads, admin charges, communications and other small costs; 4) Trading and optimisation fees may have both fixed and variable elements but are represented here as a single fixed charge.

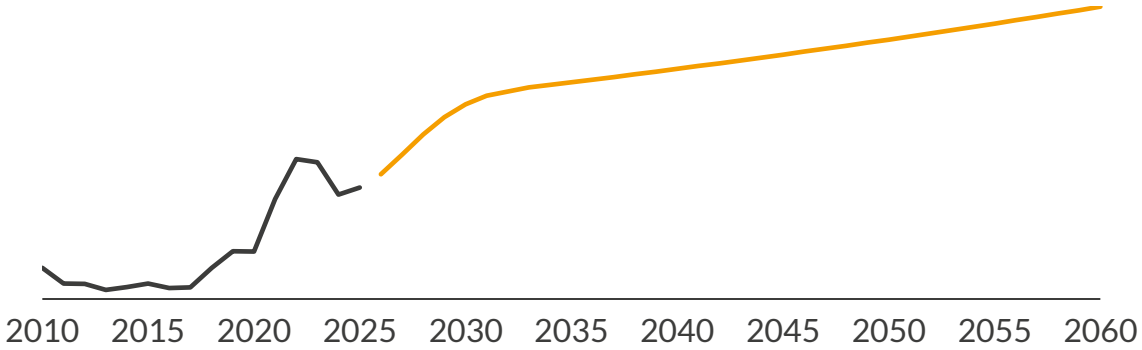
Source: Aurora Energy Research

Gas prices rise over the forecast period due to increasing Asian demand and limited LNG export buildout after 2030; EU ETS prices climb due to stricter emissions targets

Gas prices
€/MWh (real 2024)[1]



Carbon prices
€/tCO_2 (real 2024)[1]



Historical Q4 2025 Central

Key trends in commodity price forecast:

- **Short term (2026-2028)**
  - **Gas prices** average in the high 30s €/MWh, lower than the previous forecast due to additional US and Qatari LNG liquefaction capacity and subdued European demand due to weak economic recovery
  - **Carbon prices** around 90 €/tCO_2 during this period

- **Mid to long term (2029-2060)**
  - **Gas prices** average in the mid 30s €/MWh. Gas prices gradually rise over the forecast, as European production declines and Asian demand surges, increasing competition for LNG
  - **Carbon prices** average about 150 €/tCO_2 in this period, and rise to over 180 €/tCO_2 by 2060, reflecting increased abatement costs in the industry sector while policy ambition remains high

Role of commodity prices

Commodity prices are important drivers of wholesale prices and capacity buildout. In the short and mid-term, fossil fuel prices indicate the upper threshold for electricity prices, as price setting plants mainly run on gas.

1) For years 2025-2028, the prices shown consider current futures prices for the years in question, with declining weights. In 2025, forecast prices include historical prices up to Feb-25. 2) Futures on trading days between 03/02/2025 and 28/02/2025. For gas, THE historical and futures prices are shown.
Sources: Aurora Energy Research, EEX, CME

There has been an increasing trend in negative prices lately; frequency is expected to drop by 2035 driven by increased demand and system flexibility

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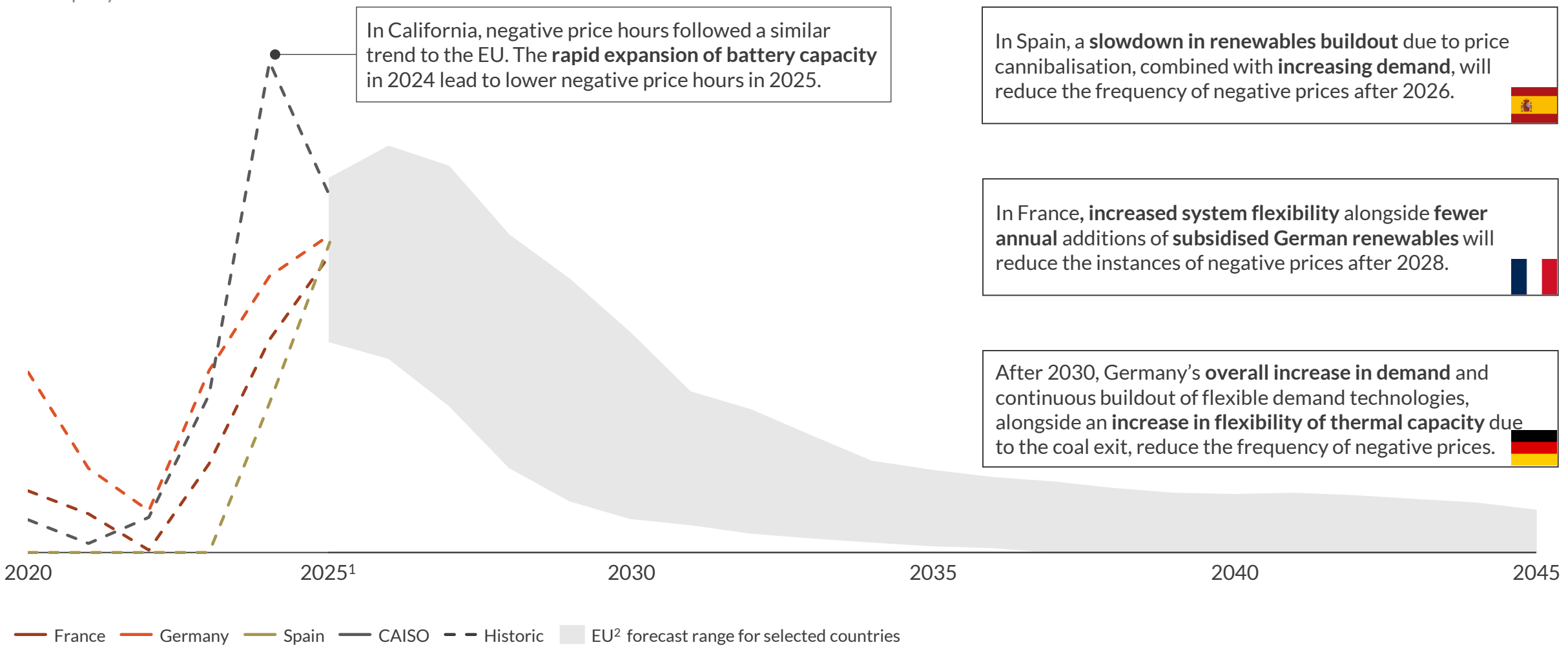
Number of instances with negative Day-Ahead prices per year [1,2]

Hours per year



In California, negative price hours followed a similar trend to the EU. The **rapid expansion of battery capacity** in 2024 lead to lower negative price hours in 2025.

In Spain, a **slowdown in renewables buildout** due to price cannibalisation, combined with **increasing demand**, will reduce the frequency of negative prices after 2026.

In France**, increased system flexibility** alongside **fewer annual** additions of **subsidised German renewables** will reduce the instances of negative prices after 2028.

After 2030, Germany's **overall increase in demand** and continuous buildout of flexible demand technologies, alongside an **increase in flexibility of thermal capacity** due to the coal exit, reduce the frequency of negative prices.

1) Historic Day-ahead prices up to 09/09/2025, Data extracted from ENTSO-E and CAISO on the 01/10/2025; 2) The range includes Belgium, France, Germany, Netherlands, Poland and Spain.

Sources: Aurora Energy Research, RTE

Recent growth in negative prices is a symptom of insufficient flexibility, creating significant opportunities for BESS

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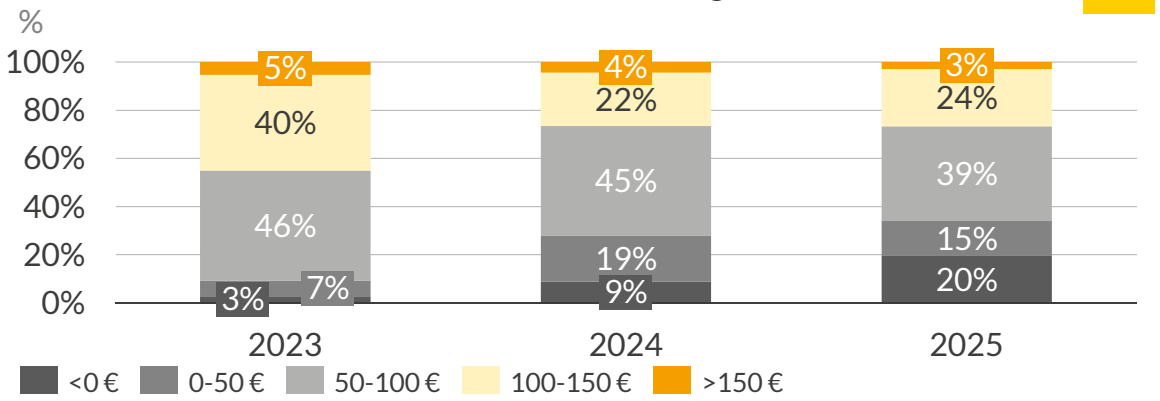
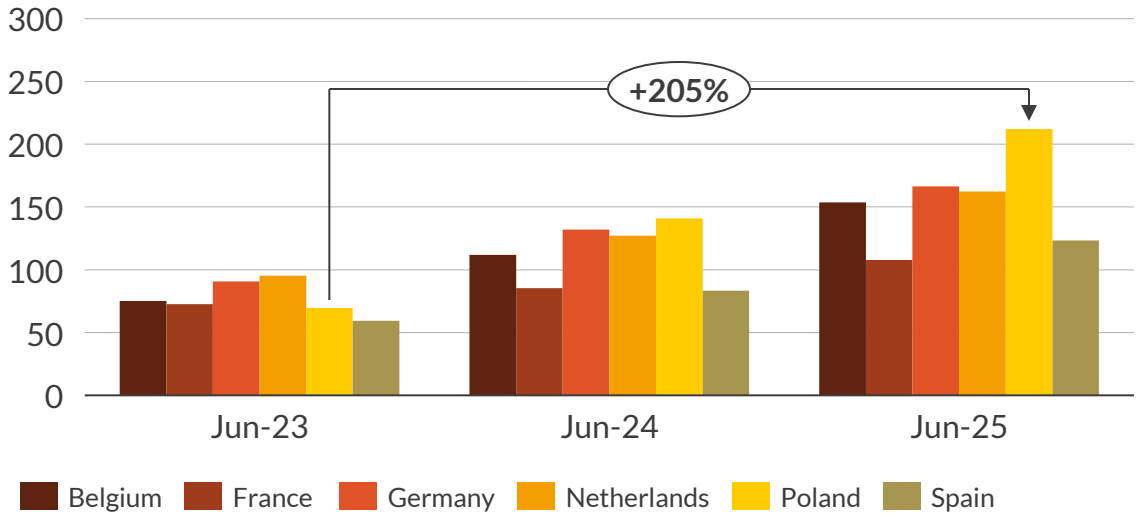
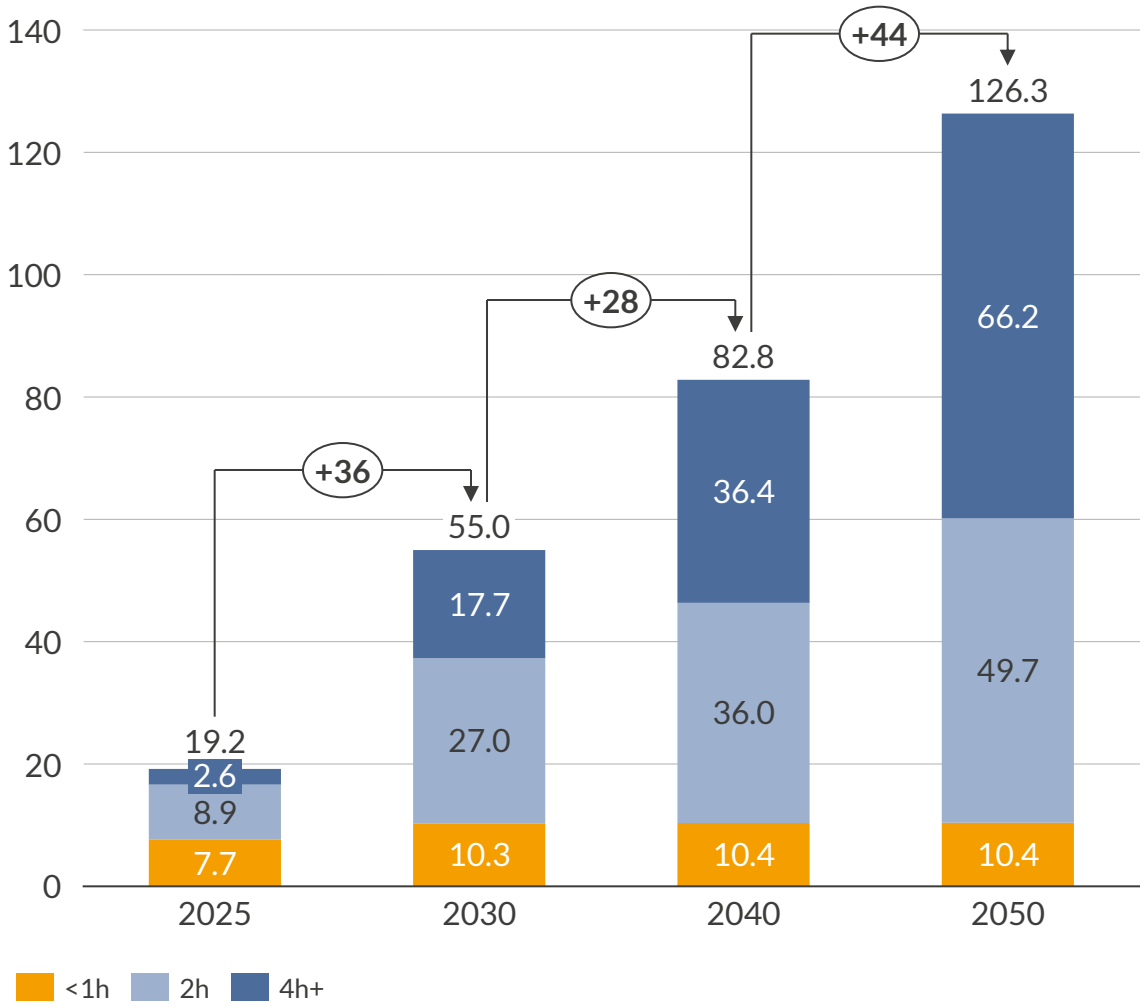
Frequency distribution of electricity prices during June in Germany[1]



Average hourly daily spread[2] in the Day-Ahead market[3]



Installed grid-scale battery capacity in Europe (Aurora Central scenario)

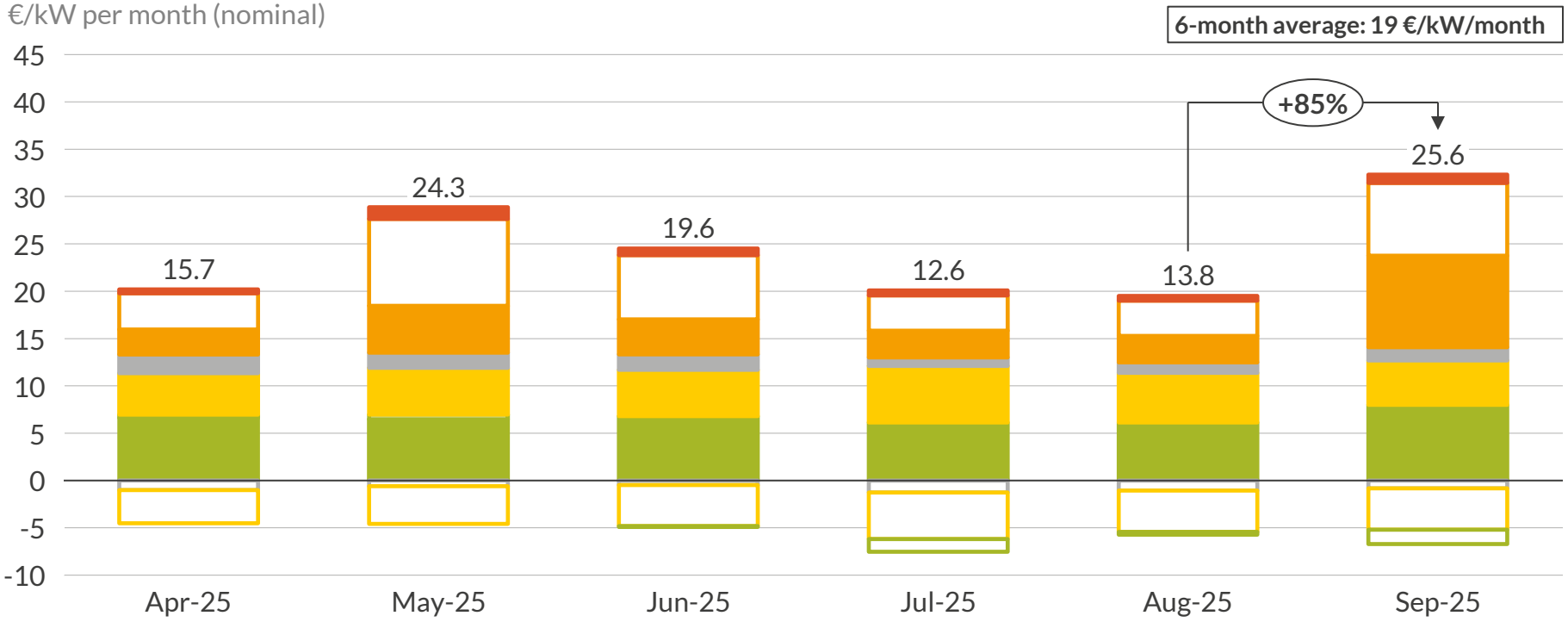


1) Based on Day-Ahead prices; 2) Largest price difference observed in a single day; 3) Data extracted from ENTSO-E on the 19/08/2025.

Sources: Aurora Energy Research, ENTSO-E

2h batteries earned 25.6 €/kW in September, the highest in over a year, mainly driven by gains in the aFRR capacity market

Revenues and costs - 2h Battery Benchmark
€/kW per month (nominal)



Annualised revenues, €/kW (nominal)

Apr-25	May-25	Jun-25	Jul-25	Aug-25	Sep-25
191	286	239	148	163	312

Average achieved cycles per day

Apr-25	May-25	Jun-25	Jul-25	Aug-25	Sep-25
1.50	1.47	1.50	1.50	1.50	1.36

FCR | aFRR capacity up revenue | aFRR energy discharge | Intraday discharge | Day-Ahead discharge
aFRR capacity down revenue | aFRR energy charge | Intraday charge | Day-Ahead charge

Sources: Aurora Energy Research

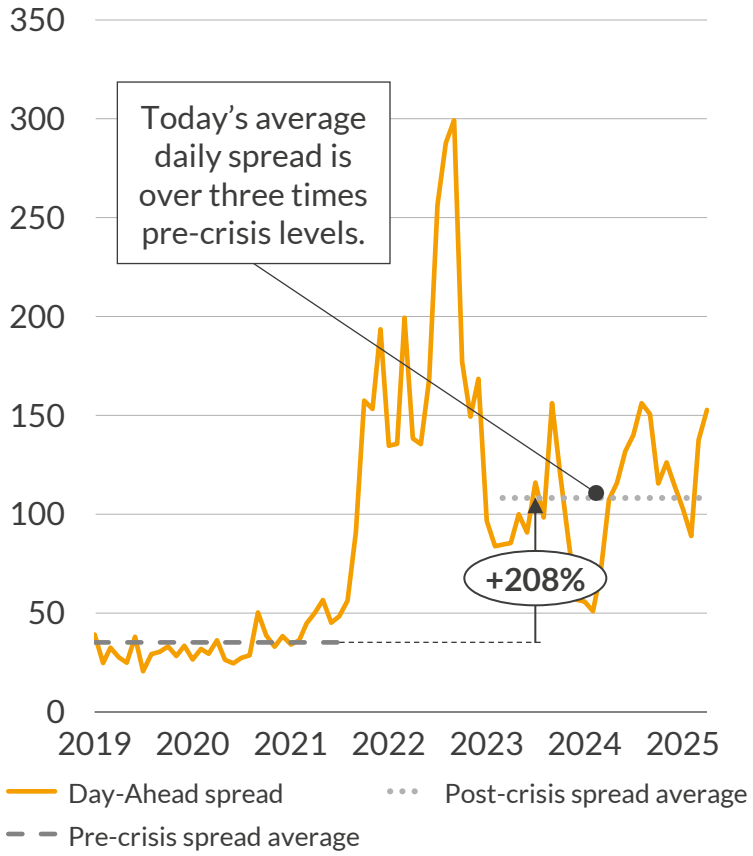
Comments

- In September, a 2h battery would have achieved 25.6€/kW margins, with 3% of the net earnings coming from the FCR market, 68% from the aFRR capacity market, and the remaining 29% from energy trading.
- Compared to August, margins increased by 85%, driven mostly by increased aFRR capacity market opportunities.
- The increase in aFRR capacity prices was driven by strong onshore wind generation, which reduced thermal commitment and tightened available capacity. This also caused a rise in activation costs as fewer units remained online to provide balancing energy.

Despite their high profitability today, revenue uncertainty and high merchant exposure are challenges for BESS financing

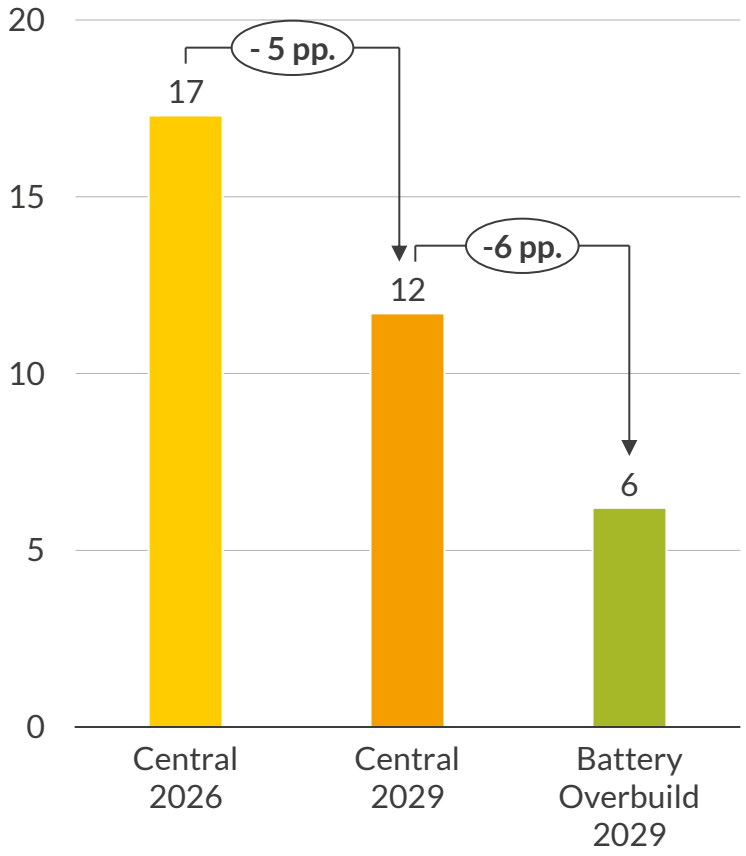
1 BESS market conditions are very attractive today as wholesale spreads are high.

Historical Day-Ahead average daily spread
€/MWh (nominal)



2 Ancillary reserve saturation and uncertain battery capacity could significantly reduce revenue potential.

Economics for 2h new-built standalone batteries[1]
Project IRR[2] (%)



3 The current standalone BESS revenue stack is fully exposed to merchant risk.

Current revenue stack for standalone assets:

- **Wholesale market (Day-Ahead, Intraday)**
- **FCR**
- **aFRR capacity and aFRR energy**

Access to contracted revenues streams is very limited in Germany:

- **No capacity mechanism today**
- **Uncertain and most likely limited compensation from new ancillary services (e.g. inertia, reactive power, black-start capability).**

1) Including degradation and repowering. 2h batteries repower at 63% state-of-health, after 15 years. Based on May 2025 German Flexibility Report. 2) Real Internal Rate of Return (IRR), Pre-tax.

Sources: Aurora Energy Research, , ENTSO-E

Tolling agreement structures are becoming increasingly prevalent as a tool to manage merchant risk for European BESS projects

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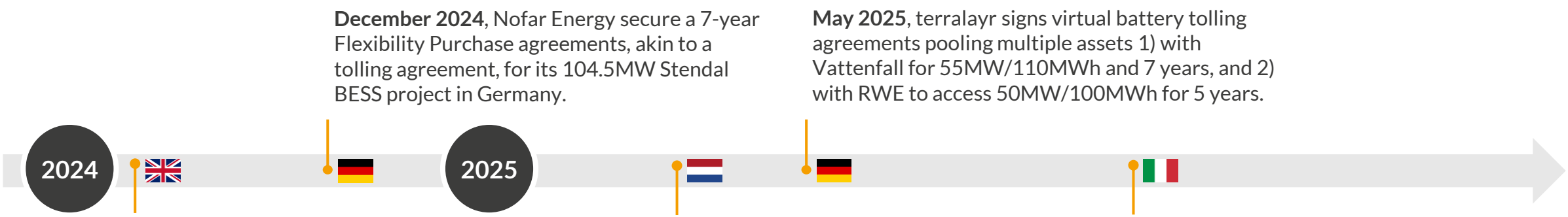
High-level overview

- A tolling agreement is a **rental contract** between a toller and an off-taker where the off-taker gains the right to earn revenues by operating the BESS. Tolling transfers operational and financial responsibilities from the asset owner to the off-taker, providing greater cash flow visibility required for project financing.
- While the off-taker gains operational rights, they are often subject to several contractual constraints, such as cycling and temperature limit restrictions.
- Tolling agreements guarantee stable income for BESS projects, providing **higher income security and lower merchant risk**.[1,2]
- For BESS, contracts akin to tolling agreements may be referred to as 'optimisation' or 'storage-as-a-service' but often hold functional similarity.

Contractual structures adhering to the principles of tolling agreements are being introduced in several European markets, spanning up to 8 years.[3] Selected projects are displayed below.[4]



1) Level of risk reduction depends on the type of contract structure; 2) This typically comes at the cost of reduced payment rates. Capacity Market payments are often excluded; 3) Capturing arrangements often described as 'optimisation' or 'storage-as-a-service', given their functional similarity; 4) Publicly announced and non-exhaustive selection of some of the first projects in different European markets.

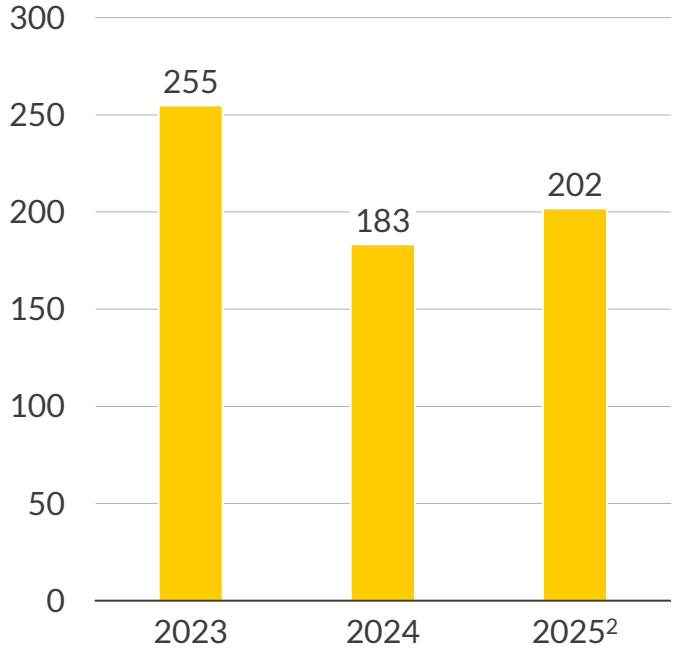
Sources: Aurora Energy Research, Penso Power, Engie, Nofar Energy, Vattenfall, Terralayr

Offtakers can benefit from tolling agreements through access to high battery revenues, reduced imbalance costs and mitigated portfolio risk

Upside participation

Because of attractive market conditions, battery systems have achieved high revenues in past years.

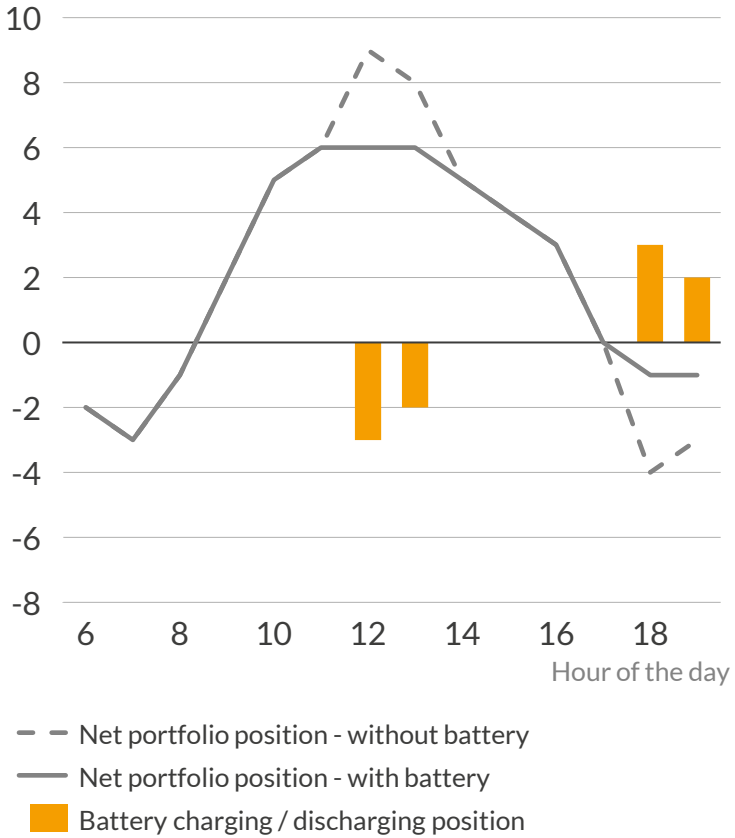
Battery 2h systems margins[1] – Aurora Index
€/kW/year (nominal)



Imbalance cost reduction

Adding a battery to a portfolio can allow for an imbalance cost reduction.

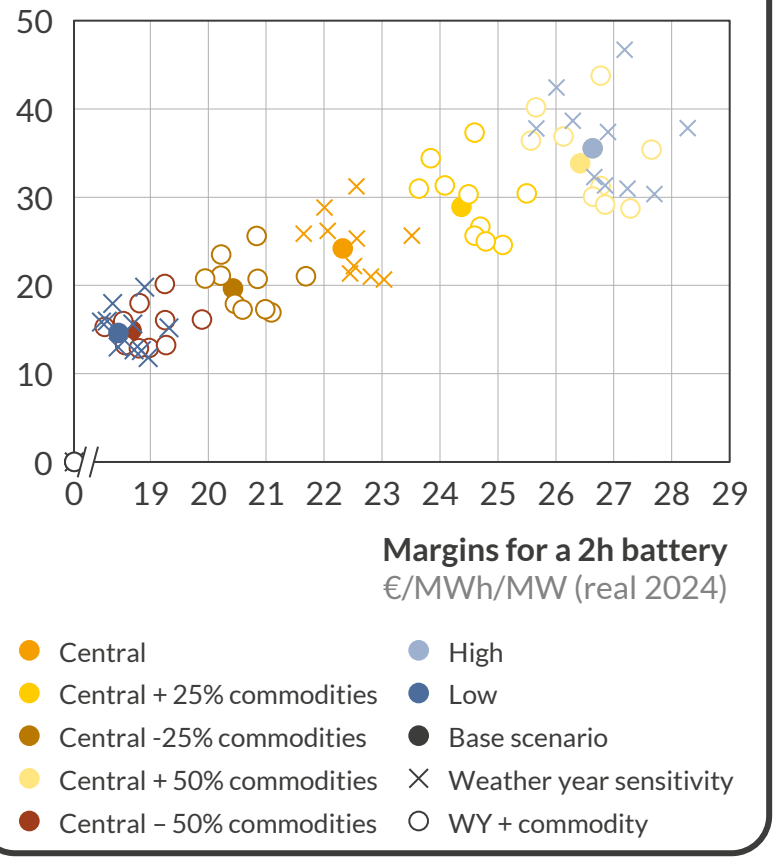
Net portfolio position (sales - purchases)
MWh, illustrative



Portfolio balancing

The battery acts as a hedge to the shaping costs, especially in commodity prices scenarios.

RES shaping costs under exemplary portfolio[3]
€/MWh/MW (real 2024)

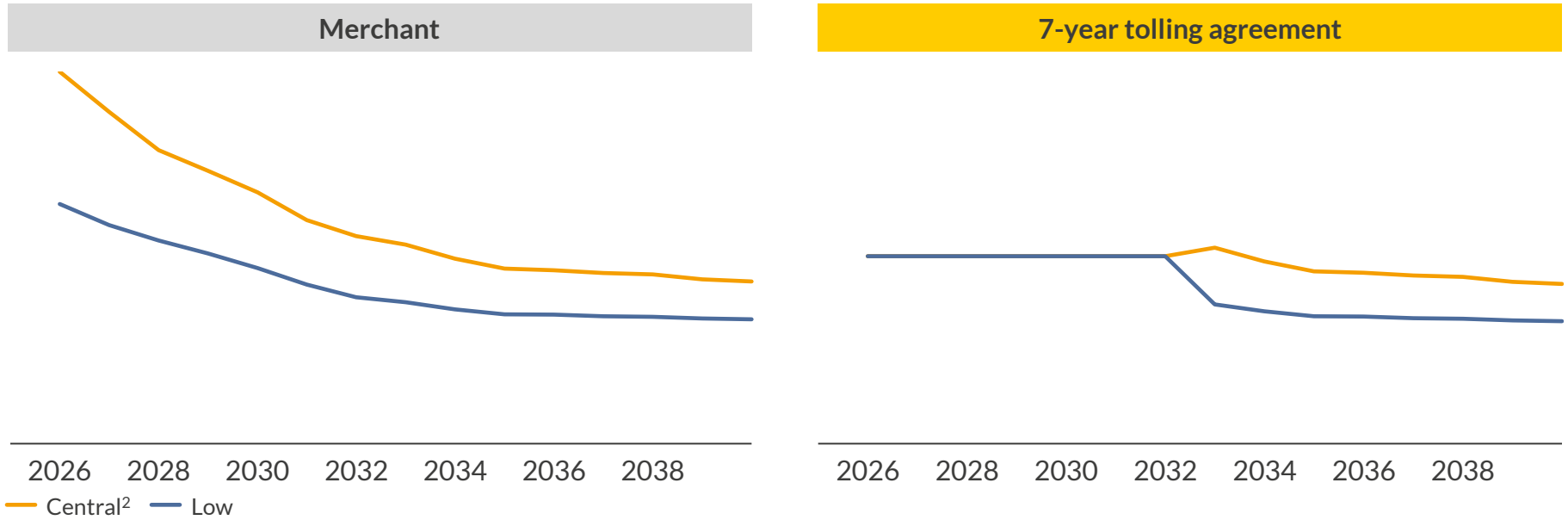


1) Including Continuous Intraday trading. 2) Until June 2025. 3) Portfolio with 100 MW solar, 50 MW wind and 50 MW BESS. Baseload PPA of 28 MW.

Source: Aurora Energy Research

Tolling agreements facilitate financing for developers and even increase the equity IRR in the Low scenario to 12%

Annual gross margins in the merchant case compared to a 7-year tolling agreement[1] for a 2h battery in Germany, COD 2026
€/kW/year, nominal



Impact on equity IRR and debt tenors

	Low	Central[2]
Equity IRR[3]	9%	20%
Debt tenor	5 years	5 years

Low	Central[2]
12%	15%
7 years	7 years

The equity IRR in a Low scenario is ~ 3 p.p. higher for a tolling agreement compared to the merchant case.
This comes **at the expense of a lower equity IRR in the Central case** as merchant margins outperform the fixed tolling price.

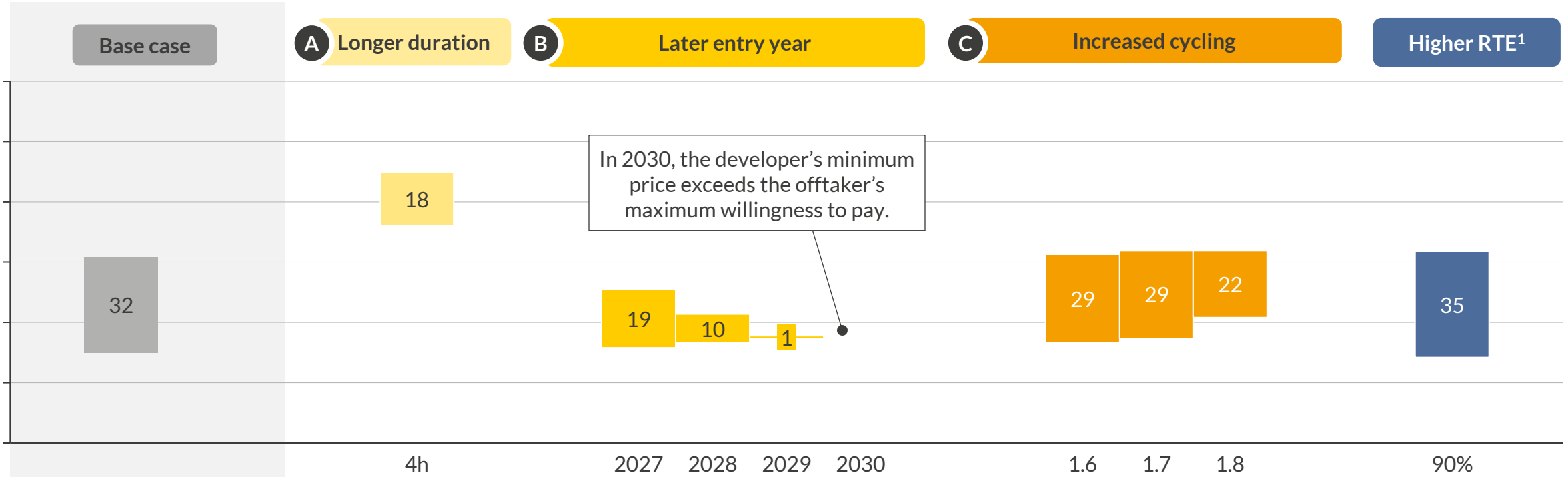
1) Assumed tolling agreement price: 126 €/kW/year, i.e., the average of upper and lower bound in the Base Case of this report. 2) The Central case includes revenues from continuous intraday trading (CID). 3) Post-tax, nominal currency. 4) Computed as the ratio of the i) Cash Flow Available for Debt Service (CFADS) to the ii) debt scheduled for repayment in each period.
Source: Aurora Energy Research

Impact of tolling agreement on battery financing

- A common metric used by lenders is the Debt Service Coverage Ratio (DSCR)[4]. Banks permit lower DSCRs for tolling agreements as revenue streams are secured:
  - We assume that a 7-year tolling agreement can **decrease the DSCR from 1.45 to 1.10**.
- Debt is generally a cheaper source of capital than equity, so increasing leverage tends to decrease the overall cost of capital.
  - We assume that a 7-year tolling agreement can **increase the debt share of capital from ~45% in the merchant case to ~70%.**

Changing project parameters can have strong impact on the tolling agreement value – especially later commission years reducing its value

7-year tolling agreement fixed price upper and lower bounds – sensitivities
€/kW/year, nominal



- **Entry year:** 2026
- **Daily cycling target:** 1.5
- **Efficiency[1]:** 86%

Additional costs exceed revenues, narrowing the negotiation range.

Market saturation narrows the negotiation range as **revenues fall faster than costs**. From 2030, there is little room for negotiation.

Higher cycling marginally raises the upper bound but **visibly lifts the lower bound**, as it comes at the cost of a **shorter project lifetime**.

Higher RTE[1] increases revenues for offtaker and developer, **increasing the range.**

Green → Offtaker's maximum willingness to pay Red → Minimum price for developer

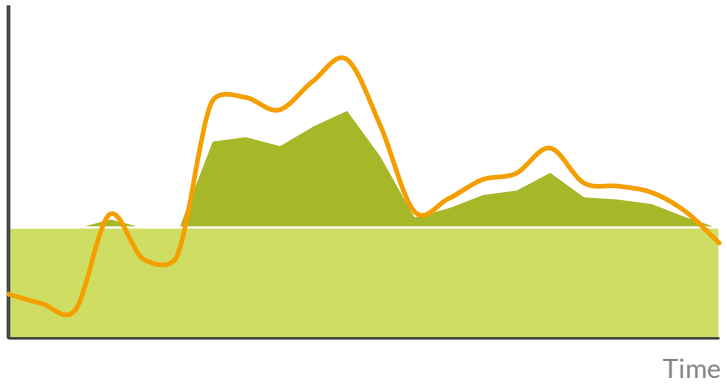
1) Round-trip efficiency measured at AC inverter output.

Source: Aurora Energy Research

Alternative contract structures, including floor prices, swaps or combining assets in hybrid PPAs, are becoming more popular

A Floor prices and revenue shares

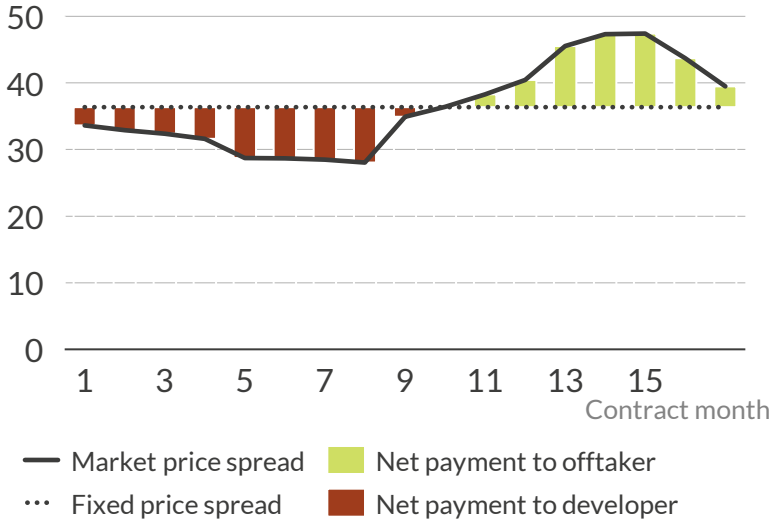
Floor price and revenue share agreement illustration
€/kW/year, illustrative



- Developers receive upside potential, while offtakers take market risk for lower fixed costs.
- High revenues today allow offtakers to take the full market risk but late 2020s saturation will make this more difficult.
- Floor prices are emerging in more saturated or less volatile markets like GB or France.

B Day-Ahead swaps

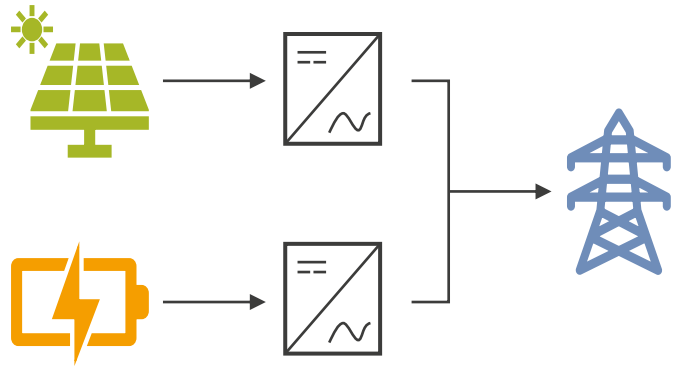
Example settlement of "Top / Bottom 3"[1] swap
€/MWh, nominal



- If the actual spread exceeds the agreed upon strike spread level, the developer pays the offtaker – if not, the offtaker pays the developer.
- While they only mitigate the Day-Ahead component of the merchant risk, these swaps still offer attractive downside protection.
- One contract was closed in Germany to this date.

C Co-location tolling agreements or hybrid PPAs

High-level overview



- Fixed price contracts are applicable co-located projects and are often referred to as hybrid PPAs or co-location tolling agreements.
- These contracts offer significant flexibility depending on the specific co-location setup.
- While widely discussed, very few contracts have been matured to date.

1) „Top / Bottom 3" refers to the difference between the average of the 3 hours with the highest prices, and the 3 hours with the lowest prices, in a day.

Source: Aurora Energy Research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