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 Close Down Report Document

Date of Submission

Mar 2025

Project Reference Number

NIA2_NGESO048

Project Progress

Project Title

GB Inertia Forecasting with Regional Extrapolation

Project Reference Number

NIA2_NGESO048

Funding Licensee(s)

NESO - National Energy System Operator

Project Start Date

December 2023

Project Duration

0 years and 7 months

Nominated Project Contact(s)

Anna Blackwell (ESO)

Scope

This project will focus on two potential solution areas:

1. Explore enhancements that can be applied outside the existing machine learning algorithms, including normalisation of data in and out of the machine learning model.
2. Evaluate alternative approaches and enhancements to the existing machine learning algorithm.

If these solutions are successful, the project will also consider an implementation plan for the chosen enhancements into operational inertia tools. Implementation of any recommendations to the existing solution will be made through a separate investment.

Objectives

- To establish if it is possible to use a model based on Scottish inertia metering data to forecast the inertia of England and Wales, and therefore the whole GB inertia.
- If successful, provide a proposal for implementing the enhancements into the relevant operational inertia tools.

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.
- Improvements made to existing inertia forecasting algorithms are demonstrated.
- GB inertia forecast method(s) developed using normalised data from installed metering and validated against both relevant events across England and Wales and other available inertia tools.

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 GB Inertia Forecasting with Regional Extrapolation, NIA2_NGESO048 ("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).

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We have demonstrated an improvement in inertia forecasting exclusively for the region of Scotland. Our neural network model (Model 4), has shown superior performance compared to the baseline model. The percentage improvement in both root mean squared error (RMSE), at 74.67%, and mean absolute percentage error (MAPE), at 75.79%, is significant. The additional appendix illustrates that the inertia forecast tightly follows the expected inertia over a 24 hour period processed.
As the Model4 input was also provided with the historical 6 hours of Scottish inertia metering values alongside the predictors (the input forecasts for synchronous inertia, demand and renewable generation) this model is not suitable for the extrapolation task to other regions.
For the extrapolation of the model to other areas, we trained several different types of neural network models, including transformer-based, MLP-based, and recurrent-based models. These models showed a slight improvement compared to the baseline model in the region of Scotland.
After applying the predictors from Wales and England to the Scottish model, we observed that the process did not generalise well to the unseen regions, with the forecast inertia falling significantly below that observed. Graphs showing the forecasting results with expected inertia values provided by NESO (linear combination of sum of rotating inertia and demand) are provided in the available appendix document "NIA2_NGESO048 Final Report-public".

We identified two potential reasons for this:
(i) the relationships between the predictors across regions are not sufficiently similar,
(ii) the length of the training data is insufficient to train models with adequate generalization capabilities.
We have also outlined steps for further investigation of the problem, including domain adaptation via adversarial training and hierarchical reconciliation.

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

No modifications to the planned deliverables, timelines, or cost occurred during the project.

Lessons Learnt for Future Projects

- Regional behaviour differences between Inertia & predictors have been highlighted during the process.
- Dataset: during the timeline of the project, data availability was limited to 6 months. Having access to a more extended dataset (12-15months) would be more beneficial for this type of analysis, however as the indications were that it was unlikely that a GB model could be developed from the Scottish model only it was not considered sensible to extend the duration of the project to analyses additional data.
- It would be beneficial to obtain any number of labels (actual inertia values) data for the other regions. Even a very small amount (a couple hours/a day/an event) of inertia values for a given region can significantly reduce the magnitude of problem.

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

Training new models on Scotland area highlighted potential improvement for inertia forecasting of Scotland area inertia, especially when using Model 4. More investigation and refinement of the technique might be beneficial in future, especially as PMUs will become more available in other areas.

Extending the inertia forecasting to England and Wales by using a model build with Scottish data did not prove to be performing well. It was identified that the Scotland network is very different to England & Wales and it was not possible to scale the Scottish result to act as an accurate proxy for the inertia across GB.

Data Access

Details on hownetwork 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 final report will be published on the Smarter Networks Portal.

Planned Implementation

For future work, it is recommend to particularly focus on acquiring a more extensive and diverse dataset, incorporating inertia data from other regions, and exploring advanced domain adaptation techniques.

Net Benefit Statement

The project provided valuable insights into the challenges of domain adaptation in forecasting inertia across diverse regions with varying energy consumption, generation, and grid dynamics. While it identified limitations in achieving the intended objectives, it also highlighted potential advanced techniques that could improve forecasting accuracy overall. These findings lay the groundwork for future research and innovation, helping to refine methodologies that could enhance GB-wide forecasting and support more resilient grid operations.

Other Comments

The Project outcomes and results contain confidential information and intellectual property rights that cannot be disclosed in this Report due to their proprietary nature. Should the viewer of this Report ("Viewer") require further details this may be provided on a case by case basis following consultation of all Publishers. In the event such further information is provided each and any Publisher that owns such confidential information or intellectual property rights shall be entitled to request the Viewer enter into terms that govern the sharing of such confidential information and/ or intellectual property rights including where appropriate formal licence terms or confidentiality provisions. Dependent upon the nature of such request the Publishers may be entitled to request a fee from the Viewer in respect of such confidential information or intellectual property rights.

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