Sizing the impact of BESS on grid emissions

Motivation, methodology, results, and next steps

18 February 2025
Energy Storage Summit

BESS carbon emissions – what did we do

Working group

1. **Develop** methodology to calculate BESS emissions impact
   - Find the right metrics
   - Collect necessary data
2. **Validate** methodology's results
   - Use actual inputs
   - Finetune methodology

Focus of presentation

3. **Standardize** methodology and make it widely accessible
   - Make methodology public
   - Create online tool

Focus of panel

Pulse motivation – why participate

 **Mission**	▶	**Do good**: are we having the desired impact
 **ESG**	▶	**Reporting**: LCA to consistently track and update this number
 **Investors**	▶	**Requirement**: asked to track our environmental impact
 **Industry**	▶	**Credentials**: BESS industry struggles to prove its carbon benefits

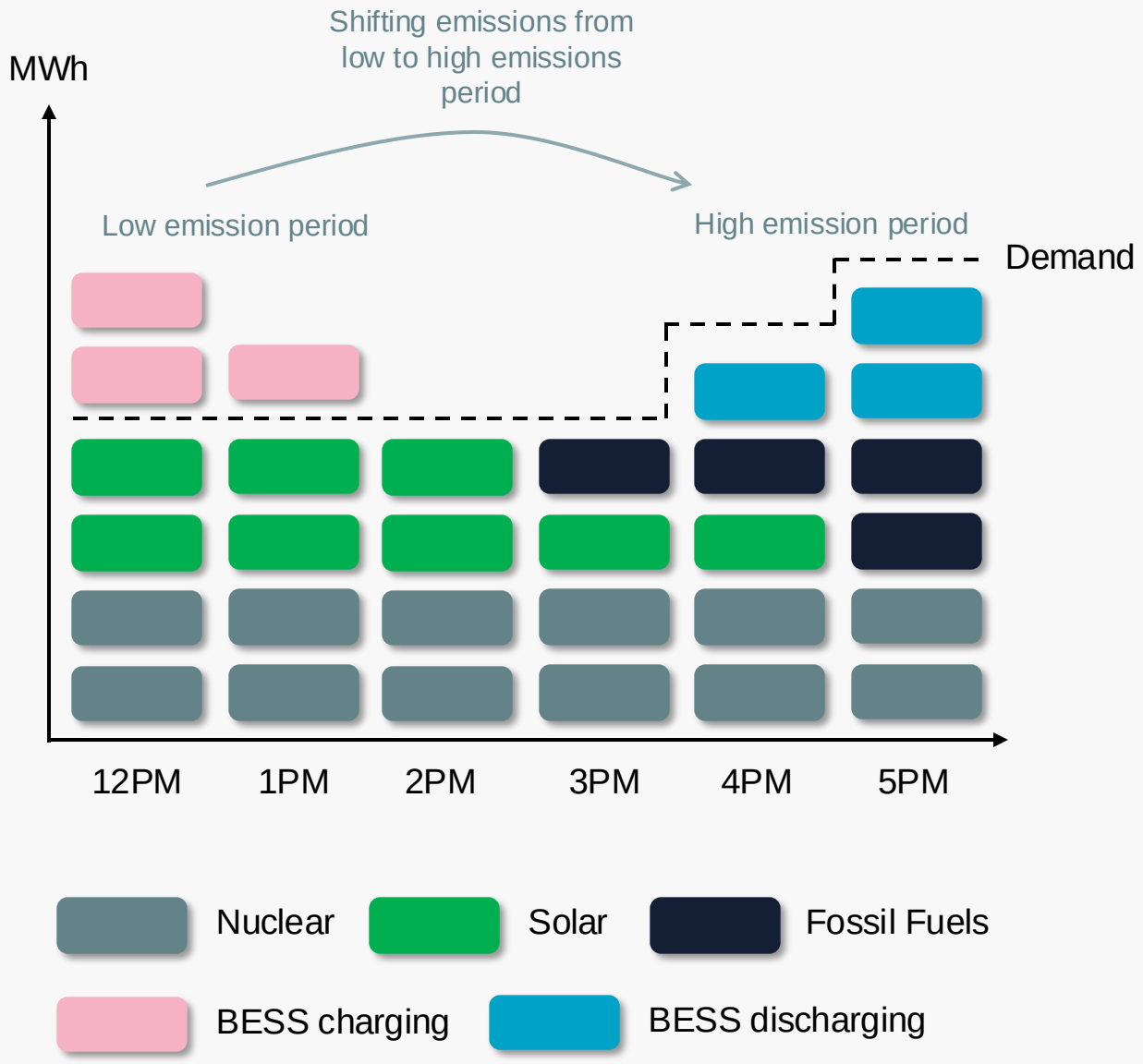
LCPDelta

Developing the methodology

How can a battery reduce emissions

1) Energy actions

- Batteries follow price signals, shifting energy **from low price periods to high price periods**.
- **Low price periods tend to be lower carbon emitting**, high price periods tend to be higher carbon.
- The **marginal unit** in a period responds to the BESS asset charging/discharging.
- The difference in emissions between these marginal units **can cause a net emission or abatement.**

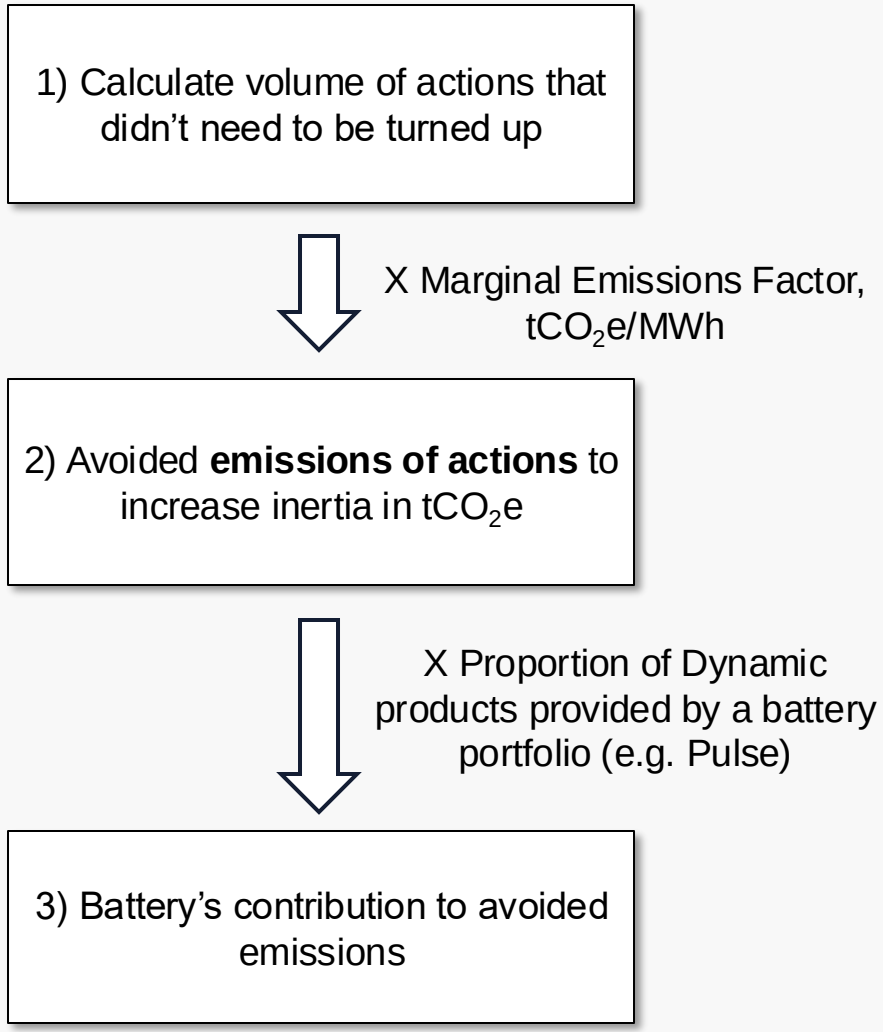


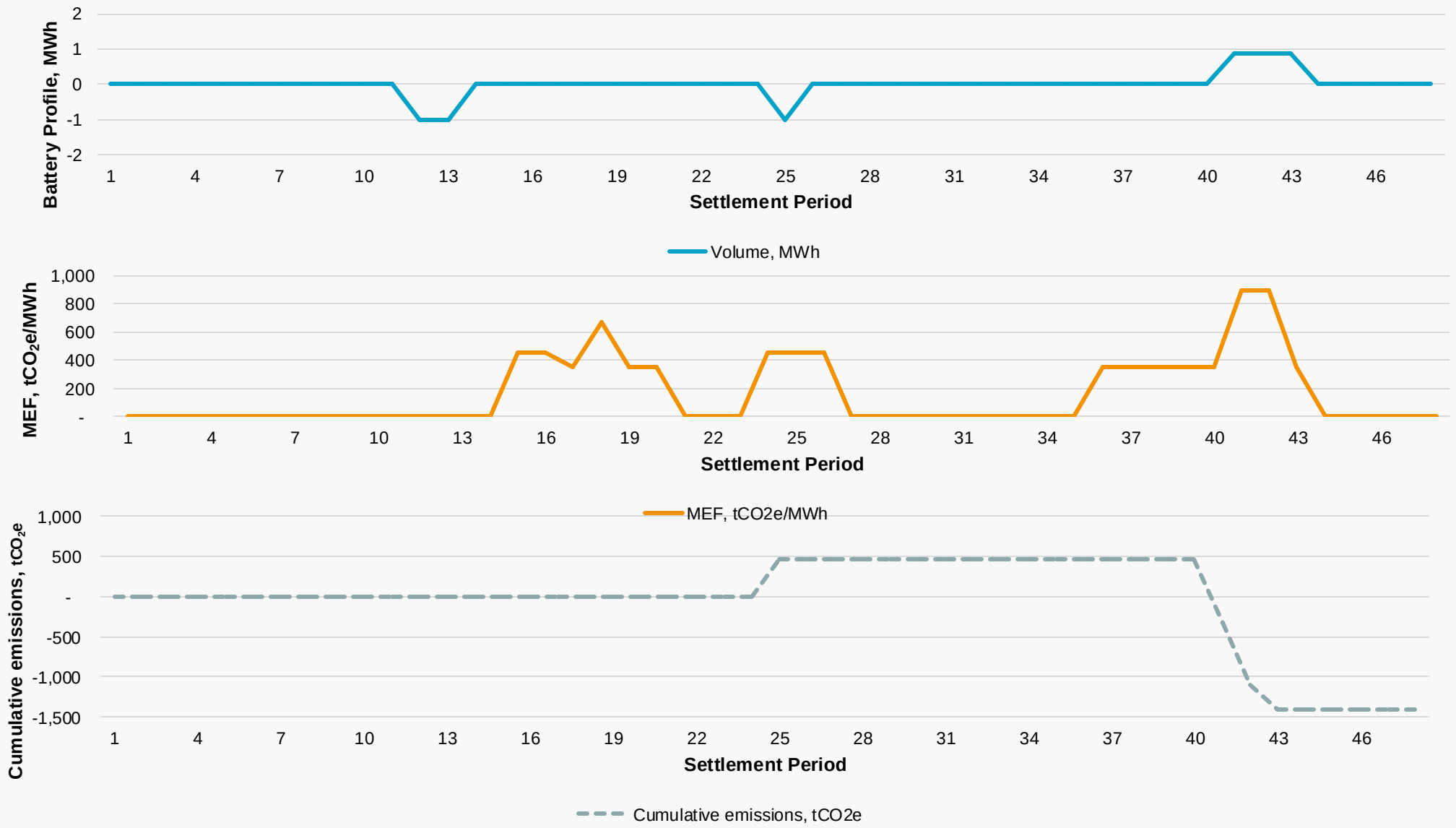
How can a battery reduce emissions

1) Energy actions

2) **System services**

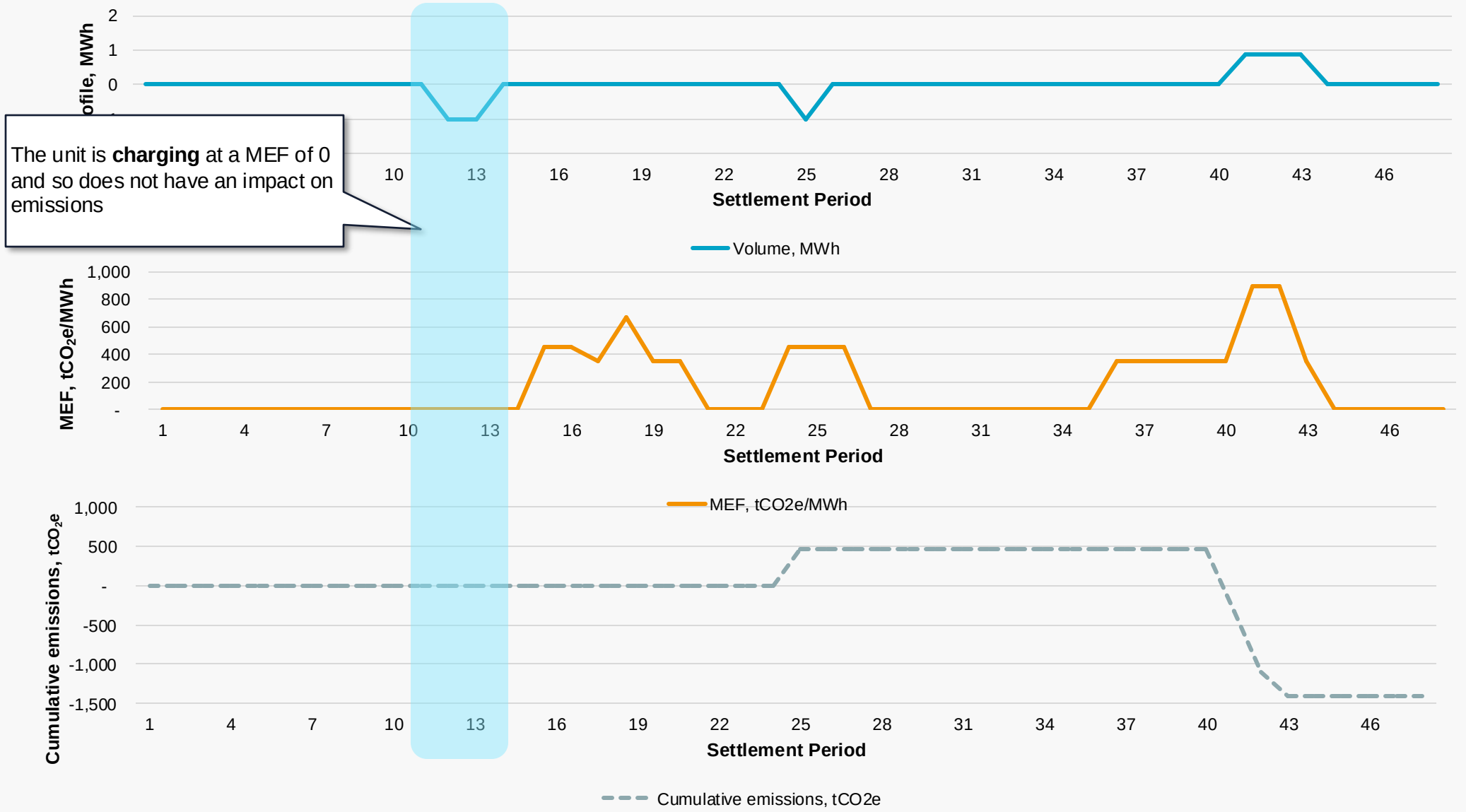
- NESO must procure a certain level of inertia on the system, typically from fossil fuel generators.
- The dynamic suite of flexibility products has reduced the inertia level that NESO must procure.
- This means on some occasions fewer fossil fuel generators need to be turned up, leading to carbon savings, and some of this can be attributed to batteries participating in Dx.
- This will **always be an emission reduction**




Battery Profile, MWh
2
1
0
-1
-2
1 4 7 10 13 16 19 22 25 28 31 34 37 40 43 46
Settlement Period
Volume, MWh
MEF, tCO2e/MWh
1,000
800
600
400
200
-
1 4 7 10 13 16 19 22 25 28 31 34 37 40 43 46
Settlement Period
MEF, tCO2e/MWh
Cumulative emissions, tCO2e
1,000
500
-
-500
-1,000
-1,500
1 4 7 10 13 16 19 22 25 28 31 34 37 40 43 46
Settlement Period
Cumulative emissions, tCO2e

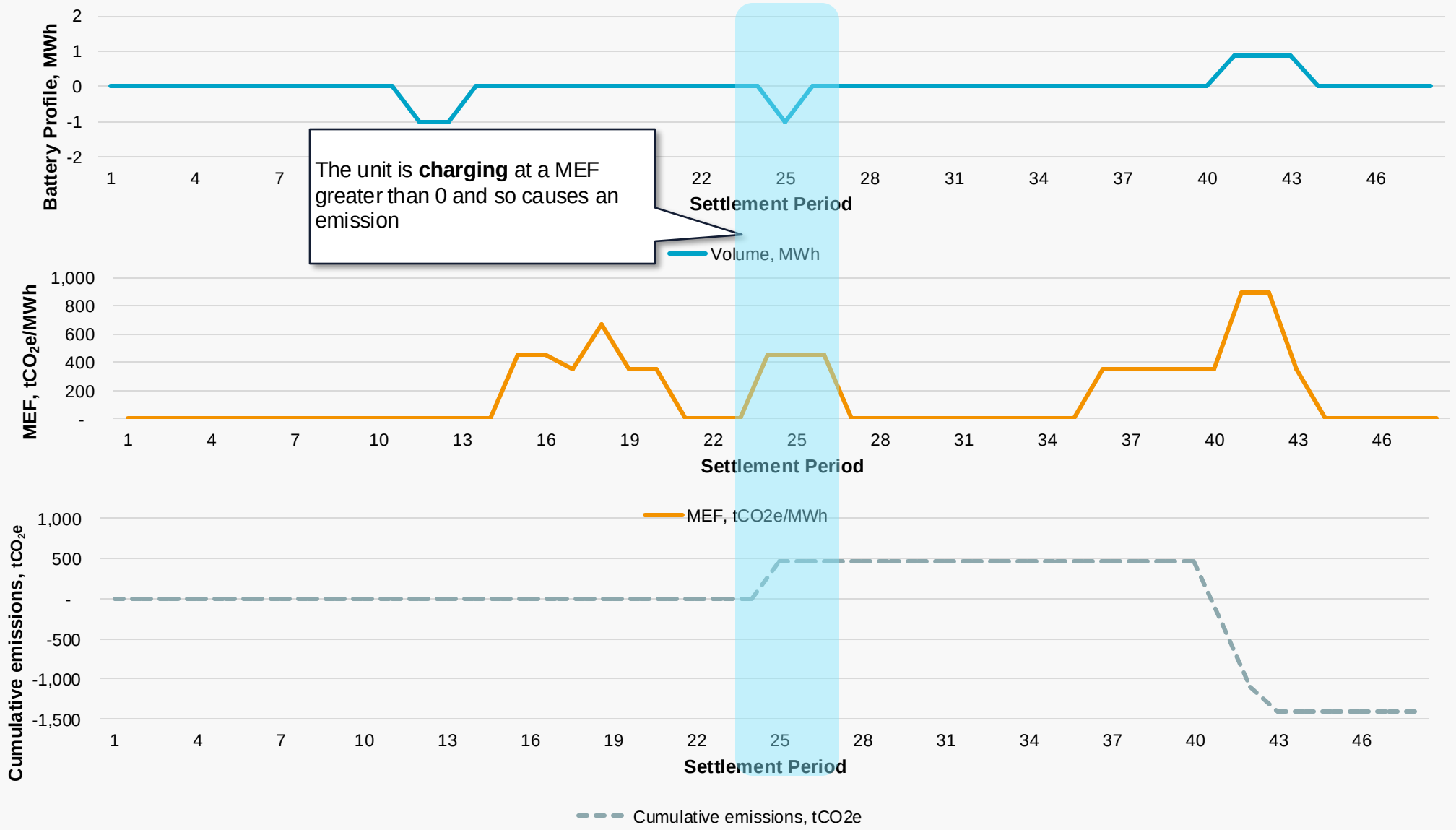
7

Aim 1: Developing a methodology



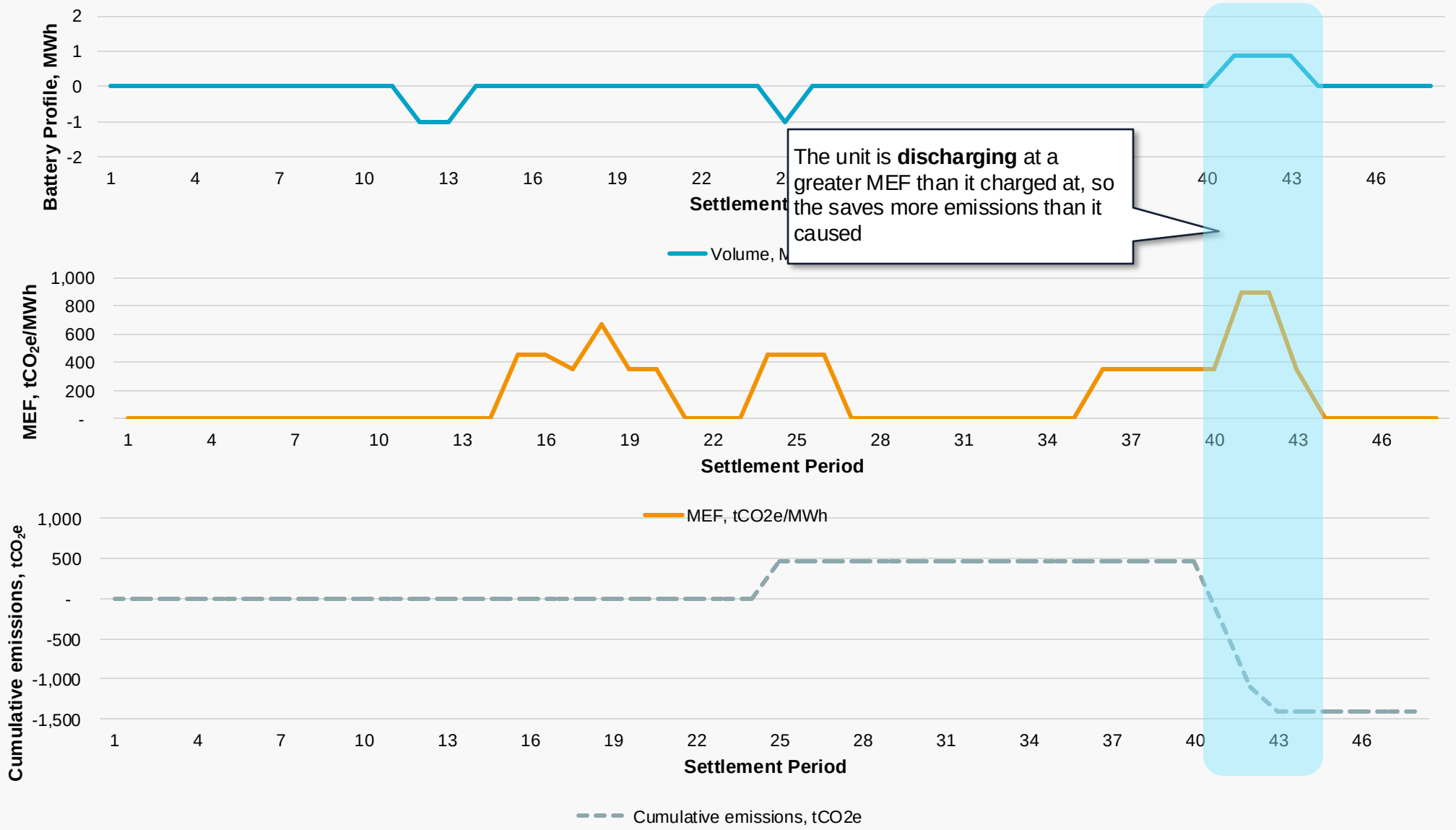
8

Aim 1: Developing a methodology

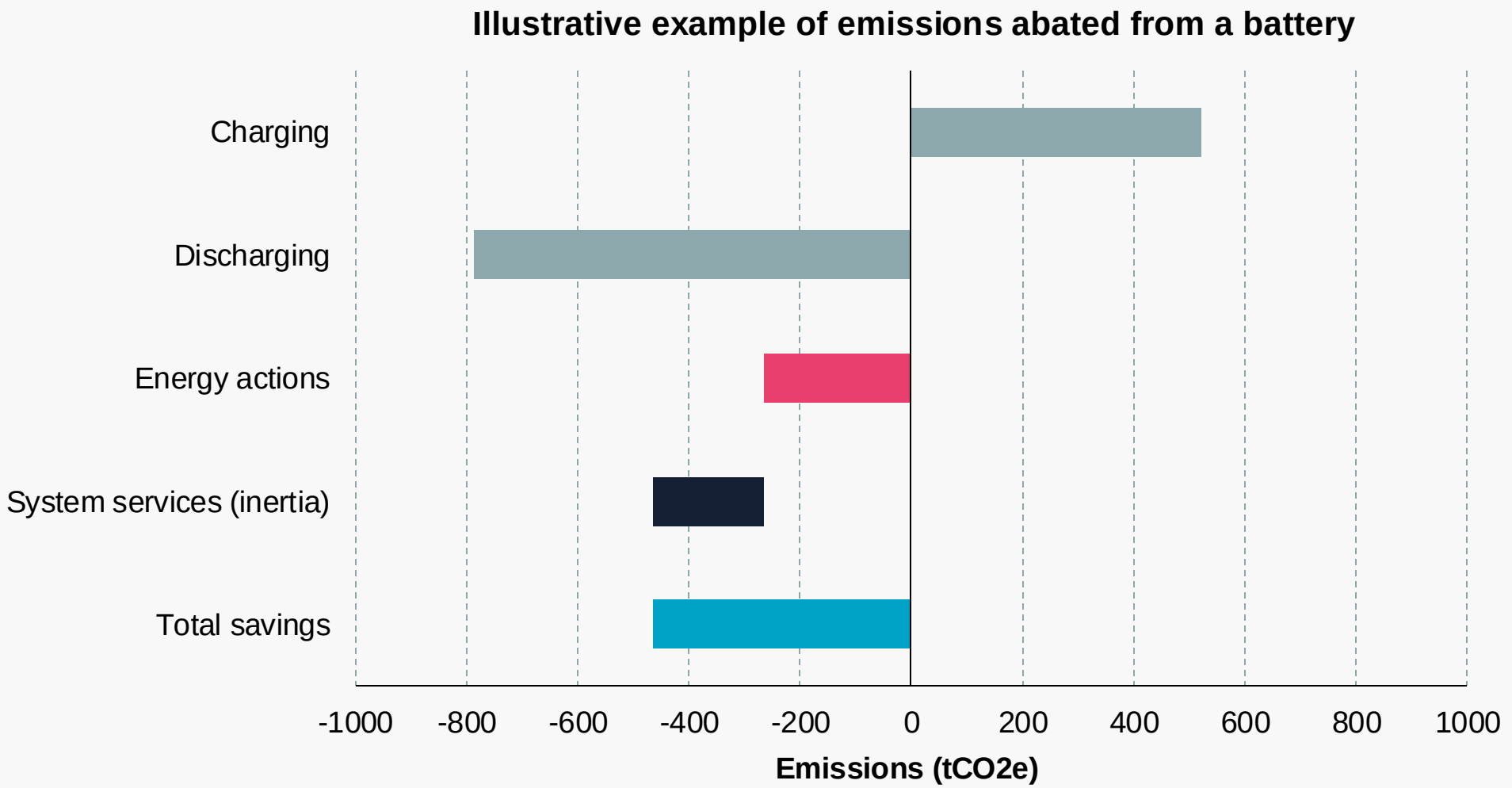


9

Aim 1: Developing a methodology



10


Illustrative example of emissions abated from a battery
Charging
Discharging
Energy actions
System services (inertia)
Total savings
-1000
-800
-600
-400
-200
0
200
400
600
800
1000
Emissions (tCO2e)

We have developed a free to use tool to allow users to certify their emissions

Project objectives

PDF

Certificate of Battery Emissions

LCP Delta and the National Wealth Fund certify that

Company X has run LCP Delta's BESS carbon emissions calculator tool on the **BESS asset X** battery asset. Based on the data provided, the battery

helped avoid **56.611** tCO_2e of emissions

due to the actions it took in the GB energy markets and ancillary services in the time period between 01/01/2024 and 08/02/2024.

The unique hash associated with this run is **215953392**, which can be recreated by running LCP Delta's BESS carbon emissions calculator tool with the same data.

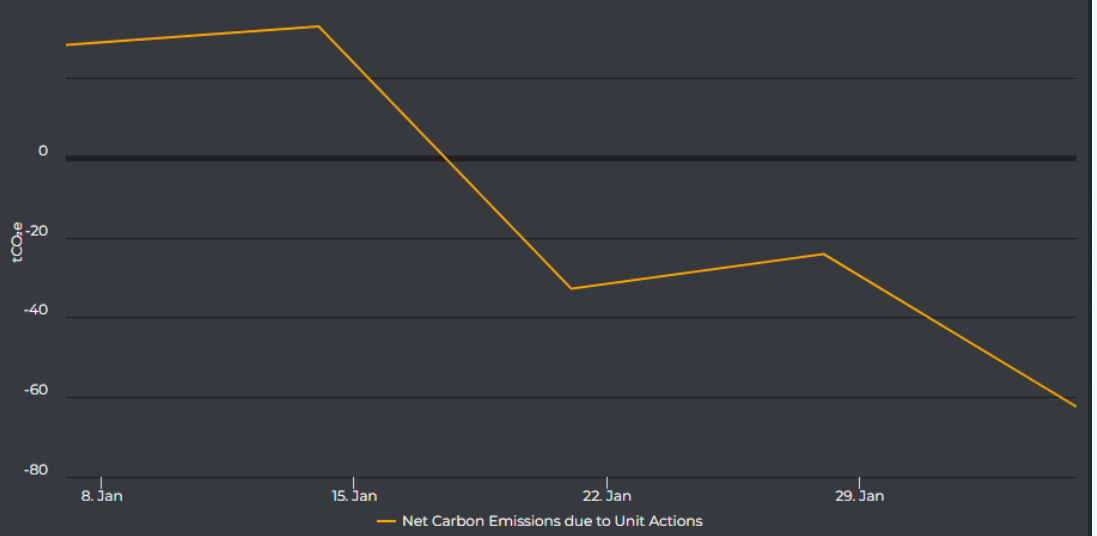
LCPDelta

NATIONAL WEALTH FUND

You can find detailed information on our open-source methodology here. Our disclaimer can be found here.

Total Emissions By Weekly Noncumulative

Upload new file | Excel



Summary Metrics

Settlemet Period Summary Metrics	Settlement Period	tCO_2e
Highest settlement period emissions	07/01/2024 09:30	7.79
Highest settlement period abatement	07/01/2024 17:30	5.03

01/01/2024 to 08/02/2024 Summary Metrics	
Number of abating settlement periods	1,357
Number of emitting settlement periods	474
Standard deviation of emitting settlement periods	1.17
Average of emitting settlement periods	0.76
Standard deviation of abating settlement periods	0.69
Average of abating settlement periods	0.31

enact.lcp.energy/bess-carbon-emissions-calculator

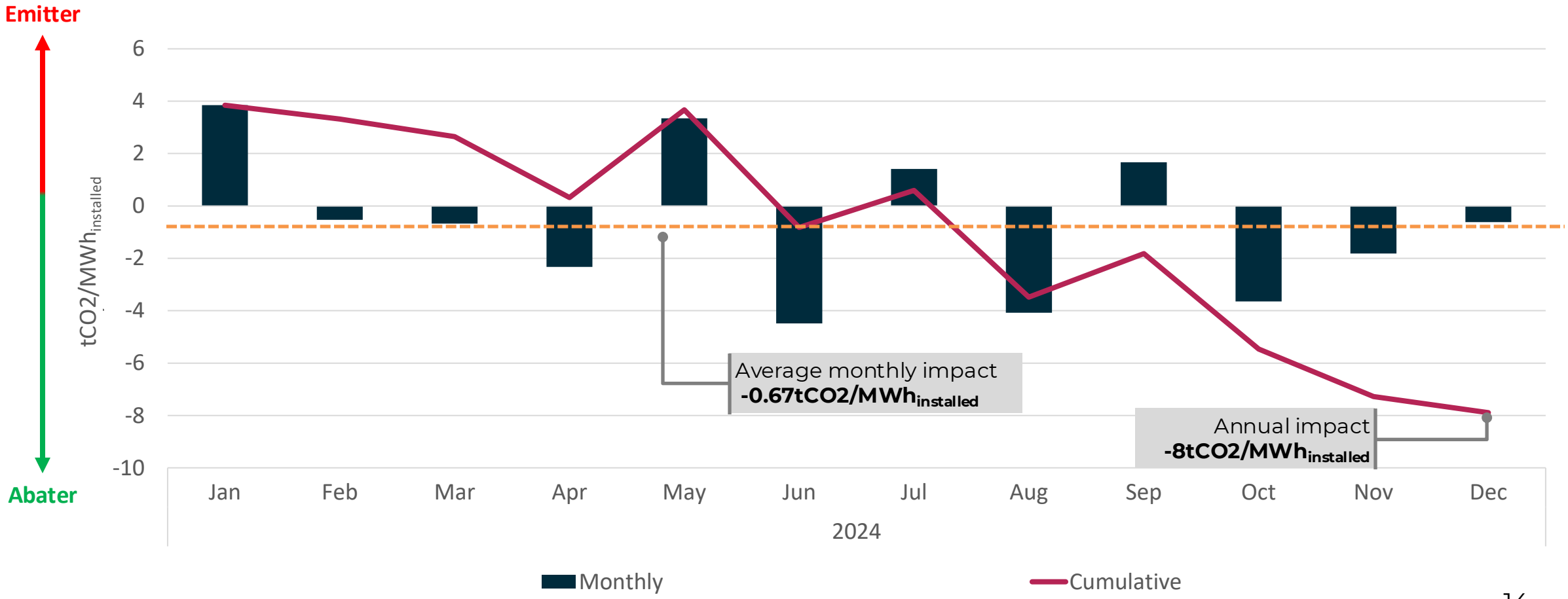
SCAN ME

Results

PCE – Andreas Gandolfo

PCE assets have successfully reduced grid emissions already

Monthly Emissions of PCE Projects in 2024

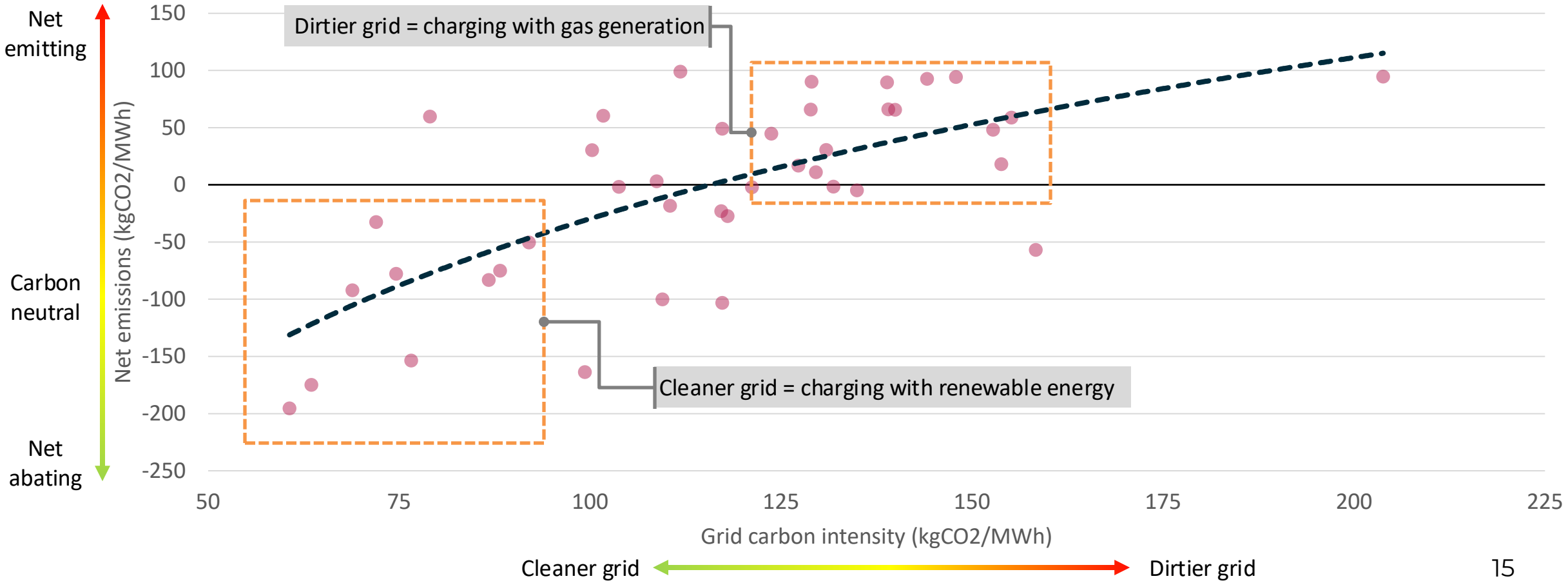


Combined power of 82MW and duration of 1.2 hours

Batteries' carbon impact on the grid relates to fossil fuel generation

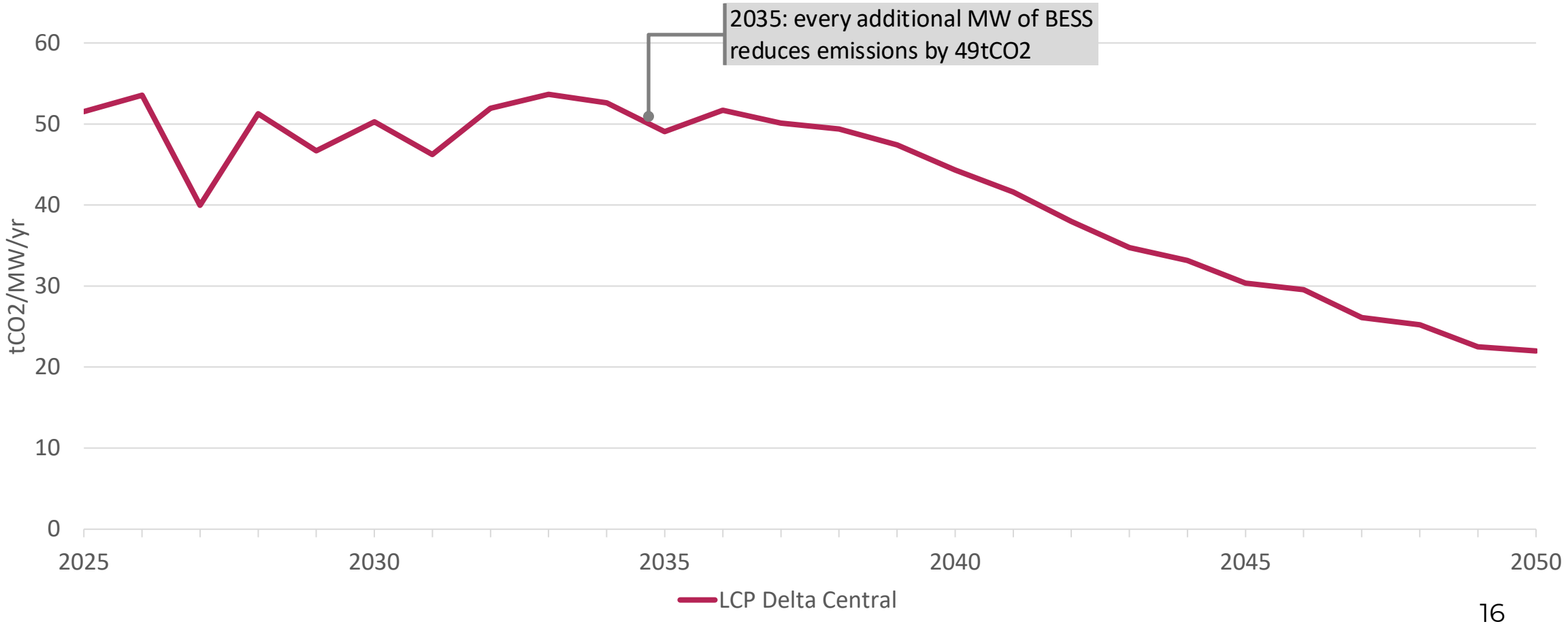
pulse clean energy

UK Grid Weekly Avg. Carbon Intensity vs. Carbon Impact per MWh Shifted by a PCE Battery



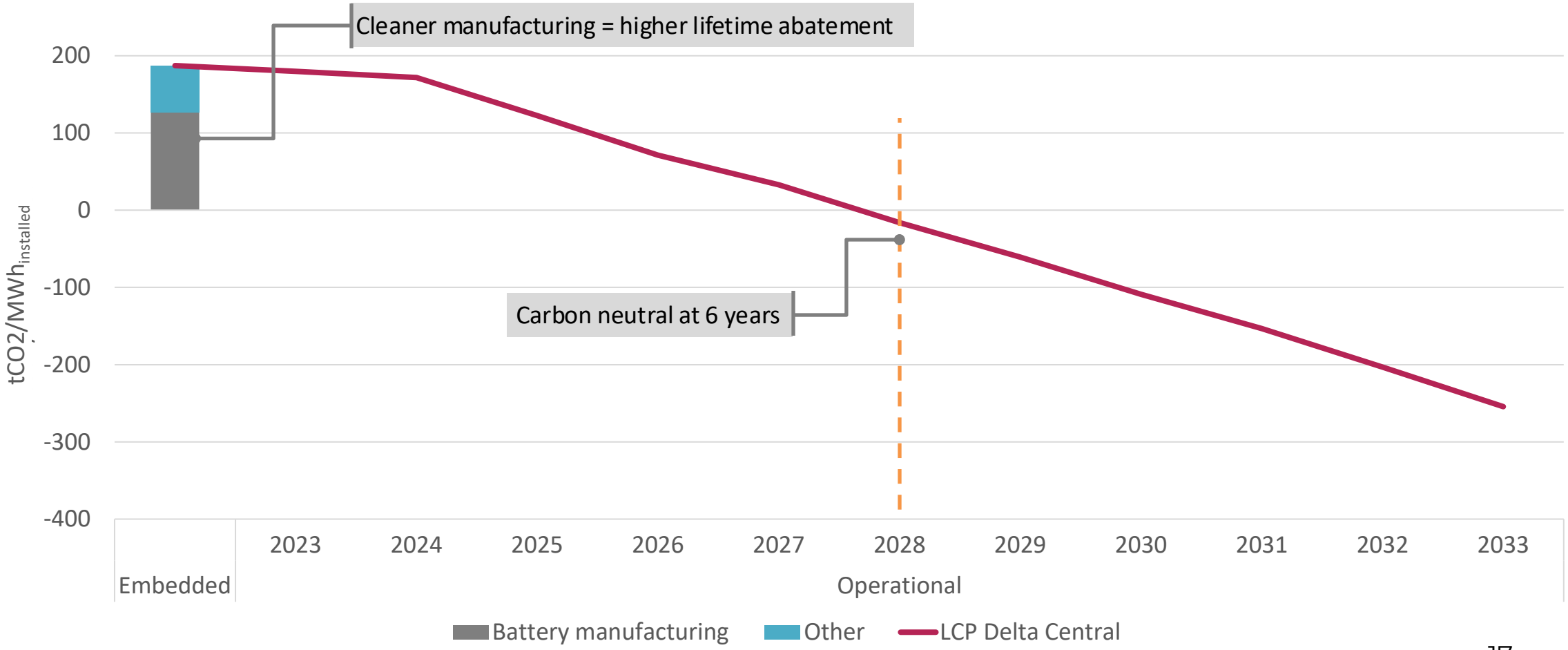
How the carbon impact of batteries evolves

Impact of Battery Capacity on UK Grid Emissions (average of 2 and 4 hr assets)



Lifetime emissions of PCE assets

Annual Trends in Lifetime Emissions of Operational PCE Batteries



Combined power of 82MW and duration of 1.2 hours

LCPDelta

Appendix

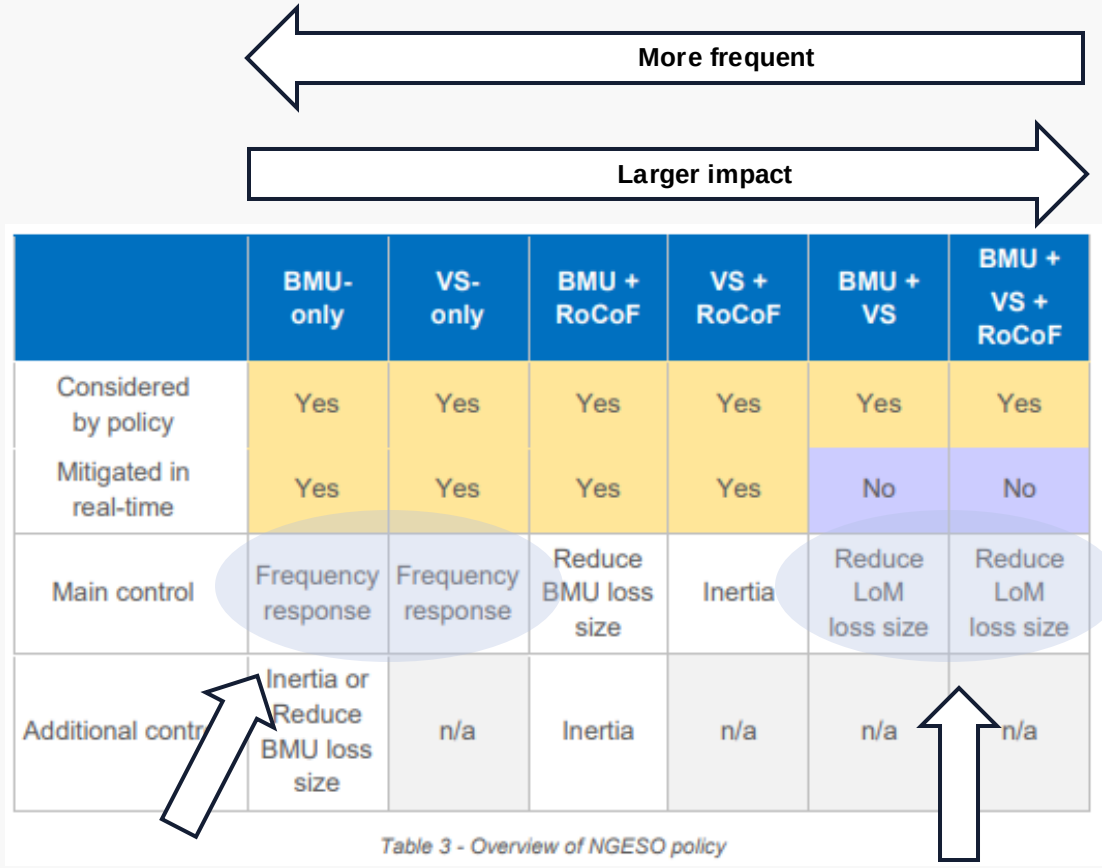
Batteries impact on emissions from System Solutions

How does a battery avoid emissions from System Solutions

ESO must maintain various **non-energy system requirements**, such as inertia. Historically these have been provided by **unabated generators**.

ESO has introduced new products and requirements which better account and reward technologies like batteries for their key characteristics. These changes have also resulted in a reduction in emissions related to the procurement of these services.

- **New Frequency Response Products:** by leveraging the quick reaction time of batteries, the ESO needs to take fewer carbon-intensive actions in the Balancing Mechanism.
- **Accelerated Loss of Mains Change Programme (ALoMCP):** by speeding up the process for upgrading special hardware in distributed generators, the ESO has reduced the risk of blackouts. This has allowed the ESO to lower the number of generators kept online for back-up.



	BMU-only	VS-only	BMU + RoCoF	VS + RoCoF	BMU + VS	BMU + VS + RoCoF
Considered by policy	Yes	Yes	Yes	Yes	Yes	Yes
Mitigated in real-time	Yes	Yes	Yes	Yes	No	No
Main control	Frequency response	Frequency response	Reduce BMU loss size	Inertia	Reduce LoM loss size	Reduce LoM loss size
Additional contr	Inertia or Reduce BMU loss size	n/a	Inertia	n/a	n/a	n/a

Table 3 - Overview of NGESO policy

New Dynamic suite can address smaller events automatically

ALoMCP has reduced the expected impact of less frequent but larger risk

Calculating inertia impact

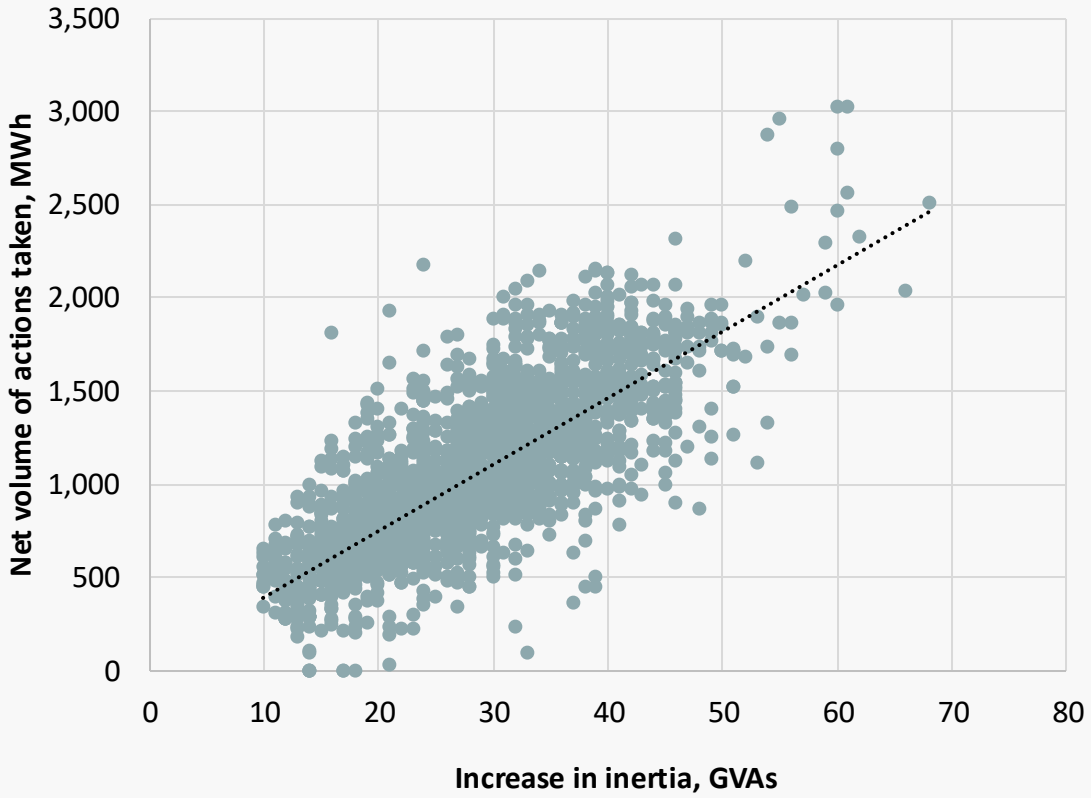
Mapping inertia increases with volume actions taken

In early 2023 the ESO started trials when it allows inertia to fall down to 120GVAs from the current minimum of 140GVAs.

During these lower inertia periods, the ESO would have taken action by turning on **synchronous generation in the Balancing Mechanism**.

In order to associate how much **emissions were avoided** from operating a low inertia system we first calculate what **volume of actions** would have been **needed** to **increase inertia** from **120 to 140 GVAs**.

We use a regression-based approach to model the relationship between the increase in inertia that is needed, and the corresponding net volume of actions taken by the ESO.



Increase in inertia: difference between outturn and market-provided inertia - which accounts for all balancing actions. The difference between these two values is the change in inertia that was caused by ESO balancing actions.

Net volume of actions taken: accepted bids and offers from synchronous generators that ESO marked to be 'turning on' or 'turning off'. The overall net volume of these actions is what ESO took in MWh with an impact on inertia.

Avoided emissions from System Solutions

Calculating avoided emissions from System Solutions

Calculate volumes associated with ESO actions when the initial market-provided inertia was between 120 and 140 GVAs

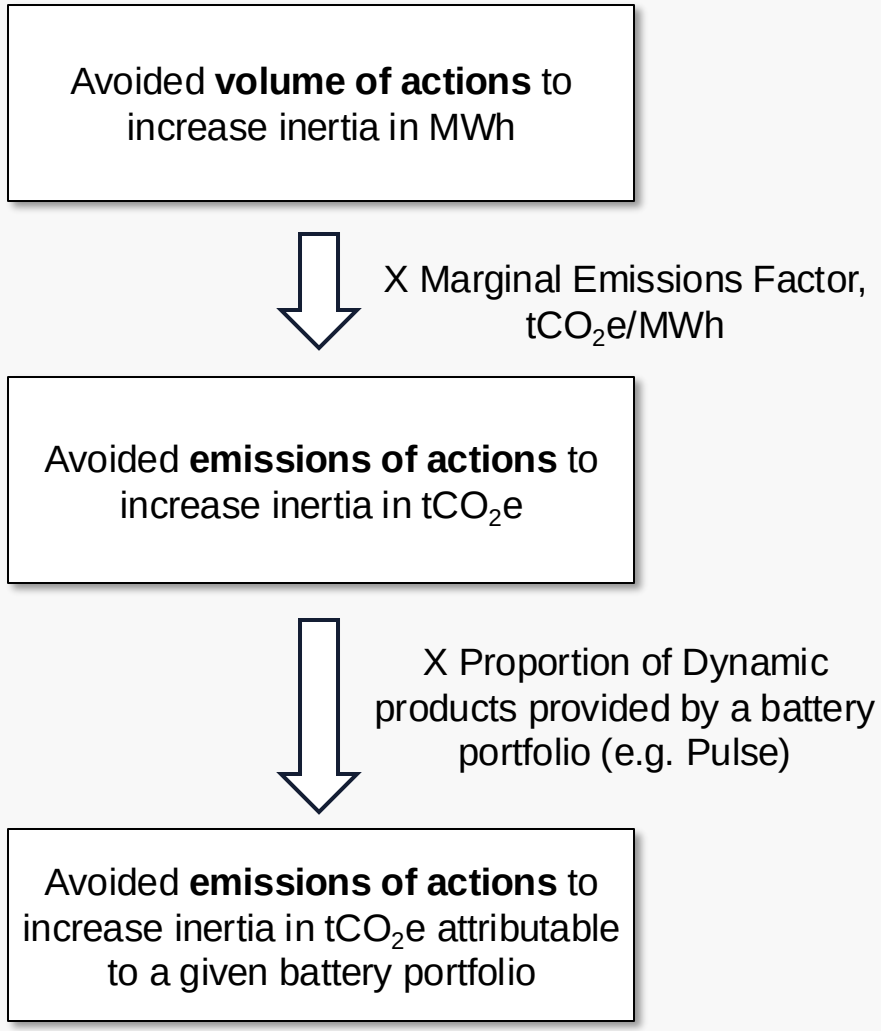
- ESO recently reduced the inertia requirement from 140 GVAs to 120 GVAs partly thanks to the adoption of the Dynamic flexibility products that are only provided by batteries.
- This means that in the past, ESO would have taken additional action in the time periods when the market provided inertia between 120 GVAs and 140 GVAs. These actions and their associated carbon emissions are now avoided.
- We calculate the volume of actions that would need to have been taken to increase inertia to 140GVAs using a regression-based model.

Calculate the MEF & avoided emissions for the volumes associated with ESO actions

- We calculate the avoided emissions for each period associated with this volume using a **Marginal Emissions Factor (MEF).** This MEF is a modified version of the one used to calculate emissions impacts of Energy Arbitrage actions, using only **offers** from **synchronous generators**, as these are the only possible actions that can increase inertia in these circumstances.

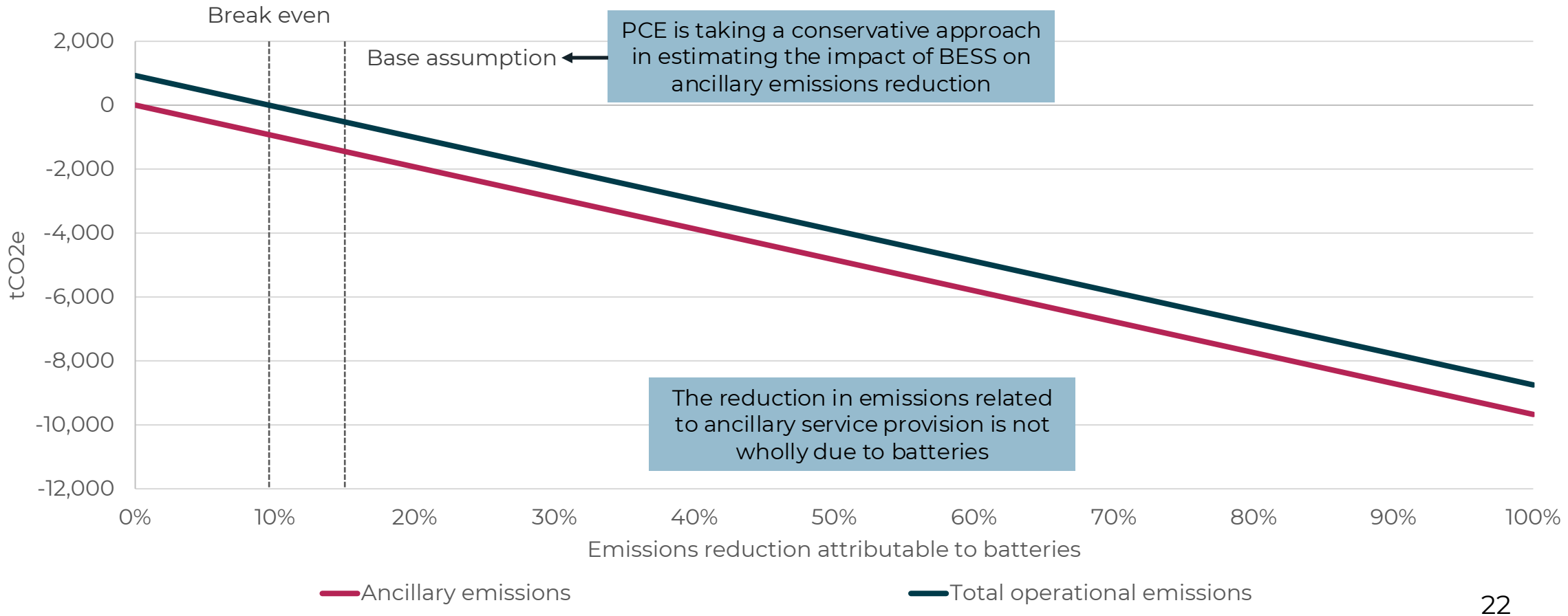
Assign the share of avoided emissions to a given battery, or battery portfolio

- Finally, we assign a share of these avoided emissions to a given battery portfolio depending on the proportion of the ESO's Dynamic products they were providing in each period, as it is thanks to the Dynamic products that these actions are now not taken.



Ancillary service carbon impact requires assumptions

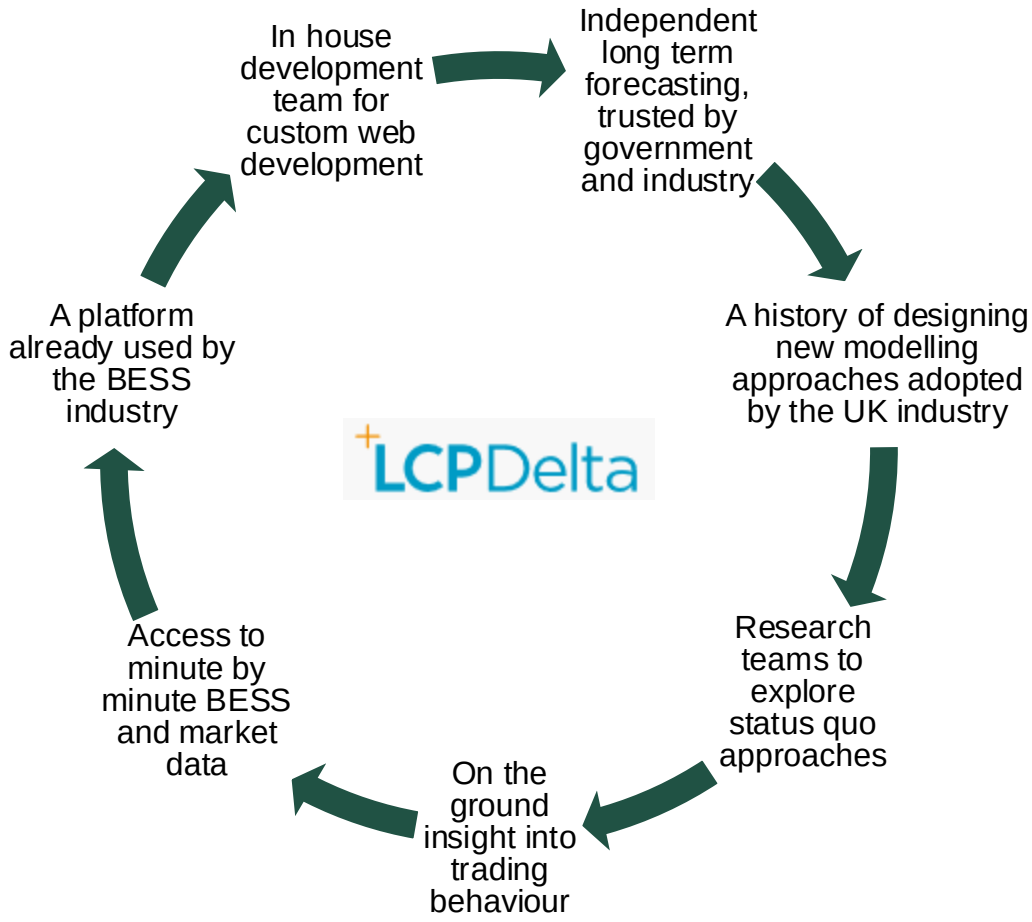
PCE project operational emissions as a function of ancillary emission reduction attribution



Data for Briton Ferry, Flatworth, Tir John, Willoughby

Why LCP Delta

LCP Delta brought together a number of teams spanning on the ground research, power trading and operations, web development and long term forecasting to work with Pulse Clean Energy and the National Wealth Fund to deliver this project.



LCP Delta

About LCP Delta

LCP Delta provides data-driven consultancy, research, technology products and training services to companies investing in and navigating the energy transition.

Generation ← ***Coverage across the full Energy value chain*** → **Consumer Demand**

Our People

120+ Energy transition experts:

- Power system modellers
- Economists and policy experts
- Researchers
- Market Specialists
- Technical specialists

Our Expertise

Pan European client/research base covering:

- Grid-scale generation
- Storage
- Solar
- Networks
- Hydrogen
- Electrification of heat
- Flexibility services
- EV charging
- Home Energy Management

Our Clients

250+ clients across multiple sectors:

- Investors
- Regulators
- Utilities
- Governments
- Developers
- Asset owners
- OEMs
- Manufacturers
- Policy associations
- Power traders

We help clients across the full energy storage value chain, enabling them to build a successful storage business, from strategic advice and market entry through to financing, operation and sale.

Strategy

- In depth research to identify which European market to enter and when
- Regular reports on policy, regulatory, country and key player trends
- Europe's leading database of storage projects and players to identify the best partnerships and opportunities

Financing

- Bankable revenue forecasting, trusted by industry, government, equity and debt for ~15 years for buy and sell side.
- Fundamental first modelling to capture a changing power system, rooted in the reality of on the ground trading
- Stochastic approach to help clients minimise risk through understanding full range of outcomes

Operations and insights

- Benchmarking storage performance through leaderboards and custom indices for asset owners, diving deep into trading strategy.
- Real time trading support and storage specific workflows for optimisers, with advanced weather and imbalance forecasting.
- An insights service that produces regular research into policy, regulation and market events to keep your finger on the pulse.

"We've worked closely with LCP for almost a decade, and they've provided us with market-leading analysis and modelling tools to support key commercial decisions. They get to grips with the most significant issues and invariably deliver significant insights."

Mark Jones, UK market analysis manager

RWE

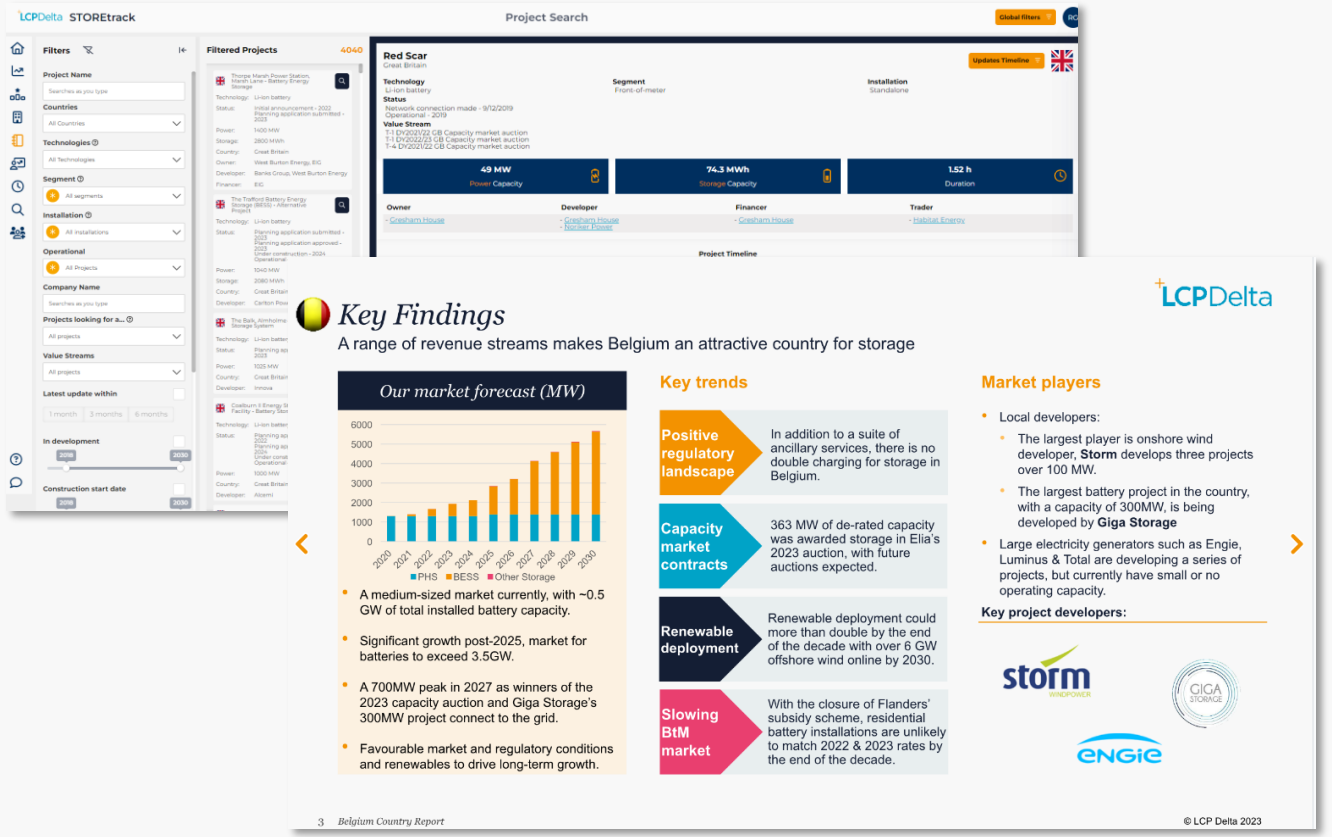
Our research services provide unparalleled insight into the evolution of the storage sector, ensuring our clients can anticipate market trends and enter markets at the right time

The European Storage Research Service

The European storage research service publishes regular analysis, commentary and data across Europe covering the evolution of policy, regulation and the competitive landscape. This allows clients to understand at a country and technology level the attractiveness of each market.

This team also produce the flagship annual market monitor for EASE, and maintains a database of 4,000+ storage projects, tracking key players and milestones.

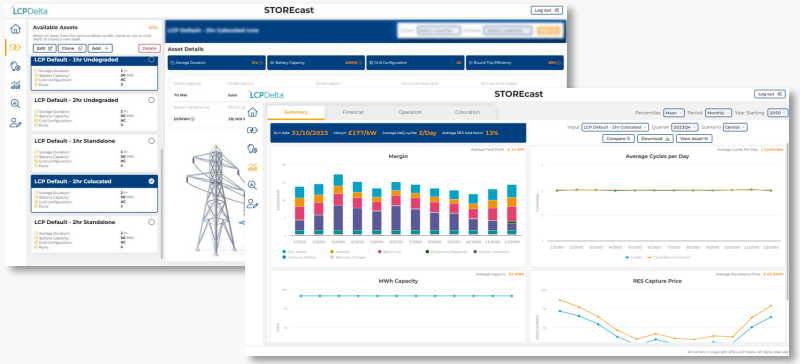
The service is primarily aimed at investors, developers and manufacturers to keep their fingers on the pulse of the key trends, landscapes and players in each European storage market, to help formulate their next strategic steps and develop key partnerships.



"The geographic coverage of your research, combined with the quality of analyst interaction really impressed us and made us want to expand this partnership"

Pulse Clean Energy

We have been at the forefront of power market modelling for 15 years, providing modelling that has driven market wide reform, shaped policy and underpinned £billions of investment decisions. We offer storage forecasts off the shelf through our fully customisable, self-serve STOREcast platform, or through our bespoke consulting service.



- **Deeply embedded** with GB power market decision makers and at the forefront of evolving policy and regulation, supporting over 100 clients with GB power market forecasts.
- A reputation for **independent, trusted, bankable** advice, delivered through rigorous models that are used extensively by government, industry and financers, built and maintained in-house and **continuously updated**.
- Extensive experience **modelling storage** assets, including developing a standalone platform for self-service storage revenue forecasting with high configurability.
- **Real world expertise** in how storage assets are traded, powered by working with storage optimisers and owners through our Enact platform, uniquely placing us to review trading arrangements.
- In depth research of **the full value chain** to ensure our scenarios capture the evolution of flexibility and demand side behaviour, powered by our storage and flexibility research services.
- Supported £billions of energy transition investment through **commercial due diligence** projects
- Significant experience in producing ad-hoc policy insight and analysis for lobbying in conjunction with our **Economics and Policy team.**

"We engaged with LCP because we want reliable and consistent market forecasts. Their analytical approach to forecasting has provided us with invaluable insights into the fundamental factors driving the UK electricity market through the energy transition"

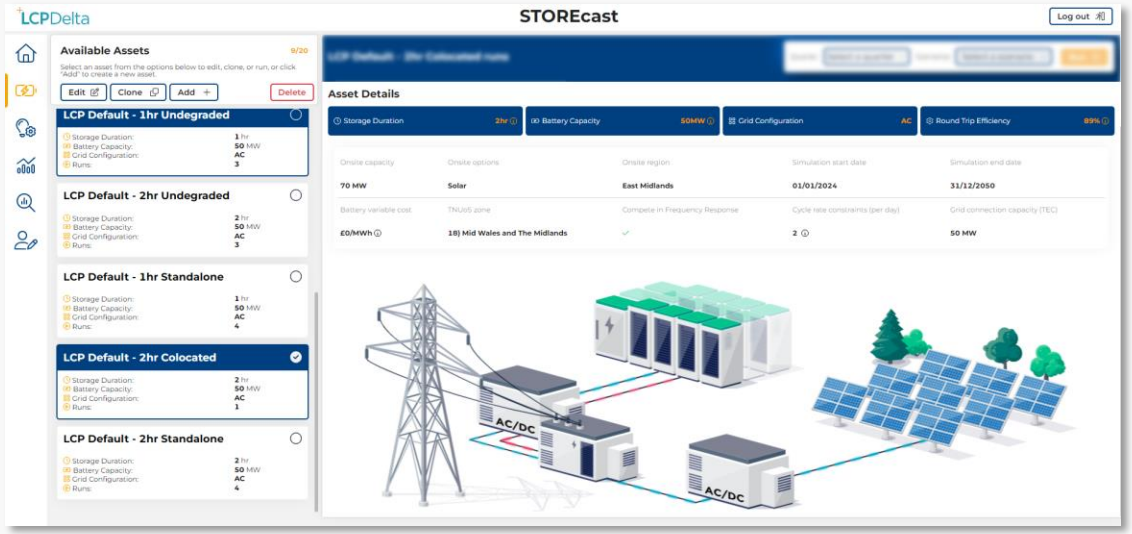
Tom Vernon, Managing Director

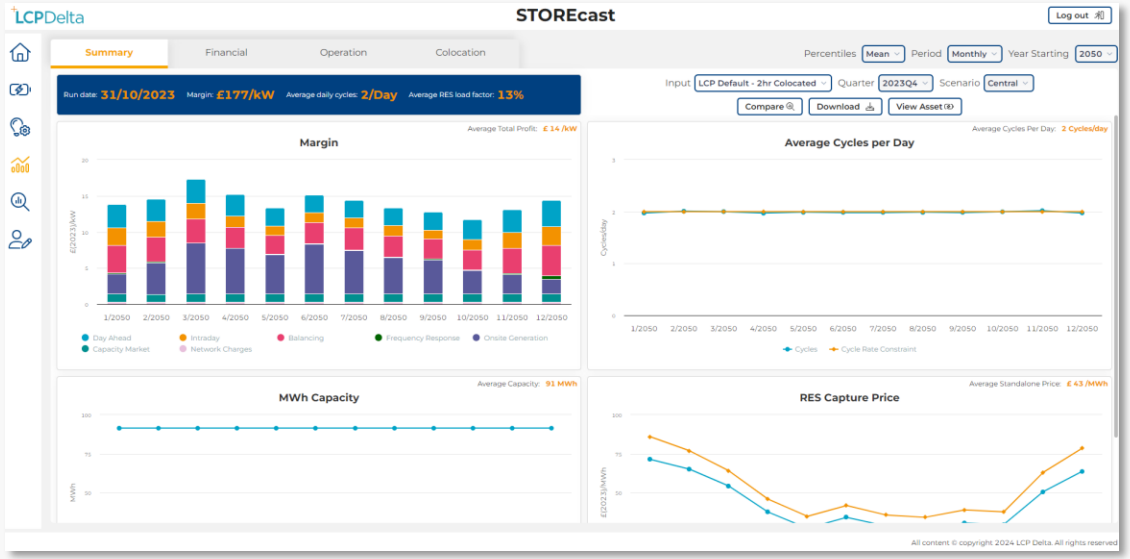
STATERA BALANCING THE GRID

We provide quarterly forecasts for BESS assets (standalone and co-located) through our highly customisable STOREcast platform, combining the ease of a subscription service with bespoke configurability

Our STOREcast platform

- **Quarterly updates** to storage forecasts under LCP Delta's Central, Low & High scenario, with the option to develop custom scenarios with clients.
- Clients can configure their own **bespoke storage assets** (in addition to generic assets provided) specifying: location, efficiency, costs, solar and wind co-location options, grid configuration and cycling limits, rather than relying on generic curves or libraries.
- Uses LCP Delta's **trusted models** that have been used to support Government, NESO and the majority of the UK power industry for over a decade
- Results can be downloaded into excel format and each quarterly update comes with an **accompanying report** summarising assumptions & results.





Our Enact platform

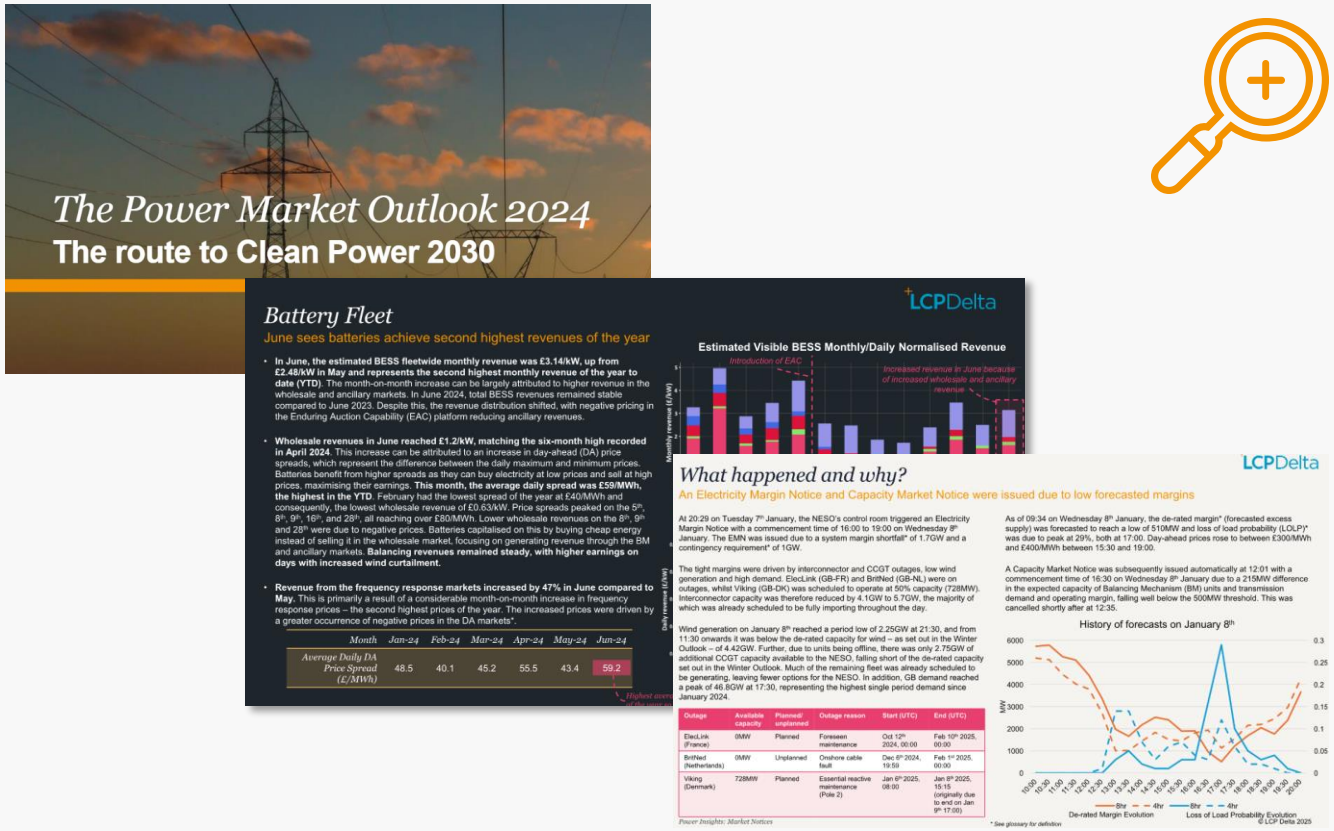
- Enact is a SaaS platform that provides analysts and traders with **real-time trading analytics**. Enact integrates data from a range of sources and provides intuitive visualisations and real-time NIV/system price forecasts to help traders make better decisions.
- Access to this tool allows asset owners to monitor individual assets' profits and strategies, benchmark performance and deep dive into trading strategy, through leaderboards, indices and specific analytical workflows
- High level of customisation enables clients to increase the level of sophistication of their analysis, and facilitate meaningful, data-driven conversations between route to market providers and asset owners.

"We required a platform to help us make decisive investment decisions across the power space, with a particular interest in assessment of trading strategies and benchmarking of battery storage assets. After assessing multiple platforms on the market, Enact was the clear choice. It was the only platform where we could perform both macro, high level analysis as well as micro, detailed investigations in a quick, easy and extremely user-friendly manner."

Leading UK storage asset owner

Our Power Insights Service

- A collection of must-have research services for UK power market participants.
- **Market Frameworks** provides key analysis on power and gas markets, including policy and regulatory shifts, and the impact they will have on investors and asset owners.
- **Market Operations** provides regular and ad-hoc insight into the operations of the UK market, including research papers on optimiser trading strategy, summaries of BESS performance and the impact of market reforms on revenues and operations.
- **Market Forecasts** provides our bankable regular forecasts for BESS and all technology types, with commentary on how changing conditions impact future revenue outlook.



"The team at LCP Delta demonstrated a unique insight into power markets and government workings to allow us to assess how policy changes could impact us as investors in the UK."

Ross Grier, Managing Director

Contact us

Rajiv Gogna
Partner
+44 (0)20 7550 4594
rajiv.gogna@lcp.uk.com

Bertalan Gyenes
Consultant
+44 (0)20 7432 0613
Bertalan.Gyenes@lcp.com

About LCP Delta

LCP Delta is a trading name of Delta Energy & Environment Limited and Lane Clark & Peacock LLP. References in this document to LCP Delta may mean Delta Energy & Environment Limited, or Lane Clark & Peacock LLP, or both, as the context shall require.

Delta Energy & Environment Limited is a company registered in Scotland with registered number SC259964 and with its registered office at Argyle House, Lady Lawson Street, Edinburgh, EH3 9DR, UK.

Lane Clark & Peacock LLP is a limited liability partnership registered in England and Wales with registered number OC301436. All partners are members of Lane Clark & Peacock LLP. A list of members' names is available for inspection at 95 Wigmore Street, London, W1U 1DQ, the firm's principal place of business and registered office. Lane Clark & Peacock LLP is authorised and regulated by the Financial Conduct Authority and is licensed by the Institute and Faculty of Actuaries for a range of investment business activities.

LCP and LCP Delta are registered trademarks in the UK and in the EU. Locations in Cambridge, Edinburgh, London, Paris, Winchester and Ireland.

https://www.lcp.uk.com/emails-important-information contains important information about this communication from LCP Delta, including limitations as to its use.

Disclaimer and use of our work

This work has been produced by LCP Delta under the terms of our written agreement with Pulse Clean Energy (Client) for the Client's sole use and benefit, subject to agreed confidentiality provisions, and for no other purpose. To the greatest extent permitted by law, unless otherwise expressly agreed by us in writing, LCP Delta accepts no duty of care and/or liability to any third party for any use of, and/or reliance upon, our work. This document contains confidential and commercially sensitive information. Should any requests for disclosure of information contained in this document be received, LCP Delta request that we be notified in writing of the details of such request and that we be consulted and our comments taken into account before any action is taken.

LCP Delta is not able to provide legal advice and you may therefore wish to speak to your legal adviser on this matter.

Where this report contains projections, these are based on assumptions that are subject to uncertainties and contingencies. Because of the subjective judgements and inherent uncertainties of projections, and because events frequently do not occur as expected, there can be no assurance that the projections contained in this report will be realised and actual events may be difference from projected results. The projections supplied are not to be regarded as firm predictions of the future, but rather as illustrations of what might happen. Parties are advised to base their actions on an awareness of the range of such projections, and to note that the range necessarily broadens in the latter years of the projections.