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

Feb 2025

Project Reference Number

NIA2_NESO100

Project Registration

Project Title

Data-Driven Oscillation Tracing

Project Reference Number

NIA2_NESO100

Project Licensee(s)

National Energy System Operator

Project Start

April 2024

Project Duration

2 years and 1 month

Nominated Project Contact(s)

innovation@nationalenergyso.com

Project Budget

£650,000.00

Summary

Power system oscillations caused by inverter-based resources (IBRs) have been detected in GB since 2021. Existing model-driven methods have been unsuccessful in identifying the origins of these oscillations due to the absence of vendor-specific IBR models. This project aims to:

- Evaluate the effectiveness of existing data-driven (model-free) methods such as dissipating energy flow (DEF) and compass plot method for identifying and analysing IBR-induced oscillations
- Develop new methods tailored to IBR-related oscillations
- Create criteria to select the optimal tracing method based on oscillation type.
- Define specifications for the minimum resolution, bandwidth, and data measurement coverage
- Identify the best combination of measurement devices to meet these requirements.

Preceding Projects

NIA2_NGESO052 - Oscillation and regional RoCoF monitoring

Nominated Contact Email Address(es)

box.so.innovation@nationalgrid.com

Problem Being Solved

Oscillations have occurred in GB transmission system with increasing frequency in recent years. Investigating these events is challenging due to the lack of detailed vendor-specific models for inverter-based resources (IBRs). Model-driven methods often fail to replicate the oscillations due to the lack of vendor-specific IBR models. Data-driven methods, like the DEF method, have been attempted but the results have been inconsistent because the DEF (dissipating energy flow) method is based on principles suited to synchronous generators, which operate very differently from IBRs.

Method(s)

The project will investigate the applicability of existing data-driven methods for tracing the origins of IBR-induced oscillations and develop new data-driven tracing methods where the existing tracing methods fail. These methods include energy-based methods such dissipating energy flow method. The project will also specify the measurement strategy needed for effective data-driven tracing, including the combination of measurement devices, minimum sampling rates, maximum delays, and the need for synchronisation. 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 consists of the following work packages:
WP1 – Applicability of existing tracing methods
WP2 – Testing of new oscillation tracing methods
WP3 – Measurement strategy for oscillation tracing
WP4 – Validation and demonstration

In line with the ENA's ENIP document, the risk rating for the Assurance of Stability programme is low.
TRL Steps = 2 (3 steps)
Cost = 2
Suppliers = 1 (1 supplier)
Data Assumptions = 1 (Assumptions known)
Total = 6 (Low)

Scope

The project aims to provide a trustworthy tool for NESO to rapidly identify the origins of oscillations directly from measurement data. The outcome of this project will enable NESO to reduce the risk of oscillations recurrence and take rapid and economic actions when oscillations occur, avoiding the use of expensive solutions. It thereby enhances the reliability of the power supply for consumers, reduces the risks of power cuts, and reduces the operational cost of the system which is reflected in the electricity price.

Objective(s)

The objectives of this project are:
1. Deliver an evaluation of the effectiveness of the existing data-driven tracing method in identifying and mitigating oscillations induced by inverter-based resources (IBR)
2. Develop a new data-driven tracing method that has better applicability to IBR-induced oscillations
3. Develop and deliver a measurement strategy for effective data-driven tracing, specifying the combination of measurement devices, minimum sampling rates, maximum allowable delays, and the necessity for synchronisation

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

This project has been assessed as having a neutral impact on customers in vulnerable situations because it is a transmission project.

Success Criteria

- The applicability of existing data-driven oscillation tracing methods clarified for typical IBR-induced oscillations.
- New data-driven oscillation tracing methods developed with better applicability to IBR induced oscillations.
- The conclusions and methods verified via desktop simulations.

Project Partners and External Funding

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

Potential for New Learning

The expected learnings include:

- The applicability of existing data-driven oscillation tracing methods to IBR-induced oscillations
- New data-driven oscillation tracing methods and their principles

- Guidelines on the selection of data-driven tracing methods
- The measurement strategy needed for effective data-driven tracing of oscillations.

Standard routes of dissemination such as regular project review meetings, stakeholders' workshops and international conferences would be used. Reports will be published on the smarter networks portal.

Scale of Project

The project spans 24 months with 1 project partner. The project will consist of continuation of existing proof of concept research to consolidate the rigour and applicability of the proposed oscillation tracing method. This research will then inform which methods should be developed and taken forward for demonstration on a GB-like simulation.

Technology Readiness at Start

TRL3 Proof of Concept

Technology Readiness at End

TRL6 Large 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

There are slightly differing requirements for RIIO-1 and RIIO-2 NIA projects. This is noted in each case, with the requirement numbers listed for both where they differ (shown as RIIO-2 / RIIO-1).

Requirement 1

Facilitate the energy system transition and/or benefit consumers in vulnerable situations (Please complete sections 3.1.1 and 3.1.2 for RIIO-2 projects only)

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 manage oscillations in the electricity system. It helps with removing the “stability bottleneck” of the system and enables the reliable and stable integration of renewable resources into the network.

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 (RIIO-1 projects only)

N/A

Please provide a calculation of the expected benefits the Solution

The benefits of this solution will be received by energy consumers via a reduction in system operations costs avoiding extensive oscillation mitigation. The value of this benefit cannot be directly calculated as the nature of the oscillations that are appearing on the system make their frequency and impact difficult to predict and measure. The impact of an oscillation event can have a cost impact of multiple millions of pounds for a single event so the expected benefit from this solution if successful would be significant.

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

The approaches for data-driven oscillation tracing are tailor-made for IBRs and is applicable to the GB system where the IBR penetration is high.

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

As NESO is the system operator for the whole of GB the solution will already cover the whole region.

Requirement 3 / 1

Involve Research, Development or Demonstration

A RIIO-1 NIA Project 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

RIIO-2 Projects

☐ 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 new data-driven oscillation tracing methods as well as the guidelines of selection of the best tracing methods based on the type of oscillations can be adopted by NESO as part of the standard tool kits for system monitoring and operation.

Or, please describe what specific challenge identified in the Network Licensee's innovation strategy that is being addressed by the project (RIIO-1 only)

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.

Please demonstrate below that no unnecessary duplication will occur as a result of the Project.

The related work to this project is listed below, where the difference and the added value of this project is explained.
1. NIA project with Imperial College: DOME NIA2_NGESO049
The DOME project has different motivations and objectives to the proposed project. DOME focuses on a pre-oscillation early-warning system and has a need to deliberately perturb the system to “excite the data”. The proposed project aims at a post-oscillation tracing method which “listens to the data” passively. The difference in focus calls for different, but related, analysis methods.
2. SSO Identification Automated Identification of Sub-Synchronous Oscillations (SSO) Events | ENA Innovation Portal
The SSO Identification Tool project has recently concluded, resulting in the development of a Python-based tool designed to identify potential system operating conditions that could lead to Sub-Synchronous Oscillations (SSO). The tool, created through the project, employs a combination of innovative frequency domain methodologies and machine learning techniques. This allows for the unattended execution of Electromagnetic Transient (EMT) simulations and the automatic identification of SSO events.
2. SIF project Alpha phase, led by SSEN: INSIGHT
This SIF project, which has just finished its alpha phase, tried out one existing tracing method, namely the oscillation power flow method, on a very simple system. There were no rigorous conclusion reached, no real-world systems investigated, and neither was a new method developed. The proposed project, on the other hand, aims at developing new methods with both theoretic rigour and practical validation in a comprehensive close-to-real-world context.

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 because it aims to develop new data-driven oscillation tracing methods and specify new data measurement strategy, which have not been tried in the GB or internationally.

Relevant Foreground IPR

The following Foreground IPR will be generated from the project:

- Proof of concept tool for new tracing methods that is applicable to IBR-related oscillations.
- Proof of concept tools for existing tracing methods tested throughout the project.
- Simulation models and data used to generate oscillation cases for testing and benchmarking.
- Report on the applicability of existing data-driven tracing method.
- Report on recommendations of data measurement strategy
- Final report that details the finding of the project throughout its 4 work packages.

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 apart of it's business and usual activities

The project plans to research the weakness of existing techniques and develop new technique to resolve the oscillations tracing challenge in IBR-based system, which does not fall into the current business as usual (BAU).

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 concept currently has a relatively low TRL of 3 with some experimental proof of concepts carried out. Therefore, innovation funding is more suitable for exploring the project's potential and increasing the TRL to demonstrate viability in a realistic environment 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