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.

NIA Project Registration and PEA Document

Date of Submission

Dec 2025

Project Reference Number

NIA2_NESO101

Project Registration

Project Title

Enhanced Connection Compliance and Post-Event Studies

Project Reference Number

NIA2_NESO101

Project Licensee(s)

National Energy System Operator

Project Start

November 2025

Project Duration

2 years and 1 month

Nominated Project Contact(s)

innovation@nationalenergyso.com

Project Budget

£650,000.00

Summary

The existing connection compliance process for inverter-based resources (IBRs) is based on a relatively simple grid model which cannot necessarily capture the risk of IBR-induced sub-synchronous oscillations (SSO). Once an IBR is implicated for its role in SSO, the relevant IBR vendor/developer can investigate using their detailed IBR model but, with a simple grid model which could not cover large impedance spectra to check for extreme scenarios. In parallel, the NESO could undertake an investigation using detailed grid models but black-box IBR models. The difficulty is over how black-box IBR models and grid models are exchanged with richness of operating points and frequency spectrum retained. The project will study the effectiveness of using a bank of grid impedance spectra that covers extreme grid conditions and suggest small-signal tests to be carried out with the model bank. We will establish principles/rules to shape the response of an IBR to mitigate further risk of SSO.

Nominated Contact Email Address(es)

Innovation@neso.energy

Problem Being Solved

The existing connection compliance process for IBRs relies on a simple grid. This cannot identify adverse interaction with other IBRs across the grid and therefore can't necessarily foresee the potential risk of SSO. If an SSO event happens, and an IBR is implicated for its role in SSO, there isn't a clear way for NESO to specify how the IBR response should be shaped to mitigate further risk of SSO. This project aims to address these two issues.

Method(s)

This project will be delivered with a work package approach and will form part of the larger Assurance of Stability program of work. This project will create model banks with grid impedance spectra under extreme scenarios to ensure rigorous connection compliance. The project will also devise small-signal tests to be carried out on the model banks with detailed IBR models to identify potential risks of SSO. Furthermore, the project will develop algorithms for tools to add to the simulation environment that can identify the root cause of SSO in black-box simulations using mode shape and participation. Finally, the project will establish principles or rules that allow shaping the response of an IBR to mitigate the SSO problem.

In line with the ENA's ENIP document, the risk rating for the Assurance of Stability programme is low.
TRL Steps = 1 (2 steps)
Cost = 1
Suppliers = 1 (1 supplier)
Data Assumptions = 2
Total = 5 (Low)

Scope

The outcome of this project will enable NESO to
1) reduce the risk of SSO through an enhanced connection compliance process that identifies potential SSO more rigorously and
2) specify the IBR response requirement to vendors/developers to mitigate any further risk of SSO.
It is not straightforward to quantify exactly the benefit of using an enhanced connection compliance process and post-event investigation in terms of the savings in GB system operation cost due to reduced wind curtailment, for example. Nevertheless, there is anecdotal evidence that potential savings by avoiding unnecessarily wind curtailment could run into several tens of millions each year.

Objective(s)

The objectives of this project are:
Enhance the existing connection compliance process for IBRs to make it more robust to identify potential risk of SSO
Establish a way of specifying to the IBR vendors how to shape an IBR response to mitigate any further risk of SSO

Consumer Vulnerability Impact Assessment

NESO does not have a direct connection to consumers, and therefore is unable to differentiate the impact on consumers and those in vulnerable situations. Benefits to all consumers are detailed in 3.1.

Success Criteria

The success of the project would be based on the following:
Validation of SSO events in simulation against their risk identified through the enhanced connection compliance process.
Accuracy of root-cause identification in a simulation environment.
Effectiveness of SSO mitigation by shaping of IBR response.

Project Partners and External Funding

Imperial College will carry out the research in collaboration with NESO. No external funding is needed.

Potential for New Learning

This project expects to deliver new methods and tools for enhanced connection compliance to identify risk of potential SSO and support post-event investigation for mitigating SSO. There is potential for new learning in terms of:
A method for creating model banks covering extreme grid conditions (e.g., strong to weak) and guidelines on how connecting parties would use the model banks.
Small-signal tests to be carried out with the model bank to identify the potential risk of SSO.
Algorithm to perform mode-shape and participation analysis with black box simulation.
Principles for shaping an IBR response to mitigate SSO.
Standard routes of dissemination such as regular project review meetings, stakeholders' workshops and international conferences would be used as well as any relevant reports published on Smarter Network Portal.

Scale of Project

The project spans 24 months with 1 project partner. The project consists of desk-based research and workshops with relevant NESO teams such as operability policy.

Technology Readiness at Start

TRL3 Proof of Concept

Technology Readiness at End

TRL5 Pilot Scale

Geographical Area

The project is based in Great Britain within NESO's jurisdiction

Revenue Allowed for the RIIO Settlement

None

Indicative Total NIA Project Expenditure

£650,000

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:

This project will deliver new methods and tools to enable a more rigorous IBR connection compliance process that is able to identify the risk of potential SSO and also support post-event investigation for mitigating SSO. Without enhancements to the current connection compliance, potential IBR-induced SSO will not necessarily be foreseen. This either risks SSO events or forces NESO to constrain off renewables in an overly conservative way. The outcome of this project will make sure that higher fractions of renewables (IBRs) can be accommodated on the grid without compromising the security of supply to facilitate net zero transition while providing reliable and affordable electricity to the customers.

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

Not applicable as this is a research project

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

The enhanced connection compliance process and principles for post-event analysis would be generic hence, applicable to any point of connection of an IBR to the grid across the GB system.

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

This will be considered during the project.

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

The outcome of this project can be taken forward by NESO as follows:
Update the IBR connection compliance process and specifications with specific small-signal tests to be carried out with model banks.
Work with IBR vendors/developers to specify how the shaping of IBR response for mitigation of SSO can be translated as a control requirement for them while respecting confidentiality.

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.

The know-how for related NIA projects will be leveraged as follows:
Data-driven Network Dynamic Representation for Derisking the HVDC and Offshore Wind (D3) – Potential synergies will be explored with the data-driven approach adopted in the D3 project to build a reduced-order grid model with the proposed model-bank impedance spectra approach.
Strength to Connect – This project has identified new system strength indices as indicators of small- and large-signal stability problems which could be exploited in the connection compliance process in this project.
Data-Driven Online Monitoring and Early Warning for GB System Stability (DOME) and Enhanced RMS modelling for stability assurance (e-RMS) – The methods for identifying the root cause of SSO developed in these two projects using impedance methods and enhanced RMS models, respectively, will be leveraged in this work to trace the root cause of SSO within a simulation environment.
NESO recently published guidance notes on how to use small-signal techniques to demonstrate appropriate damping performance of IBRs against potential system oscillations. This will inform the work to be done in this project.

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

This project is innovative in addressing the following research questions which have not been answered before:
How to determine how large a model bank is needed for reasonable representation of a particular location (i.e., IBR PoC) and how worst-case models can be identified?

What type and range of small-signal tests to be carried out with the model banks to capture potential SSO under various scenarios?
How to identify the root cause of SSO from black-box simulation?
What should be the basis for shaping the response of an IBR to mitigate SSO?

Relevant Foreground IPR

The following foreground IPR will be generated from the project:
Report on methods for creating model banks and guidelines on how to use model banks
Report on small signal tests to identify potential risk of SSO
Report on principles and rules for shaping an IBR response to mitigate SSO
Code to develop tools to identify the root cause of SSO
All reports will be shared on Smarter Network Portal. Each WP will have separate report.

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:
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 Energy System Operator already publishes much of the data arising from our innovation projects here so you may wish to check this website before making an application.
Via our Innovation website at Innovation | National Energy System Operator
Via our managed mailbox innovation@nationalenerygso.com

Details on the terms on which such data will be made available by National Energy System Operator can be found in our publicly available "Data sharing policy relating to NIC/NIA projects" at www.neso.energy/document/168191/download

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

As this project will be assessing new methods and developing tools which were not previously demonstrated in an electricity system operation environment with high levels of uncertainty and risk, this would not fall into BAU activities and will need NIA funding to be carried out

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

The project has a relatively low TRL. Therefore, innovation funding is more suitable for exploring the project's potential and increasing the TRL before transferring into BAU activities. The methods are novel and have not yet been developed or trialled. There are potential risks associated with the availability of required data and the acceptable performance of the methods. Standard procedures may also need to change to integrate the developed tool due to the practicality of the runtime and the need for high computational resources. There are risks associated with acceptable performance of the methods when applied to the detailed GB network model.

This project has been approved by a senior member of staff

☑ Yes