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# NIA Project Registration and PEA Document

### Date of Submission

May 2024

### Project Reference Number

NIA2_NGESO063

## Project Registration

### Project Title

Causal Analysis of Balancing Costs

### Project Reference Number

NIA2_NGESO063

### Project Licensee(s)

National Energy System Operator

### Project Start

April 2024

### Project Duration

1 year and 7 months

### Nominated Project Contact(s)

innovation@nationalgrideso.com

### Project Budget

£330,000.00

### Summary

Balancing costs have been increasing significantly over the past three years and are forecast to increase even further out to 2030. There are many factors which influence increasing balancing costs. Identifying what system conditions lead to higher-cost outcomes, and which of these have the most significant effect, is vital to improve control room decisions and to ensure the ESO's balancing cost reduction strategy is fit for purpose. This project will deliver a method to quantify the probability that certain conditions will lead to high balancing costs, and a more detailed causal and statistical analysis will then be completed for the most impactful factors identified. If successful, the methodology will be used to produce a prototype tool that can identify the probability of high balancing costs outcomes and inform the control room on how to best mitigate these conditions.

### Preceding Projects

NIA2_NGESO022 - BC Forecasting

### Third Party Collaborators

I C Consultants

### Nominated Contact Email Address(es)

Innovation@neso.energy

## Problem Being Solved

The Balancing Mechanism, balancing (ancillary) services, and ESO energy trading are the tools used to balance the energy system. Whilst the electricity market in the UK operates on the principle of self-dispatch, to manage the resulting imbalances between supply and demand the ESO will re-dispatch to manage energy imbalances and system constraints. Balancing costs are those costs associated with the Balancing Mechanism, balancing services, and energy trading.

Due to the complex nature of balancing the grid, there are many different segments that contribute to the overall balancing costs. The cost of actions for energy and system imbalances depends on the submitted bids and offers into the Balancing Mechanism by market participants. The ESO will re-dispatch BMUs in the most economically efficient way, given system security can be maintained.

Balancing costs have been increasing significantly over the past three years, from less than £2bn in 2020 to over £4bn in 2022, it is likely as the ESO is required to intervene in generators' schedules more and more, that these costs will increase even further out to 2030. There are many factors which influence increasing balancing costs, including wind generation, constraint management, outages, interconnector behaviour, wholesale prices, among many others. Identifying what system conditions lead to higher-cost outcomes, and which of these have the most significant effect, is vital to improve control room decisions and to ensure the ESO's balancing cost reduction strategy is fit for purpose.

## Method(s)

This project will seek to quantify the probability that certain conditions will lead to high balancing costs, and will consider the Balancing Mechanism, balancing services, and energy trading as a resulting cost. The research is open and investigative in identifying the factors and conditions leading to these high-costs, and it is one of the objectives to identify the most impactful factors that result in high costs. The project will be delivered in 3 key work packages:

**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.

**WP 2(a) – In depth analysis**

The most impactful factor from phase 1 that the ESO has control over mitigating will be prioritised for a more detailed causal and statistical analysis to produce a more granular output of methodologies. This phase will outline the methodology to identify conditions that lead to this cause being particularly influential on balancing costs.

**WP 2(b) – Prototype tool** (Stage gate will be present prior to starting this phase.)

The methodology developed in earlier phases will be used to produce a prototype tool for the control room that can identify the probability of high balancing cost outcomes and inform the control room decisions on how they can best mitigate these conditions.

The threshold for what is considered as a high-cost day will be reviewed continuously throughout the project.

In line with the ENA's ENIP document, the risk rating is scored Low:
TRL steps = 1 (2 TRL step)
Cost = 1 (<£500k)
Suppliers = 1 (1 supplier)
Data assumptions = 2
Total = 5

## 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

## Objective(s)

- 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.

## Consumer Vulnerability Impact Assessment

This project has been assessed as having a neutral impact on customers in vulnerable situations because it is a transmission project.

## 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.

## Project Partners and External Funding

Imperial Consultants are the primary partner on this project
No external funding to be provided.

## Potential for New Learning

The primary learnings from this project can be summarised in three main ways:

Firstly, identifying in a definitive and quantitative manner which factors are influencing Balancing Costs, for example wind outturn, network outages, generator outages, wholesale prices, interconnector behaviour, etc; this will help inform the ESO's strategy to better tackle Balancing Costs in the future. It will also help the ESO identify new initiatives, such as a new market or service, that can be provided to reduce costs. This will enable prioritisation of new and existing initiatives to better communicate the ideal strategy to keep minimising Balancing Costs.

Secondly, the prototype tool to be developed within this project has the potential to be of value to the control room for use on a day-to-day basis. This may improve understanding of how certain system conditions and control room decisions can result in higher Balancing Costs. The potential for new learning will be shown in how the control room may better understand what will lead to high Balancing Costs.

The third main learning is gained from the benefit of working with some of the leading data scientists in the world at Imperial College London. The methods and analysis that are being used in this project are new and novel to the ESO and have not been conducted before. Working with Imperial to develop this study will improve the capability of the ESO's data scientists, incorporating vanguard techniques in data science and understanding of European electricity markets.

## Scale of Project

This project will be delivered over 18 months, with phase 1 taking place first over 7 months, and phase 2a & 2b then being completed in parallel over 11 months considering the results from phase 1.

## Technology Readiness at Start

## Technology Readiness at End

| | |
|---|---|
| TRL5 Pilot Scale | TRL7 Inactive Commissioning |

## Geographical Area

This project is applicable for GB system operation, is being delivered by UK based suppliers and is funded by National Grid ESO, it therefore has a geographical scope of Great Britain.

## Revenue Allowed for the RIIO Settlement

None

## Indicative Total NIA Project Expenditure

£330,000

# Project Eligibility Assessment Part 1

## Requirement 1

Facilitate the energy system transition and/or benefit consumers in vulnerable situations

Please answer **at least one** of the following:

## How the Project has the potential to facilitate the energy system transition:

Balancing costs have been increasing significantly over the past three years and are forecast to increase even further out to 2030. Quantifying which behaviours and conditions influence balancing costs most significantly will help to create clarity for the control room in decisions and help to reduce balancing costs.

## How the Project has potential to benefit consumer in vulnerable situations:

N/A

## Requirement 2 / 2b

Has the potential to deliver net benefits to consumers

Project must have the potential to deliver a Solution that delivers a net benefit to consumers of the Gas Transporter and/or Electricity Transmission or Electricity Distribution licensee, as the context requires. This could include delivering a Solution at a lower cost than the most efficient Method currently in use on the GB Gas Transportation System, the Gas Transporter's and/or Electricity Transmission or Electricity Distribution licensee's network, or wider benefits, such as social or environmental.

## Please provide an estimate of the saving if the Problem is solved

N/A

## Please provide a calculation and/or description of the expected benefits of the solution

Balancing costs incurred in 2022 were upwards of £4bn. Although they have decreased in 2023 to £2.8, the ESO should continue to produce and lead initiatives that will continue to reduce Balancing Costs and reduce the likelihood that high Balancing Costs are incurred. These are a cost that are paid for by both Generators and Suppliers, and ultimately gets passed onto consumers.. It is one of ESO's primary objectives to operate an economically efficient electricity grid.

The specific economic benefits of this project will depend on the project findings and how any resolutions could be implemented in the future. For example, if there was just one interval in which the ESO were able to reduce the impact of interconnector swings, it could save millions in balancing costs.

The ESO have generated the opportunity to achieve up to £18bn in savings through leading initiatives such as the Holistic Network Design, REMA, new markets and many more. More information on these initiatives can be found on the ESO's Balancing Costs webpage. This project will inform what future initiatives may be designed, how they may reduce Balancing Costs, and how they should be prioritised against one another. Informing the ESO's Balancing Costs strategy will be a major benefit from this project. This project is expected to begin informing the ESO's Balancing Costs strategy within the first 6-months of its work.

More directly, one of the deliverables of this project is a tool to be used by the control room at the ESO to identify the current system conditions and potential control room decisions and produce a probability that there may be a high-cost day. This tool will be crucial in informing the control room how they may remediate system conditions that lead to high-cost days and avoid decisions that lead to high-cost days. The benefits of this tool can be significant as some days have reached upwards of £20m in costs in 2023 to manage balancing the system. The ESO can realise a significant amount of benefits if this tool helps avoid conditions for high-cost days.

## Please provide an estimate of how replicable the Method is across GB

This project will consider factors affecting balancing costs across the whole GB electricity system. The method will be 100% replicable across GB, as it will be using post-hoc data in its methodology. The methodology itself will produce an open-source code that can replicate the results

### Please provide an outline of the costs of rolling out the Method across GB.

This project will consider factors impacting balancing costs across the GB electricity system operation, and then develop a proof-of-concept tool for potential use in the control room in the future. Strategic insights gained from this project will inform the ESO on how best to prioritise mitigating initiatives around minimising balancing costs. Incorporating the findings of this research will not require any significant time or cost to roll out into the ESO Balancing Costs strategy.

The tool will be developed using an open-source code, however if successful this will need to be trialled, tested, and verified prior to implementation into system operations. At this stage, costs for implementation of these results are expected to be low. As this will be an open-source code, it is expected that it will be feasible to implement the tool within ESO systems with relative ease.

### Requirement 3 / 1

Involve Research, Development or Demonstration

Projects must have the potential to have a Direct Impact on a Network Licensee's network or the operations of the System Operator and involve the Research, Development, or Demonstration of at least one of the following (please tick which applies):

☐ A specific piece of new (i.e. unproven in GB, or where a method has been trialled outside GB the Network Licensee must justify repeating it as part of a project) equipment (including control and communications system software).

☐ A specific novel arrangement or application of existing licensee equipment (including control and/or communications systems and/or software)

☐ A specific novel operational practice directly related to the operation of the Network Licensees system

☐ A specific novel commercial arrangement

Involve Research, Development or Demonstration - Please select all that apply

☐ A specific piece of new equipment (including monitoring, control and communications systems and software)

☐ A specific piece of new technology (including analysis and modelling systems or software), in relation to which the Method is unproven

☑ A new methodology (including the identification of specific new procedures or techniques used to identify, select, process, and analyse information)

☐ A specific novel arrangement or application of existing gas transportation, electricity transmission or electricity distribution equipment, technology or methodology

☐ A specific novel operational practice directly related to the operation of the GB Gas Transportation System, electricity transmission or electricity distribution

☐ A specific novel commercial arrangement

### Specific Requirements 4 / 2a

### Please explain how the learning that will be generated could be used by the relevant Network Licensees

This project will investigate key drivers of balancing costs and the associated impacts of these through statistical and causal analysis. The results and key learnings from this project will be shared with government and industry to inform how balancing costs can be minimised.
The research developed through this project will inform the ESO Balancing Costs strategy and will identify areas in which the ESO may reprioritise in tackling Balancing Costs. Should these findings suggest that there may be new initiatives and cost savings to be made through networks then these will certainly be distributed and circulated through the relevant stakeholders.

N/A

### Is the default IPR position being applied?

☑ Yes

## Project Eligibility Assessment Part 2

### Not lead to unnecessary duplication

A Project must not lead to unnecessary duplication of any other Project, including but not limited to IFI, LCNF, NIA, NIC or SIF projects already registered, being carried out or completed. Networks must explicitly mention similar projects that they have considered and how these differ.

### Please demonstrate below that no unnecessary duplication will occur as a result of the Project.

More interconnectors are being connected over the next 4 years, this will exacerbate the impact of interconnector swings as there are more sources for these, therefore requiring greater and more frequent balancing actions. Project NIA2_NGESO015 Future of Interconnectors will help inform the setting of future interconnector direction, and the learnings from this will be considered in this project when analysing the effects of interconnectors on balancing costs. Understanding the impact of interconnector behaviour in conjunction with, and relative to, other impacting factors on Balancing Costs will complement project NIA2_NGESO015. We will be able to understand what other conditions lead more quantitatively to influence these high-cost outcomes and how we may remediate them through control room decisions.

The ESO is already proposing ramp rate restrictions for interconnectors which will halve the extent to which individual interconnectors will be able to swing and create imbalances. Whilst this minimises the impact interconnectors can have; it does not identify the root cause for the behaviour and is a short-term solution. Innovation project NIA2_NGESO042 developed a cost benefit analysis review of possible solutions to managing interconnector swings.

Project NIA2_NGESO022 BC Forecasting focused on improving the predictions of balancing costs up to a year ahead, however, did not go into detail on causes of balancing costs. This new innovation project will build upon what was developed in BC Forecasting and develop methodology for probabilistic analysis of balancing cost causes. Forecasting long-term costs and generating a probabilistic forecast that costs the next day will be high are two different, but complementary processes. The short-term probabilistic forecast will help inform day-to-day decisions made by the control room. It will also help prioritise the Balancing Costs strategy of the ESO and inform how the longer-term forecasts may be improved or refined.

The ESO balancing costs team is undergoing numerous activities to understand the influences on balancing costs and how the ESO can best minimise these costs. This project compliments this ongoing work, exploring novel methodologies in detail, helping the ESO to achieve its broader priority of operating an economically efficient system.

### If applicable, justify why you are undertaking a Project similar to those being carried out by any other Network Licensees.

N/A

## Additional Governance And Document Upload

### Please identify why the project is innovative and has not been tried before

The datasets in the electricity market, and the complexity of decision making in operating the power system are incredibly vast and complicated. This makes it an ideal topic to be researched by statistical and causal analysis. Combining world-leading research and data science from Imperial College London with the on-the-ground expertise and context from the ESO will produce innovative findings. Informing the technical expertise of the methods of this research with the experience of the ESO is crucial to provide innovative and applicable insights.
This project is leveraging academic experience with European electricity markets where this type of analytical research has been used, however this has not been applied when analysis the GB electricity market. Currently, very little knowledge exists in how the wealth of data being collected at system and market level can be used to appraise the drivers of balancing costs. Similarly, causal analysis has never been applied to the analysis of balancing costs.

### Relevant Foreground IPR

- Balancing costs influence methodology report
- High priority influence methodology report
- Probabilistic analysis of balancing costs prototype tool

### Data Access Details

Data for this project and all other projects funded under the Network Innovation Allowance (NIA), Network Innovation Competition (NIC) or the new Strategic Innovation Fund (SIF) can be found or requested in a number of ways:

1. A request for information via the Smarter Networks Portal at https://smarter.energynetworks.org, to contact select a project and click 'Contact Lead Network'. National Grid ESO already publishes much of the data arising from our innovation projects here so you may wish to check this website before making an application.
2. Via our Innovation website at https://www.nationalgrideso.com/future-energy/innovation
3. Via our managed mailbox innovation@nationalgrideso.com

Details on the terms on which such data will be made available by National Grid ESO can be found in our publicly available "Data sharing policy relating to NIC/NIA projects" at https://www.nationalgrideso.com/document/168191/download.

## Please identify why the Network Licensees will not fund the project as a part of it's business and usual activities

The balancing costs function within ESO is newly established due to the large increases in balancing costs seen in the last few years. While there is ongoing work within BAU to understand influences on balancing costs, this project goes far beyond what is in the scope of this existing work and applies more advanced techniques from academia to provide in-depth analysis and new ways of prioritising key factors. It therefore cannot be funded through BAU.

## Please identify why the project can only be undertaken with the support of the NIA, including reference to the specific risks (e.g. commercial, technical, operational or regulatory) associated with the project

This project requires expertise and experience from other electricity networks in Europe and will leverage impartial expertise from academia that is enabled by NIA funding. There are technological risks around the data required and the feasibility of being able to incorporate this data into a developed methodology and a potential probabilistic tool for use in the ESO control room. There is also a regulatory risk around how changes to policy may alter the operation of the balancing mechanism and therefore what needs to be accounted for within the project. By using NIA, a level of flexibility can be considered to address these risks and ensure the methodology developed can be adapted to suit any emerging data or regulatory requirements.

The use of NIA will also ensure that project outcomes and learnings can be shared with the industry.

## This project has been approved by a senior member of staff

☑ Yes