Notes on Completion: Please refer to the appropriate NIA Governance Document to assist in the completion of this form. The full completed submission should not exceed 6 pages in total. Network Licensees must publish the required Project Progress information on the Smarter Networks Portal by 31st July 2014 and each year thereafter. The Network Licensee(s) must publish Project Progress information for each NIA Project that has developed new learning in the preceding relevant year.

NIA Project Annual Progress Report Document

Date of Submission

Jul 2025

Project Reference Number

NIA2_NGESO063

Project Progress

Project Title

Causal Analysis of Balancing Costs

Project Reference Number

NIA2_NGESO063

Funding Licensee(s)

NESO - National Energy System Operator

Project Start Date

April 2024

Project Duration

1 year and 7 months

Nominated Project Contact(s)

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Scope

The tools used to balance the system are extremely complex with many different behaviours that contribute to balancing costs. For example, improvements to Balancing Services Use of System (BSUoS) forecasts have been made, but these do not deal with fine-grained influences on balancing costs. Similarly, the effect of interconnectors on balancing costs have been identified but these are not yet fully understood. The aim of this project is to use the wealth of data being collected at system and market levels to comprehensively quantify the probability that certain conditions lead to the greatest balancing costs. The project will consider the Balancing Mechanism, balancing services, and energy trading throughout the causal analysis on balancing costs.

Previous work has shown how semi-parametric modelling may allow for the modelling and predicting unscheduled flows over the EU; this project will build upon this research. The project will also look to build a prototype tool that can be used by the control room to identify the probability of a high balancing cost outcome

Objectives

- Develop a methodology for identifying the most probable factors that impact balancing costs.
- Identify a prioritised factor and identify the key influences on this prioritised factor when considering balancing costs.
- Develop a tool using open-source code that can identify the probability of a high balancing cost outcome when operating the system.

Success Criteria

- At least six influencing factors on balancing costs identified and reviewed.
- Clear methodology developed to quantify the probability of factors leading to certain cost outcomes.
- Single prioritised factor identified and developed further to establish key influences on this in relation to balancing costs.
- Open-source code tool developed to identify probability of higher cost outcomes.

Performance Compared to the Original Project Aims, Objectives and Success Criteria

National Energy System Operator ("NESO") has endeavoured to prepare the published report ("Report") in respect of Causal Analysis of Balancing Costs, NIA2_NGESO063 ("Project") in a manner which is, as far as possible, objective, using information collected and compiled by NESO and its Project partners ("Publishers"). Any intellectual property rights developed in the course of the Project and used in the Report shall be owned by the Publishers (as agreed between NESO and the Project partners).

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As of May 2025, the report has progressed in line with its original aims, objectives, and success criteria. We set out to conduct causal and statistical analysis with world-leading experts from Imperial College London to identify the quantitative impact of different influences on Balancing Costs. The work is still ongoing and is expected to produce its final results in the next few months, but a particular sub-section of the analysis – honing in on a specific influence of Balancing Costs (Wholesale Prices) and seeing how different factors affect that influence – has yielded the expected results. This has been a reassuring test of the methodology for the broader project.

The order of work has been rearranged. WP2(A) – in depth analysis, was completed first in order to test/hone the methodology for suitability for the more critical work on balancing costs. This work identified a quantitative impact of wind and solar generation on wholesale prices, which is in turn a significant impact on balancing costs. These results were reliable and reasonable and gave us high confidence to continue the work on the broader research into balancing costs. It has also resulted in the publication of material at a conference (EEM25).

In terms of WP 1 – Research, the initial phase of the project will include a comprehensive overview of all major influences on balancing costs. This will cover at least six different factors and will likely include observations into wind generation, constraint management, outage optimisation, and interconnector swings. A methodology based on semi-parametric modelling and causal discovery will be developed based on these influences to quantify the probability that certain conditions lead to certain cost outcomes. An initial review will be used to prioritise which influences have the greatest impact, and which the ESO have the greatest control of in terms of mitigations. The qualitative relationships have been established and quantified. We are now in the process of confirming the conclusions from this study.

Once the conclusions have been established, we will begin work on the prototype tool (WP 2(B)).

As the final results are produced, we will continue to see what inferences and conclusions can be drawn from them, and whether they can be used to produce the forecasting tool of costs that was originally intended.

Required Modifications to the Planned Approach During the Course of the Project

The steps in which the analysis would be conducted have changed over the course of the project. We initially planned to carry out the overall analysis on the influences of Balancing Costs first, and then select a specific influence for a deep-dive. However, we decided to swap the order of these two components, as conducting the deep-dive on one specific influence first allowed us to test the methodology and assess whether the results were suitable for the project's aims.
So, there have been no major changes to the project's scope other than a reordering of the phases.

Lessons Learnt for Future Projects

It has been helpful having regular catch ups with Imperial College on a weekly basis, this has allowed for regular steering and discussion of the analysis. We have a very experienced data scientist working with Imperial, helping to triage which data should be

used when, and this has made the project collaboration easier than anticipated.

Note: The following sections are only required for those projects which have been completed since 1st April 2013, or since the previous Project Progress information was reported.

The Outcomes of the Project

To be yielded at the end of the project:
The project aims to develop a methodology for producing a prototype tool that can identify the probability of high balancing costs outcomes and inform the control room on mitigation strategies. A key benefit of this project is understanding how various factors impact balancing costs specifically. For example, reducing the impact of interconnector swings during a single interval could result in significant savings in balancing costs. Identifying these key factors will also contribute to our balancing cost strategy, enabling prioritisation of actions that have the greatest effect on these costs and providing clarity for our control room's decision-making process.

To date, the project has had several reports output as well as scripts for the prediction and analysis of various elements of balancing costs including thermal constraint limits, impacts of wind and solar and more. The impact of wind and solar on market prices method, which uses a double machine learning approach for causal inference can be found here: GitHub - dcacciarelli/market-impact-renewables).

The following reports have been delivered as outputs of the project work:
1.Problem Statement and Literature Review
2.Day-Ahead Wind Forecast and Wholesale Prices
3.Causational Analysis of Balancing Costs

Data Access

Details on how network or consumption data arising in the course of NIA funded projects can be requested by interested parties, and the terms on which such data will be made available by NESO can be found in our publicly available "Data sharing policy related to NIA projects (and formerly NIC)" and Innovation | National Energy System Operator.

National Energy System Operator already publishes much of the data arising from our NIA projects at www.smarternetworks.org. You may wish to check this website before making an application under this policy, in case the data which you are seeking has already been published.

Foreground IPR

n/a - information will be provided after project is completed