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

Jun 2025

Project Reference Number

NIA2_NGESO082

Project Progress

Project Title

Neural BB

Project Reference Number

NIA2_NGESO082

Project Start Date

June 2024

Project Duration

1 year and 7 months

Nominated Project Contact(s)

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Scope

The aim is to create a surrogate model that has sufficient accuracy that it can be used by ESO in stability studies.
In financial terms the largest gains are likely to occur where surrogates allow ESO and/or transmission owners to undertake more accurate EMT studies (e.g. by avoiding compatibility and model-obsolescence issues, or by allowing accurate representation of distributed generation, or by reducing complexity and hence making the creation of more detailed models feasible).
Having more accurate EMT studies will allow margins of safety to be reduced, which should result in substantial financial benefits for consumers.

Objectives

The objectives of the project are divided into the following steps:
Demonstrate how machine learning can be used to create a surrogate model that adequately reproduces the behaviour of an open (i.e. non-black-boxed) model when tested in isolation.
Demonstrate how machine learning can be used to create a surrogate model that adequately reproduces the behaviour of a single selected black box model when tested in isolation.
Demonstrate that the surrogate version of the black box model reproduces the behaviour of the original model (to a satisfactory level of accuracy) when it is tested in an actual model of British grid.

Success Criteria

The project will have been successful if the surrogate version of a black box model can be shown to reproduce the behaviour of the original black box model with adequate accuracy. In this case “adequate” means that grid studies undertaken with the surrogate model will not indicate significantly different grid power flow limits to those undertaken with the original black-box model.

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

Project Summary:

As GB’s electricity network transitions towards clean energy more and more of our generation will be reliant on renewable energy sources rather than traditional fossil-fueled sources interfacing with the network through electromechanical rotating masses. These renewable energy-based generators in contrast, interface with our grid through DC/AC converters with fast transients that may be entirely electronic in nature. Accurate stability studies of these Inverter Based Resources (IBR) dominated parts of the grid currently rely on Blackbox models provided by manufacturers and/or generators which have several challenges:

- Only work with a particular version of EMT simulation software.
- Come with severe contractual restrictions on their use or distribution.
- Vary hugely in complexity & have different arrangements for interfacing to grid models.
- Can be slow: simulation runs at the speed of the slowest black box model.

This project seeks, as proof of concept, to use machine learning to create a surrogate model from a black-box model of an IBR for use in PSCAD. The aim is for the surrogate model to be faster than Blackbox models and with sufficient ‘accuracy’ to be used in stability studies by NESO. The models must be available as source code that can be recompiled and interfaced with to work on any other future versions of PSCAD and/or other EMT analysis software. Furthermore, it must be able to run at different timesteps to ensure compatibility with other models to avoid ‘slowest-ship-in-convoy’ effect.
The project is being delivered with the following work packages:

- WP1: Literature study to establish current state-of the-art and techniques
- WP2: Train surrogate of generic model in PSCAD and test in isolation
- WP3: Testing surrogate of Generic Model in PSCAD
- WP4: Train surrogate of Black Box model and test in PSCAD

Project Progress:
The following was achieved:

- Literature study completed highlighting most viable methodologies and their limitations with a purely data driven neural network chosen for the surrogate model design
- Test data was created with a generic model subjected to a variety of system conditions and network topologies and a surrogate model was created using a coding language
- Bottlenecks were identified and addressed in both the neural network topology and the coding language used resulting in improved accuracy of the surrogate model in standalone tests (without PSCAD)
- Test data was created with a Blackbox model subjected to a variety of system conditions and network topologies and a surrogate model was created using a coding language
- Interfacing methodology of source code of surrogate model was created

- Another round of improvements to the neural network model were introduced increasing accuracy in isolation
- WP reports 1 (WP1-2), 3 and 4 delivered

Next Steps:

- Training of black box surrogate model
- Completion of Surrogate model PSCAD-interface
- Testing of black box surrogate model in PSCAD
- Delivery of final report

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

No modification to the planned approach as the approach proposed itself was research to create the methodology itself

Lessons Learnt for Future Projects

The lessons learned at this stage are the following:

- Data driven neural networks seem to the most suitable approach
- Training data may need to be tuned to capture the unstable behavior of the model being surrogate in contrast to usual machine learning use cases where instability is something to be removed
- Generic model testing in PSCAD before moving on to black box training and testing was not needed due to how well the data driven approach preformed avoiding the need of introducing domain knowledge to the model
- The timestep of the surrogate model needs to be flexible enough to run slow enough for the fastest model we intend to use so while high timesteps are possible they may not be always practical

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

The project is currently ahead of schedule on WP4, the main objective is the create a viable methodology for creating surrogate neural network models from black box models that ‘sufficiently’ similar for stability studies in EMT. This would allow faster and more flexible EMT models reducing computational needs and simplifying EMT study model requirements.

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

The surrogatisation methodology developed during this project will be confidential to NESO and any black box model created using this methodology will still be subject to same confidentiality protections currently used for sharing black box models along with the necessary permissions if needed under NDA, Grid Code and STC mechanisms.