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 2024

## Project Reference Number

NIA2_NGESO041

# Project Progress

## Project Title

Model-driven Strategy for Balancing Optimisation (MSBO)

## Project Reference Number

NIA2_NGESO041

## Project Start Date

April 2023

## Project Duration

1 year and 3 months

## Nominated Project Contact(s)

Colin Webb

### Scope

This project will formulate the energy balancing system holistically, aiming to develop a UBM and map existing manual processes to analytical equations. This will consider a top-down approach and articulate the entire balancing problem with a bespoke mathematically rooted language. By acquiring critical understanding for the ESO of the significant complexities in the current and future balancing system and markets, the project will enable the development of the analogous future strategy for balancing optimisation functionality to sit alongside the existing IT strategy for hardware and architecture.

### Objectives

- Construct the UBM using analytical equations to articulate the current balancing programme
- Articulate future system design based on top-level view afforded by the UBM
- Deliver design specific problem formulation for current and future balancing system design

### Success Criteria

The following will be considered when assessing whether the project is successful:

- The project delivers against objectives, timescales and budgets as defined in the proposal
- Development of analytical articulation of the energy balancing system, including manual interventions
- Delivery of a clear strategic approach to incorporate balancing challenges and needs of the control room in a modelling framework

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

National Grid Electricity System Operator (“NGESO”) has endeavoured to prepare the published report (“Report”) in respect of Model – driven Strategy for Balancing Optimisation (MSBO) NIA2_NGESO041 (“Project”) in a manner which is, as far as possible, objective, using information collected and compiled by NG 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 NG and the Project partners).

As grid operation evolves, ESO need a comprehensive understanding of balancing as a whole. The Model-driven Strategy for Balancing Optimisation (MSBO) aims to further this holistic understanding of grid balancing operations, both as they are today and as they could be into the future. MSBO is achieving this on two fronts:
1) a high-level mathematical model of the balancing problem, and
2) a low-level mapping of balancing system components.
Together, these will enable ESO to understand the strengths and vulnerabilities of current balancing operations and will provide a potent framework for architecting the future of balancing.

Original project deliverables were:

**Work package 1**: Underpinning Balancing Model – formulating the mathematical model of balancing
Initial formulation of the UBM
Mapping of current balancing system
Mathematical formulation of key components
Play back to ESO
Candidate future system design(s)
Identify additional control room challenges and needs that need incorporating into a future system design
Mapping new components into existing system
Play back to ESO
Iteration and refinement of UBM
Mathematical formulation of all components (including new)
Play back to ESO

**Work package 2:** Knowledge graph of balancing system components – supporting current and future decisions
Holistic problem formulation of the current system design
Mapping of how to split current balancing system into sub-systems to be individually optimised
Mathematical formulation of individual optimisation problems
Design of how optimisation problems will interact
Holistic problem formulation of the future system design(s)
Mapping of how to split future balancing into sub-systems to be individually optimised
Mathematical formulation of individual optimisation problems
Design of how future optimisation problems will interact

**Progress to date:**
Overall to date, this project has led to a deep understanding of the intricacies and information flows in balancing the electricity system. As part of the analysis of the current system, detailed low-level worksheets of roles and tasks mapping have been authored to capture the current status. In parallel, a comprehensive mathematical model of balancing – the Underpinning Balancing Model (UBM) – has been designed which highlights the current simplifications and future possibilities through the language of mathematical optimisation.

**Work package 1:**
The purpose of the UBM is to provide a consistent framework for developing a shared understanding of balancing, and for articulating optimisation problem formulations for current and candidate future system designs.
A high-level mathematical formulation for the challenge of balancing the GB electricity grid has been presented. This is sufficiently high-level such that specific system designs can be mapped onto it. The mathematical model focused on formulating and describing the high-level, underpinning equations and dynamics that defined the GB balancing system, and will apply to any future form of the GB balancing system. The UBM will be used and refined in future deliverables to create problem formulations for the current and candidate future system designs.

Fundamental to any attempt at balancing the GB electricity grid is the relationship between frequency, imbalance, and inertia.

Balancing the grid is a temporal problem, as the frequency changes across time with changes in supply, demand and inertia. The model considers forecasts of future values for controllable imbalance, latent imbalance, inertia, and the set of actions that will be available to balance the grid at future times, although this is not an exhaustive list.

The project has created defined templates for entities, services and actions. In the existing system, an entity might be a BMU, a unit not on the balancing mechanism that can be influence by balancing actions, an interconnector, etc. Different entities would align with different services that could be provided by that entity, for example response services. Actions let ESO influence the system, but they have an associated cost. These include bid offer acceptance (BOAs), frequency response actions, unit syncs etc. The model considers when an action is taken, mathematically how does it impact the system.

As an example of these templates, the entity template includes the data that is needed for each entity to define the ideal optimisation problem. In an ideal world, information would be collected for all entities (wind units, interconnectors, batteries, etc…) and can then be used to inform the overarching optimisation problem. In practice, a subset is collected and therefore simplifications made to the underlying problem to enable it to be solved. By starting out with an “ideal” maths problem and simplifying from there allows visibility of where the current system has made assumptions or simplifications, see where these could be relaxed in the future, and see what data would be needed in an ideal world.

**Work package 2:**
To enable creation of the knowledge graph for balancing system component, first a bottom-up mapping of balancing roles, tasks, data and tools was completed. This included gathering information, reviewing processes, and interviewing stakeholders relevant to balancing within the ESO to map out the current balancing system. The key output from this was the creation of a detailed spreadsheet which documents all identified balancing, roles, their actions, tools, data, manual decision-making points etc. Following this, static visualisation was explored.

This mapping included 11 different roles within the control room related to balancing the electricity system. These were then broken down to cover specific tasks, including details around the task descriptions, relevant data inputs, data & instructions sent during the task, how the task relates to balancing, the component that the task relates to within the UBM, and highlighting any aspects missing from the UBM.

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

During the MSBO project thus far, Smith Institute consultants have worked closely with ESO transition, balancing, control room and innovation stakeholders to build a deep understanding of the intricacies and information flows in balancing. Further feedback around system balancing for the project has been gathered from industry stakeholders at a Balancing Programme Engagement Event. The project has also aligned and collaborated with other parallel innovation projects including Dispatch Optimiser Transformation (NIA2_NGESO044) to ensure the immediate and future outputs of MSBO meet the needs and requirements identified in these workstreams.

Through the work done to design and develop the UBM, it became clear that the best way to achieve a flexible and future-proof mapping of the current and future balancing systems is to build a knowledge graph (KG) of balancing processes to complement the UBM and bring the key outputs to life. The KG would be a maintainable, adaptable, long-term asset, allowing ESO to interactively explore the details and interdependencies in balancing operations. This would enable informed preparation for process changes in working towards future balancing operations. The system mapping will be delivered as an interactive KG along side the UBM ready for use. To deliver this KG, the project deliverables have been restructured for the remainder of the project. The original WP1 has been broken down further into four main deliverables from the original three , and WP2 has been broken down into three main deliverables from the original two. Details of these are noted below, deliverable 1 for each work package remained unchanged so is not included below. This results in no changes to project cost, but adding an additional two months to the project timeline, with the project now due to complete September 2024:

**Work package 1**: Underpinning Balancing Model – formulating the mathematical model of balancing.
Develop component-based mathematical formulation of balancing.
Identify ESO requirements and use cases for a component-based UBM.
Design an UBM to support requirements and create execution plan.
Play back to ESO.
Expand and refine component-based mathematical formulation of balancing.
Formulate and document the overarching optimisation problem of balancing faced by ESO using the component-based model of balancing.
Identify simplifications to the overarching optimisation problem of balancing that yield a more computationally tractable problem.
Showcase how future optimiser designs can be informed by the component based underpinning balancing model and associated

overarching optimisation problem and simplifications of this.
Play back to ESO.
Hand over UBM report to ESO
Continue to improve and refine the UBM in remaining project time.
Deliver UBM as a report.

**Work package 2:** Knowledge graph of balancing system components – supporting current and future decisions
Design and build Proof of Principle Knowledge Graph of balancing system components.
Identify ESO requirements and use cases for balancing for current and future decisions Mathematical formulation of individual optimisation problems.
Devise approach to visualisation capable of supporting transition and balancing decisions for current and future time-horizons.
Build knowledge graph proof of principle which demos KG use cases for Sort and Spice.
Play back to ESO.
Holistic problem formulation of the future system design(s)
Mapping of how to split future balancing into sub-systems to be individually optimised
Mathematical formulation of individual optimisation problems
Design of how future optimisation problems will interact

## Lessons Learnt for Future Projects

All balancing actions that are taken in the control room were articulated, categorized by roles and mapped to relevant tools and applications. While it is valuable to have such articulation of balancing actions, it is still very complicated to comprehend and use for future design purposes. After several brainstorming sessions it was agreed to develop a dynamic visualization tool (Knowledge graph) to improve the ease of use of the articulated actions.

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

WP1:

- Requirements from stakeholders collected to map current balancing roles, tasks, tools, and actions. These have been used to create the high level mathematical formulation of balancing.
- Component-based mathematical formulation of balancing developed, the Underpinning Balancing Model.

WP2:

- Bottom-up mapping of balancing roles, gathering information, processes and interview of stakeholders
- Detailed spreadsheets documenting identified balancing roles, actions, tools, data, etc., this has been identified as a useful document for potential control room training and addendum to existing process mapping.
- Static visualization explored to aid decision making.

## 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 National Grid can be found in our publicly available “Data sharing policy related to NIC/NIA projects” and www.nationalgrideso.com/innovation.

National Grid Electricity System Operator already publishes much of the data arising from our NIC/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

The following is expected to be generated:

- UBM initial formulation
- Problem formulation for current system design