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

May 2025

Project Reference Number

NIA2_NGESO035

Project Progress

Project Title

Practical Transition into wider EMT GB Modelling

Project Reference Number

NIA2_NGESO035

Project Start Date

July 2023

Project Duration

1 year and 9 months

Nominated Project Contact(s)

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Scope

With Great Britain's (GB) power system moving towards net zero carbon operation, the number of inverter-based resources (IBR) is expected to increase. The amount of synchronous generation in the grid will decline, reduced system inertia and lower short circuit levels significantly changing the characteristics of the GB network. EMT simulation are particularly required for weak grid locations experience significant voltage variations, especially in phase angle, following system disturbances. Accurate measurement of phase angle changes through the Phase Locked Loop (PLL) is crucial for the grid-following inverter response. Inaccurate tracking by the PLL can result in poor fault recovery or unit tripping, violating grid codes.

Additionally, Voltage control is challenging in weak locations, particularly when multiple nearby inverter-based devices with fast reactive current control interact unstably, leading to various control interaction issues.

Conventional RMS analysis can no longer accurately identify system security risks during these conditions. Therefore, EMT analysis is required to conduct research to determine system operational risks with high penetration of IBRs.

EMT simulations take much longer than RMS simulations, even for simple networks. The currently developed full GB EMT model developed through a separate innovation project takes a few hours to run in PSCAD. Furthermore, with the increasing number of IBR sources in the GB system, EMT simulations must be carried out for many scenarios and several contingency cases to analyse system stability. There is an increasing need to develop a capability to carry out multiple EMT analyses, for a more comprehensive network, with reduced simulation time. Additionally, strategies must be developed to correctly identify scenarios requiring EMT analysis more than RMS analysis, as more effort is required for network modelling for EMT analysis.

The project will aim to enhance the GB network's EMT model by improving the models' computational efficiency, which will help the

ESO investigate more scenarios with stability risks while transitioning into zero carbon operation. It will also provide technical guidance outlining scenarios where EMT simulations are necessary under critical system conditions.

Objectives

The project has two main objectives:

- Research and development will be performed to improve the efficiency of EMT simulations, with the overall objective of running the National Grid (England & Wales) Electricity network model in PSCAD to achieve practical run time.
- Produce technical guidance outlining scenarios where EMT simulations are necessary under critical system conditions.

Success Criteria

Success Criteria:

- Developed methods to accelerate EMT simulation time, will be integrated on the full scale EMT GB network model. This will allow the ESO to “speed up” the process when performing simulations and improve the flexibility of performing transient studies.
- The ESO will have the ability to perform operation studies on the full EMT model of GB, without the need for expensive specialised hardware
- The framework and guidelines will significantly help to illustrate through practical and real examples the limitations of RMS vs EMT tools. That will benefit ESO in understanding which simulation tool to use for which purpose as the GB network transitions to a zero-carbon system.
- Provide actionable insight to improve EMT analysis efficiency and improve understanding of transient interactions and events that could be missed with current tools.
- Dissemination and training for learnings and methods developed in the project.

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 xxproject namexx, NIA2_NESO0XX (“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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Project Summary:

The detailed modelling of numerous power electronic converters within practical wide-area power networks on EMT platforms is highly simulation-intensive, significantly affecting both simulation speed and the practicality of conducting system-level studies. As Great Britain anticipates substantial growth in inverter-based resource (IBR) connections, achieving efficient simulation times is becoming increasingly important. Currently, running a 20-second simulation using the full GB EMT model (TOTEM) in PSCAD takes several hours. Additionally, with the rising number of IBR sources in the GB system, EMT simulations need to be conducted for numerous scenarios and contingency cases to assess system stability. Therefore, there is a growing need to develop the capability to perform multiple EMT analyses for wider network studies with reduced and practical simulation times.

This project establishes a robust computational framework to ensure that, as NESO continues to integrate more IBR models, wide-area EMT simulations remain practical, scalable, and capable of operating within realistic runtime targets. The project is being delivered through two work packages:
WP1 - Research & Development to improve the efficiency of EMT simulation run times.
WP2 - Technical Guide to determine when EMT simulations are necessary.
Project Progress:
WP1:

The primary objective of optimising computational efficiency for the full England and Wales (E&W) EMT model in PSCAD has been

successfully achieved, resulting in a practical runtime of approximately 20 minutes for a 30-second simulation. This includes the integration of approximately 40 detailed inverter-based resources (IBRs) in the form of HVDC links and offshore wind farms, all while ensuring compliance with the UK Grid Code. The four main tasks undertaken were as follows:
Bottleneck Identification & Optimisation: By implementing network segmentation, adjusting resistor tolerances, and utilising parallel processing, reduced the simulation time from approximately 60 minutes to 15 minutes.
IBR Modelling & Grid Code Compliance: Developed efficient models for HVDC, offshore wind farms, and STATCOM, ensuring they are validated against grid code requirements.
High-Performance Computing (HPC) Enhancements: Advanced multi-threading, parallel processing, and algorithmic improvements were implemented, significantly reducing runtime.
Final Model Delivery: The enhanced 16-zone National Grid model was delivered, fully integrated with optimised IBRs and HPC improvements, meeting the target runtime of approximately 20 minutes. This foundation supports practical and scalable EMT simulations for wide-area studies across Great Britain's power system.

The WP1 report and final model have been received from MHI, and NESO has reviewed and provided feedback. MHI is currently working on addressing the feedback on the WP1 report.

WP2:

WP2 report on Technical Guide to determine when EMT simulations are necessary under critical system conditions has been submitted to NESO and is currently under review.
This report outlines the criteria for determining when EMT studies are necessary and suggests an efficient study approach. It covers the following topics:
Types of technical issues that can arise due to penetration of IBRs in power systems
The potential screening studies commonly used in the industry to identify potential risks and the system conditions under which the risks are most likely
A discussion of methods to determine the extent of the study area,
A method to define the boundary beyond which a fault at the point of interest will not result in a ‘significant’ voltage dip at a remote location.
A method to ascertain the boundary beyond which the network impact is insignificant on the harmonic impedance profile, as measured from the point of connection or a point of interest.
Next Steps:

- Delivery of final reports
- Workshop on project outcomes and knowledge sharing

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

The original schedule for this project was set at 21 months. However, due to additional requirements from NESO, the timeline has been extended by an additional 6 months. Specifically, NESO requested MHI to develop a generic EMT model with required control structure and validate it against GB Grid Code compliance requirements, which was not included in the original scope. Consequently, MHI has developed inverter-based EMT models that align with the requested control architectures and meet the relevant grid code standards.

Despite the extension of the project duration, there has been no modification to the planned approach.

Lessons Learnt for Future Projects

The following lessons have been learned through this project:

- The process to enhance the EMT network models to improve simulation speed by employing various techniques utilised in this project.
- The potential screen studies to identify potential risks and determine the system conditions under which these risks are most likely to occur.
- Methods to determine the extent of the study boundary necessary for conducting EMT simulations.

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 following outcomes have been achieved through this project:

- An enhanced England & Wales EMT network model for 2025 has been developed, featuring integration with 40 inverter-based resource (IBR) generic models. This supports practical and scalable EMT simulations for wide-area studies across Great Britain's power system, significantly reducing the simulation time required for NESO to conduct numerous EMT simulations.
- Efficient generic EMT models have been developed for HVDC, offshore wind farms, and STATCOM. These models are versatile and can be utilised for various operational and planning studies in the future.
- A methodology for enhancing EMT network models has been established. This methodology can be applied to any type of wider network in the future to facilitate faster simulations.
- A technical guide to determine when EMT simulations are necessary under critical system conditions has been developed. This guide is applicable to any wide network and aids in identifying which scenarios need to be run in EMT and which boundaries should be considered based on screening studies.
- Python script-based tools were developed applied to the full ETYS grid model to further assist NESO and determine the extent of the study area in a systematic manner.

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

- Enhanced E&W EMT network model with integrated generic EMT model
- Report on Enhancement methods of EMT network models
- Technical Guide to determine when EMT simulations are necessary under critical system conditions
- Python script-based tool - determine the extent of the study area in a systematic manner for EMT analysis