Chronos methodology

December 2023

Batteries: Overview of Aurora dispatch methodology

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1 Description & Assumptions

- Battery margins under a **Hybrid business model** include the buying and selling of power in the Intraday and Day-Ahead wholesale markets and in the Balancing Mechanism, and the provision of Dynamic Containment, Moderation, and Regulation frequency response services, based off our Central forecast

- Cycling rates are chosen to represent what a **typical asset** might target; actual rates will vary according to business model, financing consideration, battery warranty agreements and market conditions. Cycling rate limitations are applied to total yearly cycles, i.e. volume is not capped on any individual day

Batteries considered	Value
Durations considered	1hr, 2hr & 4hr
Cycles considered	1.0x, 1.5x & 2.0x per day (average limit)

Assumptions	Value/comment
Market access	Wholesale Market (Day-Ahead and Intraday) and the Balancing Mechanism; Dynamic Containment, Regulation, and Moderation
Round-trip efficiency	86.0%
Availability	98.0% (100% availability for 98% of the time)
Degradation	Degrading investment cases use warranted energy capacity degradation curves

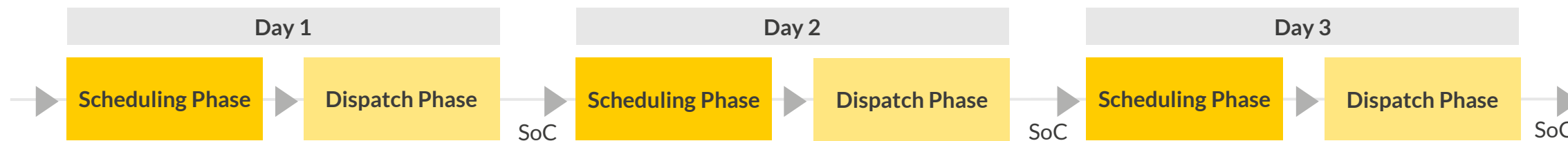## 2 Energy Trading Strategy Overview

- The asset trades in the Wholesale Market (Day-Ahead and Intraday) and the Balancing Mechanism (BM)

- The asset has up to 32 hours of foresight into Day-Ahead and Dynamic frequency response (DC, DM, and DR) prices, with an opportunity cost of Day-Ahead market participation based on Intraday/Balancing price dynamics

- When trading, the asset can choose to charge or discharge in Intraday and/or Balancing (by submitting bids/offers) if the prices are attractive based on upcoming Day-Ahead prices

- Up to 6hrs of foresight over Intraday wholesale prices, and no foresight over Balancing prices, are assumed

3 Key terms

- **Cycles:** volume of charging/discharging in terms of equivalent full cycles

- **Duration:** ratio of MWh to MW for the asset, in hours

- **Margin:** net trading profit from buying and selling power in the intraday market and balancing mechanism only; does not include any fixed charges, additional variable costs or benefits that may apply (e.g., GDUoS) or other cashflows (e.g., those from CM contracts or TNUoS EET benefits)

- **Net cashflow:** equivalent to **margin**

- **Price spread:** volume-weighted average captured discharging price minus charging price over a period

Chronos for GB optimises daily between energy arbitrage and Frequency Response service actions, with consideration for BM stacking

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Chronos is solved in **blocks of 1 day** (48 half-hours), determining all actions for each block before moving onto the next block.
Each block is solved in two stages:

Day 1	Day 2	Day 3

Scheduling Phase	Dispatch Phase		Scheduling Phase	Dispatch Phase		Scheduling Phase	Dispatch Phase	
		SoC			SoC			SoC

SCHEDULING PHASE

Outputs:

- Day-Ahead wholesale market positions (at hourly granularity)
- Frequency Response (DC, DR, DM at 4-hourly block granularity) commitments (for hybrid business models)

Method:

The Scheduling Phase is solved with an optimisation approach, with up to 32 hours foresight of remaining prices (for Day-Ahead and Frequency Response only), as well as over upcoming periods of B6/B8 boundary constraints. Participation in these markets also accounts for the opportunity cost of participating in Intraday and Balancing markets. In FR markets, assets are able to opt in/out of EFA blocks as deemed optimal, and can partially participate, allowing actions in other markets with the remaining capacity.

DISPATCH PHASE

Outputs:

- Fulfilment (or non-fulfilment) of Day-Ahead and Frequency Response commitments (including DC/DR/DM energy dispatch)
- Intraday market charging/discharging
- Balancing market charging/discharging

Method:

Day-Ahead and Frequency Response commitments are fulfilled first (subject to SoC conditions). Intraday and Balancing actions are determined using an heuristic price threshold approach based on upcoming Day-Ahead prices. No foresight over upcoming Intraday and Balancing prices is assumed.

Our model now reflects that the value available through the BM varies based on location, driven by transmission constraints

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Overview of Aurora Dispatch Zones

SCOTLAND
describes all assets located north of the B6 boundary, which also describes the national border between England and Scotland. Scotland features the highest levels of curtailment, and the lowest embedded benefits of the three regions

B6

NORTH ENGLAND & WALES
describes assets between the B6 and B8 boundaries. This region has limited embedded benefits, but offers opportunities to turn up for most of the forecast due to more limited congestion of the B8 boundary until ~2045

B8

SOUTH ENGLAND & WALES
describes assets South of the B8 boundary. This region offers the most attractive embedded benefits, as well as opportunities to turn up during constrained periods throughout the forecast

METHODOLOGY UPDATES

Zones:

- All assets are assigned to a zone, this impacts:
  - The levels of embedded benefits available (based on regional averages)
  - Utilisation in the BM for reasons relating to transmission constraints
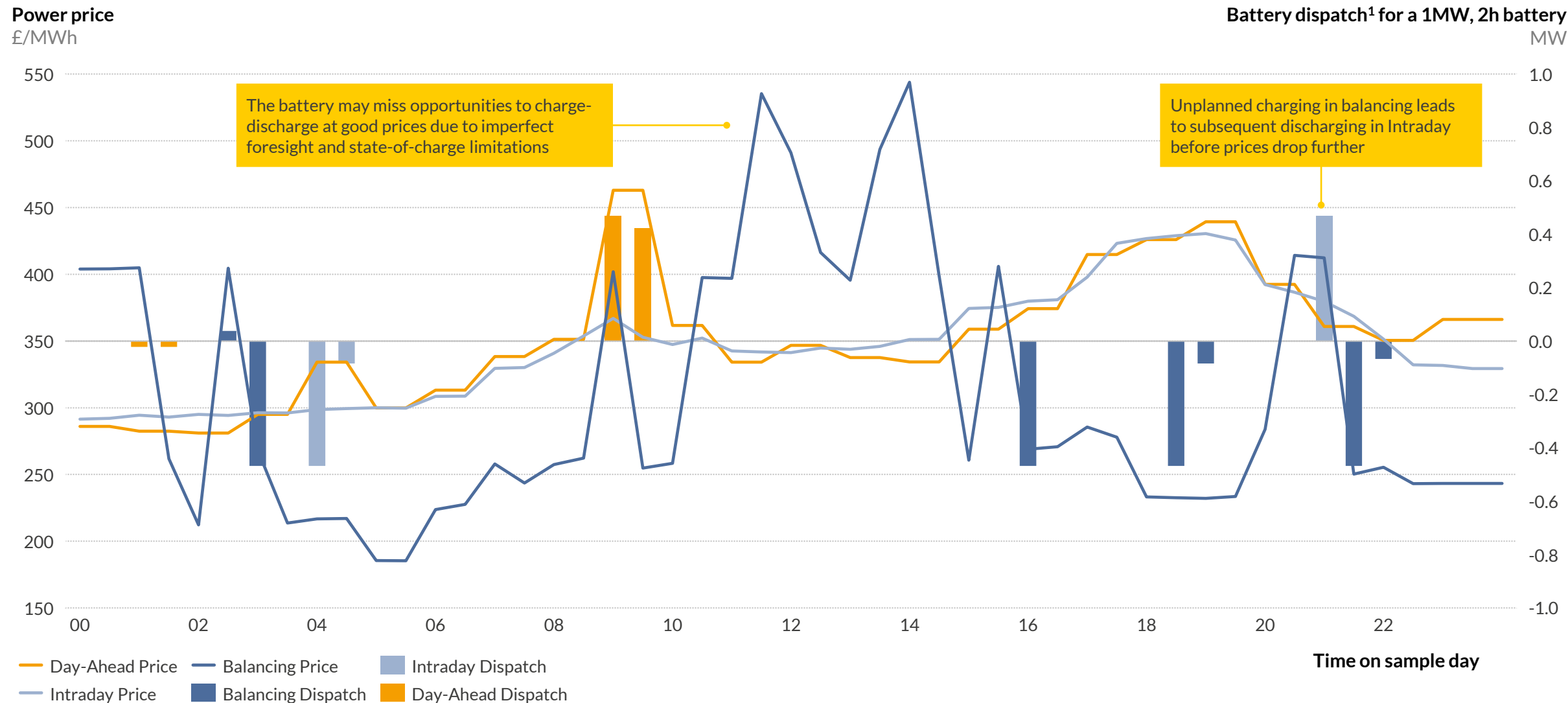
Methodology overview:

Dispatch against locational constraints is factored into decision-making in the day-ahead solve, reflecting constraints being driven mostly by boundary capacities and weather, which are possible to estimate with day-ahead data

Assets can be dispatched to help resolve a constraint, based on the **weighted-average price** of balancing actions taken to resolve constraints

This activity is limited to 1 cycle/day, as the Balancing Mechanism is unlikely to dispatch the same storage asset multiple times, in the same direction, during a continuously constrained period

In practice, assets in the South of GB are mostly dispatched upwards to help meet demand when the transmission network is overloaded. Assets in Scotland and, later in the forecast, Northern England & Wales, are dispatched downwards to absorb excess generation

Example of modelled battery: Asset is optimising to price movements, but could miss out on some prices due to imperfect foresight

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Power price
£/MWh

Battery dispatch[1] for a 1MW, 2h battery
MW

The battery may miss opportunities to charge-discharge at good prices due to imperfect foresight and state-of-charge limitations

Unplanned charging in balancing leads to subsequent discharging in Intraday before prices drop further

— Day-Ahead Price   — Balancing Price   ▢ Intraday Dispatch

— Intraday Price   ▪ Balancing Dispatch   ▪ Day-Ahead Dispatch

Time on sample day

1) Discharging/export actions are shown as positive, while charging/import actions are shown as negative.

Source: Aurora Energy Research