

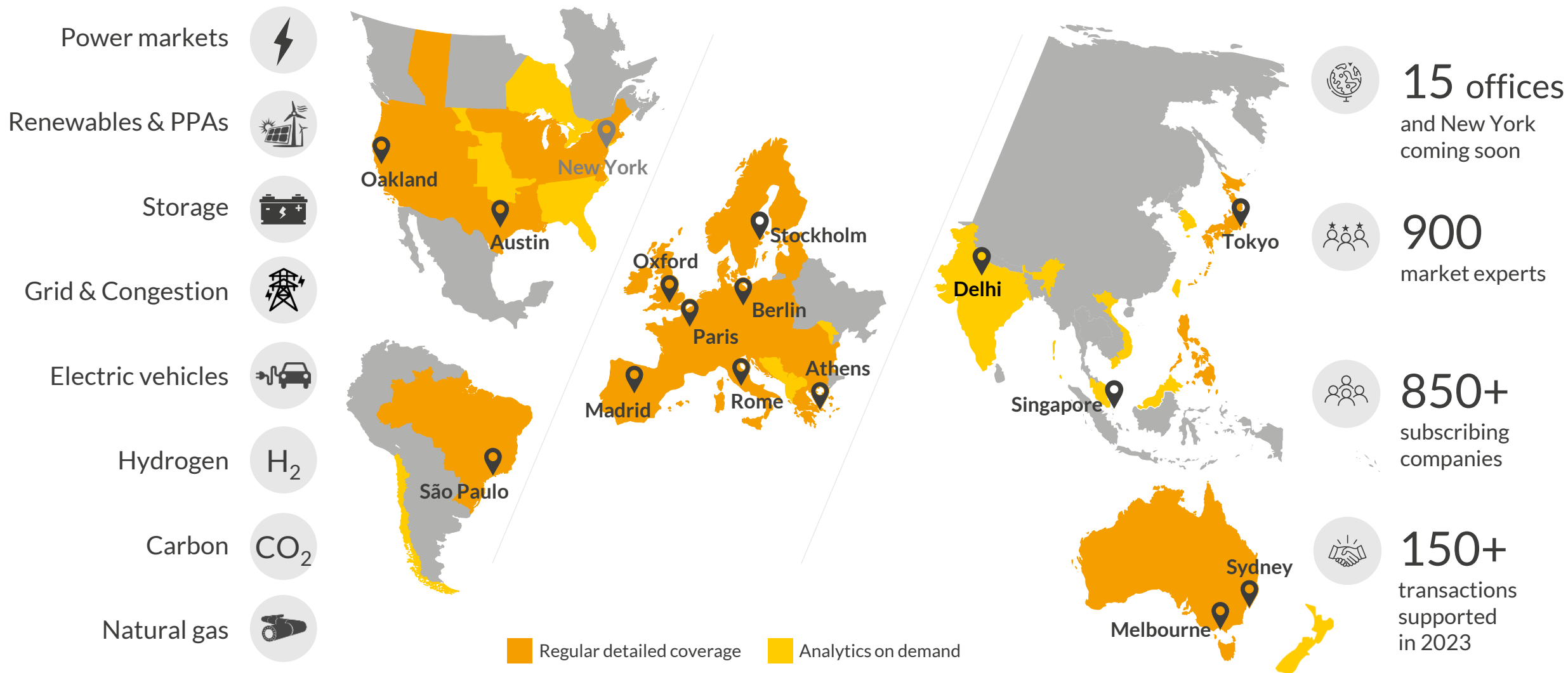
Nordic battery boom: Powering growth amid saturation risks

Public Report

22 January 2025



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



Our **Nordic Flexibility Market Add-on Service** provides you with detailed power market analysis and investment case data for batteries



Forecast Reports & Data

Technology and market development reports

- Overview of battery pipeline development
- Regulatory framework and qualification criteria for batteries
- Projections for battery CAPEX and OPEX by delivery year
- Reports and datasets follow the same format with content tailored to specific markets

Forecast data

- Hourly Day-Ahead and Intraday power prices, including spread achievable for arbitrage
- Hourly ancillary service prices for FCR-D up, FCR-D down, FCR-N and FFR in Sweden (SE4), Finland (FI) and Denmark (DK2)
- Including a projection of the ancillary market size in the Nordics until 2035

Investment cases

Standalone Battery

- At least four investment cases per country including:
 - Battery duration: 1h vs 2h
 - Aurora Central and Low scenario
 - Participation in both wholesale and ancillary markets
- Projection of annual project margins to 2050
- IRR and net present value for entry years 2025 and 2028
- Overview of benefits for co-location with wind, solar and hydropower

For ongoing analyst support, bi-annual workshops and interaction with our market experts, get in touch!



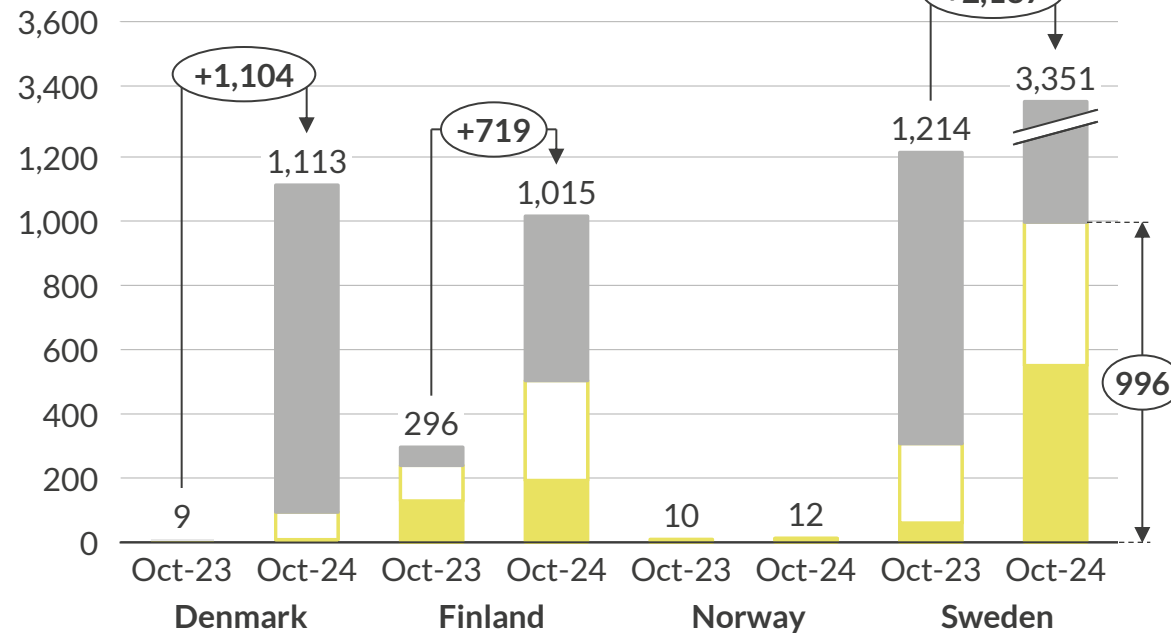
Laura Raud Pettersson, Commercial Associate

Laura.pettersson@auroraer.com

Nordic BESS capacity has skyrocketed over the last year, with 4GW added to the pipeline; the fleet consists mostly of stand-alone batteries in SE3 and SE4

Nordic battery capacity by status and location

MW

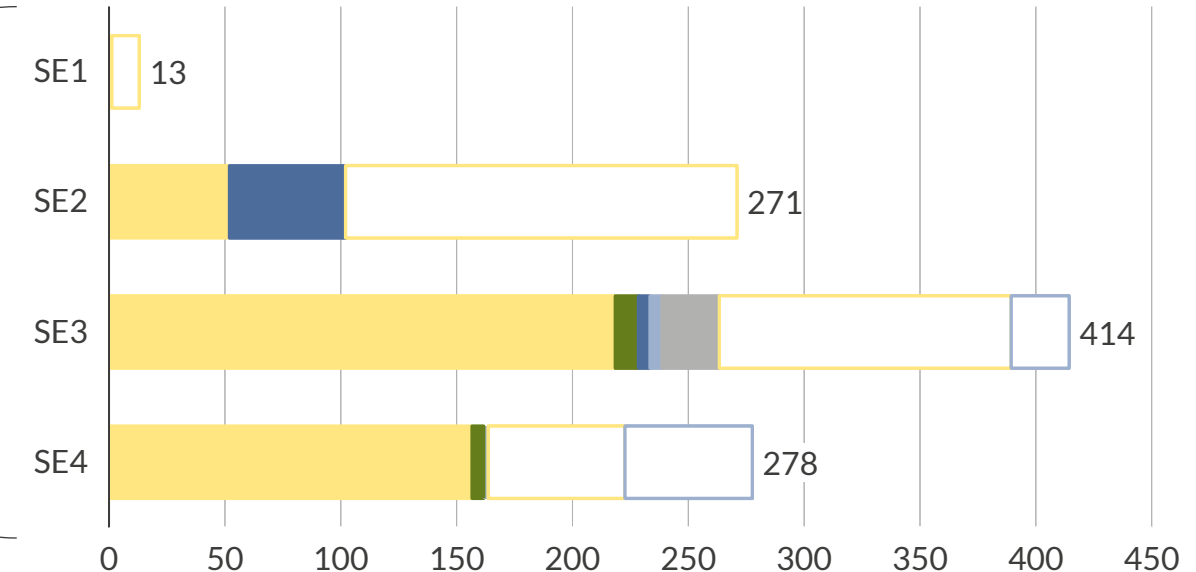


- Over the last year BESS¹ capacity in the Nordics grew by over 600MW and the total pipeline by around 4GW. The largest growth is in the established Finnish and Swedish markets, while Denmark is quickly ramping up.
- The current Nordic fleet is over 750MW. Additionally, 850MW of projects are under construction and another 3.9GW have been announced. Sweden is the biggest market with 3.3GW in the pipeline and over 500MW operational.

1) Battery energy storage system.

Operational and under construction batteries in Sweden

MW



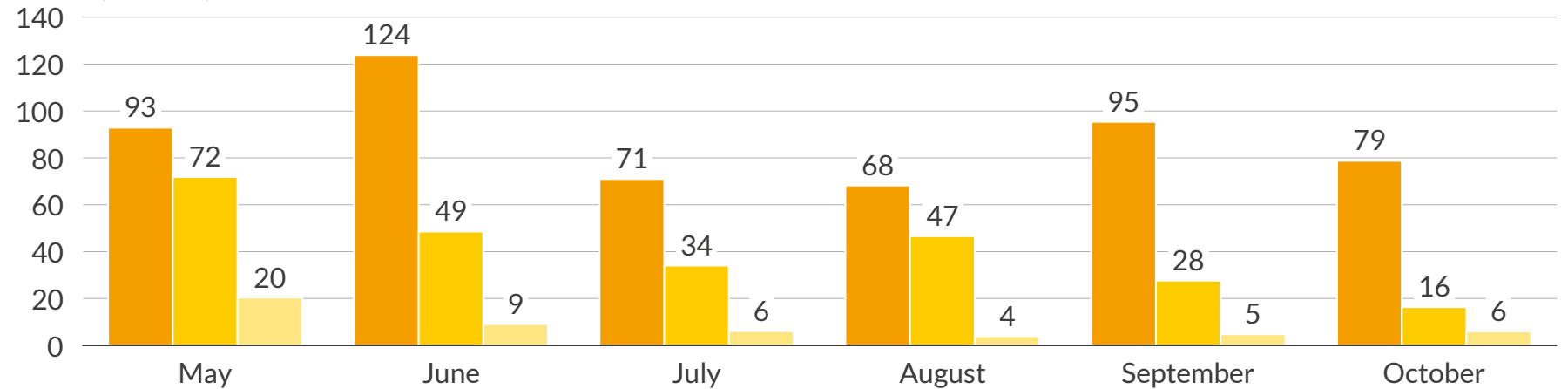
- 80% of the operational Swedish BESS capacity is situated in SE3 and SE4, the zones with undersupply of energy and higher power prices. SE2 has the largest amount of capacity under construction.
- Over 80% of the capacity consists of stand-alone assets. SE2 has 50MW of assets co-located with hydropower. Projects co-located with other energy sources have started to come online in SE3 and SE4.

Legend: Stand-alone (Yellow), Co-located with hydro (Dark Blue), Co-located with biomass/CCGT (Green), Co-located with solar/wind (Light Blue), Undisclosed (Grey), Under construction (White)

FCR-D up prices in Sweden have declined for two consecutive years, raising the question of market saturation

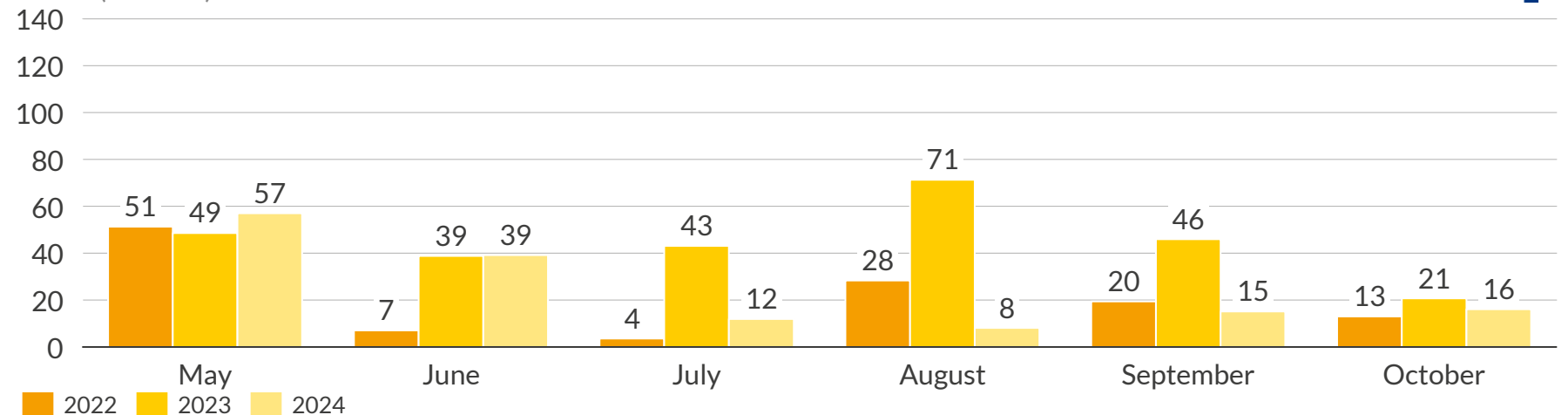
Historical FCR-D up prices in Sweden and DK2¹

€/MW (nominal)



Historical FCR-D up prices in Finland

€/MW (nominal)



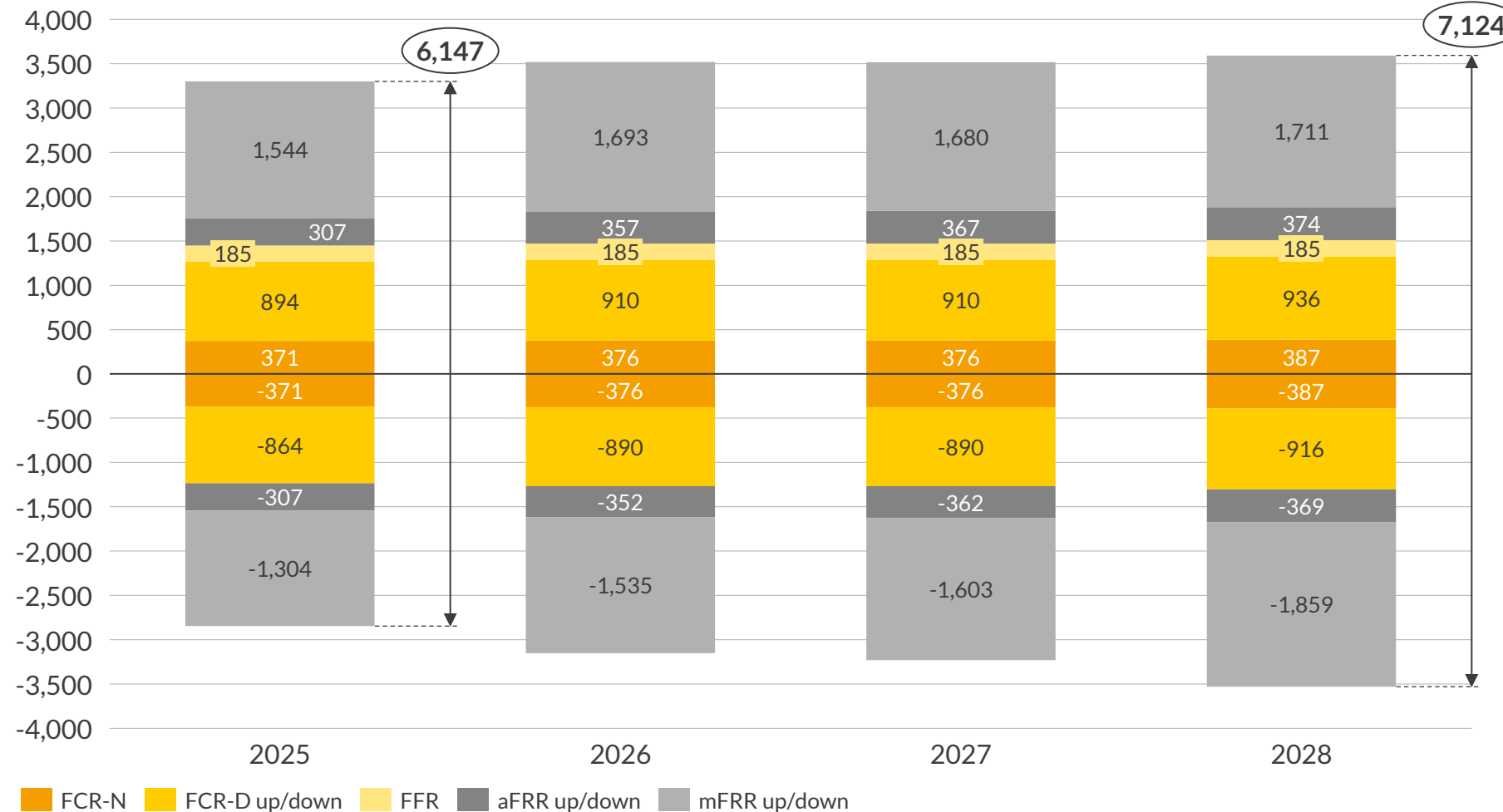
1) 2022 and 2023 show volume weighted average pay-as-bid prices whereas 2024 shows the marginal price.

Price drivers

- Over the last two summers we have seen significant drops in FCR-D up prices in Sweden, despite the shift to from pay-as-bid to marginal pricing in 2024.
- In Finland, prices increased significantly in 2023 but have rebalanced since July 2024.
- The decline in FCR-D up prices is driven by several factors:
 - Increased competition from BESS has displaced costly hydro units from the market.
 - Lower Day-Ahead power prices have led to decreases in hydro water valuations, resulting in lower bids into FCR from price-setting hydro assets.
 - The hydrology for 2024 was favourable meaning hydro assets were flexible to provide FCR at a low cost.

Procured volumes of ancillary services are expected to grow by almost 1,000 MW, driven by increasing mFRR up and down volumes

Procured capacity per ancillary market in Denmark¹, Finland and Sweden, MW



Capacity drivers

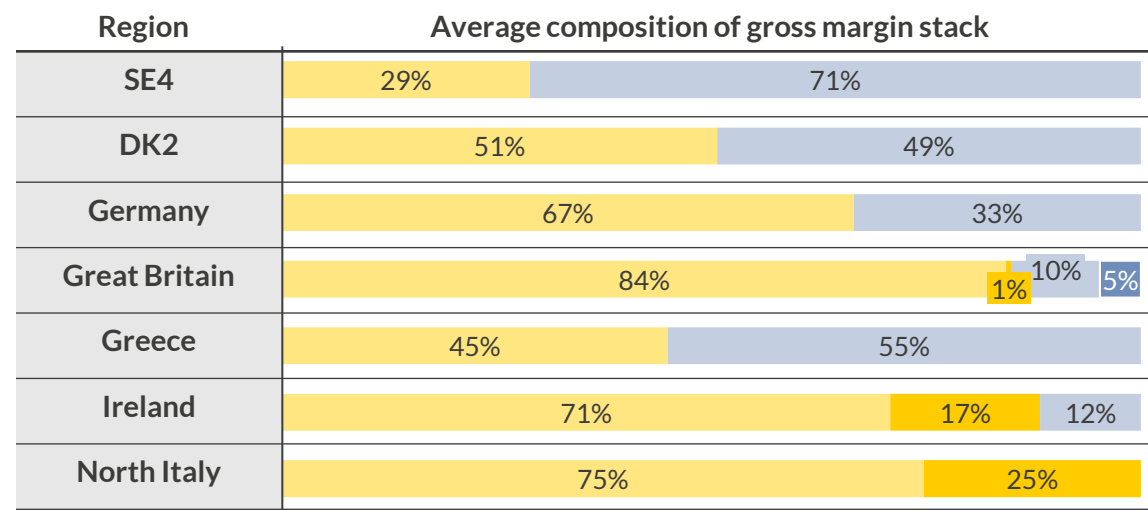
- The largest projected growth in volumes is from mFRR, particularly in the down direction, which is expected to increase by 550MW between 2025 and 2028.
- The demand for mFRR capacity is forecasted to grow to match the dimensioning fault for each price zone.
- Procurement of FCR and FFR is forecasted to grow slightly, primarily due to adjustments in the allocation among the Nordic countries.
- aFRR capacity procurement is expected to increase from around 300MW to around 375MW in both directions.

1) DK2

In more mature battery markets, such as Great Britain, arbitrage revenues are a cornerstone of the business case



Summary of gross margin stack market composition¹
% of 2027 – 2041, 2h duration batteries

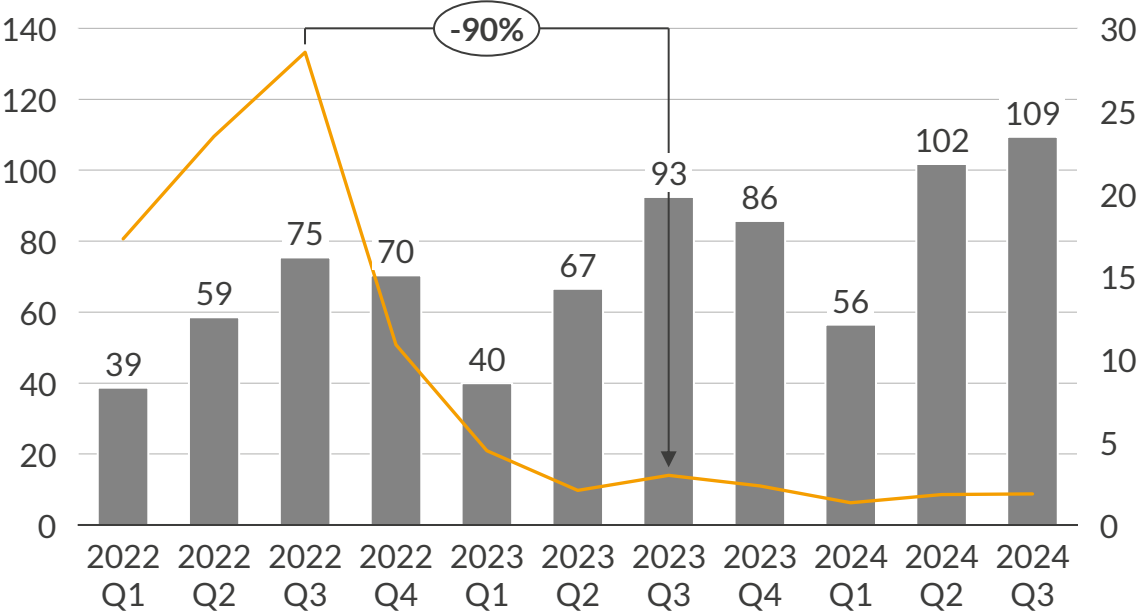


- In the Nordics, the business case for most operational batteries is mainly based on capacity payments for ancillary services. In many other countries, energy arbitrage between energy-remunerated ancillary services², wholesale, and balancing markets³ often represents the most valuable revenue stream.
- In more mature markets, such as Great Britain, frequency services tend to already be saturated or will likely saturate early, further increasing the importance of arbitrage for the business case.

 Energy arbitrage (over all markets)  Capacity payments for ancillary services
 Capacity Market Payments  Other Ancillary Markets

Dynamic Containment (DC) low volumes⁴
GW

Average DC low prices⁵
£/MW/h (nominal)















- Dynamic Containment is the primary reserve, with a separate up and down service. It is procured through Day-Ahead auction and provides availability payments (per MW) only on a pay-as-clear basis.
- Historically, exclusively participating in DC could yield sufficient revenue for a viable business case. However, due to the rapid battery build-out starting Q3 2022, regardless of the higher uptake volume the market saturated and prices fell by 90% over the course of a year.

 Cleared volume  Average price

1) Discounted. 2) Includes fast frequency products with full activation time < 10 minutes such as FFR, FCR and aFRR. 3) Includes Balancing Mechanisms in Great Britain and Ireland and slower frequency products with full activation time > 10 minutes such as mFRR, RR and Secondary/Tertiary Reserves within Italy's Mercato per il Servizio di Dispacciamento. 4) Average cleared volumes across all regions in a month. 5) Average accepted prices across regions in with non-zero procurement.
Sources: Aurora Energy Research, National Energy System Operator

Several additional revenue streams and trading strategies can give a further upside to the business case for BESS in the Nordics

Strategy	Potential impact	Accessibility	Opportunities and challenges
aFRR energy and capacity			<ul style="list-style-type: none"> Arbitrage on aFRR energy under PICASSO creates an opportunity, but capacity bids will be cannibalised by wind & DSR partly also due to shallow market size. Pre-qualification requirement for aFRR is stricter than for mFRR and currently, no batteries are pre-qualified for aFRR in Sweden.
mFRR energy and capacity			<ul style="list-style-type: none"> Go-live of the automated Nordic mFRR energy activation market in Q1 2025 will include a shift to 15-minute market time unit, increasing suitability for the battery.
Financial asset backed trading			<ul style="list-style-type: none"> Pure financial trading on the continuous Intraday market can increase arbitrage revenues, without increasing cycling.
Local flexibility market			<ul style="list-style-type: none"> Local flexibility markets can provide additional revenues for the battery, but markets are not standardised and dependent on the geographical placement of the battery.
Repowering			<ul style="list-style-type: none"> Repowering can extend the lifetime of the asset and allow for more arbitrage possibilities which could improve profitability.
Co-location			<ul style="list-style-type: none"> Co-location of batteries and renewable assets is primarily an upside from a grid perspective due to better utilisation of grid-connection which can often be a bottleneck.

- 1** Grid-scale battery capacity in Sweden has surged in 2024, rising from 80MW pre-qualified for ancillary services in January to 530MW by October. With the current project pipeline, capacity in Sweden and DK2 could soar to 1,100MW by 2025 and 1,450MW by 2026, if all projects are realised.
- 2** Prices for ancillary services in Sweden have declined for two consecutive years, with FCR-D averaging just 6 €/MW since June. This drop is driven by abundant hydropower, low Day-Ahead prices, and rapidly rising battery capacity displacing costlier units. FCR-N prices have been more resilient, averaging 40 €/MW during the same period.
- 3** As seen in other European countries, arbitrage revenues become increasingly critical for the battery business case as competition in ancillary markets grows with expanding battery capacity. The upcoming shift to a 15-minute market time unit in 2025 for both Intraday and Day-Ahead markets is likely to benefit batteries by increasing daily price spreads. Additionally, strategic market churn—closing Day-Ahead positions in the Intraday market—offers further potential to enhance arbitrage revenues.
- 4** There are multiple potential upsides for Nordic batteries in the future which are likely increase revenue potential, including accessing new ancillary markets such as mFRR, aFRR, exploring financial asset backed trading or co-location and local flexibility markets. While the scale of these benefits will depend on market developments, they offer potential for strengthening the battery business case.

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 Aurora Energy Research GmbH and Aurora Energy Research Pty Ltd (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

This document and its content (including, but not limited to, the text, images, graphics and illustrations) is the copyright material of Aurora, unless otherwise stated.

This document is confidential and it may not be copied, reproduced, distributed or in any way used for commercial purposes without the prior written consent of Aurora.

AURORA



ENERGY RESEARCH