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_NESO059

Project Progress

Project Title

Power System Oscillation Characterisation using Wavelets and Trilateration

Project Reference Number

NIA2_NESO059

Project Start Date

May 2024

Project Duration

1 year and 7 months

Nominated Project Contact(s)

innovation@nationalenergyso.com

Scope

The project outcomes will allow NESO to :
1) accurately and actively identify sources of oscillations in real time;
2) make better use of limited PMU coverage to locate oscillation sources, and reduce need for additional PMU installation;
3) reduce reliance on stakeholder data to locate oscillation sources
4) have improved accuracy and reliability of location methods through use of data processing techniques

With threats of unforeseen instabilities mitigated, higher fractions of renewables can be accommodated without compromising the security of supply. This will facilitate net zero transition while ensuring secure and affordable supply for the customers.

The project is desktop assessment based, and will implement three work packages covering:

- Review of existing methods, their applicability to the GB Transmision System and the design of new energy methods and PMU trilateration
- Derivation of new method based on wavelet arrival time of mode of interest
- Testing of new methods in different models and GB network, plus final reporting

Objectives

The final outputs should include:

- Guidance and details on fast and accurate localisation of forced oscillation events in the UK network
- A demonstration of using the developed methods to localise forced oscillation events using simulated data on the two-area and IEEE 30-bus systems and real event data from the UK network.

The next steps will be determined by the trajectory of the project, though could include:

- Further adaptation and development of the methods to close gap between outcome and implementation
- Further development and deployment of the method in NESO to allow real time detection and mitigation of oscillations
- Development of an automatic detection, location and disconnection scheme based on the method.

Success Criteria

The following will be considered when assessing the success of the project

- Improvements to the accuracy of the application of the DEF method where there is limited PMU availability
- A new method of oscillation source identification using wavelet arrival time of the mode of interest
- Guidance on the use of the methods investigated and developed, including demonstrations of their application to the GB transmission system

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 Power System Oscillation Characterisation using Wavelets and Trilateration
NIA2_NESO059 (“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).

The Report provided is for information only and viewers of the Report should not place any reliance on any of the contents of this Report including (without limitation) any data, recommendations or conclusions and should take all appropriate steps to verify this information before acting upon it and rely on their own information. None of the Publishers nor its affiliated companies make any representations nor give any warranties or undertakings in relation to the content of the Report in relation to the quality, accuracy, completeness or fitness for purpose of such content. To the fullest extent permitted by law, the Publishers shall not be liable howsoever arising (including negligence) in respect of or in relation to any reliance on information contained in the Report

Project Aims:
The project has achieved the original aim of reviewing existing methods and testing the most widely used energy method for its applicability to the GB transmission system.

Objectives:
The project has not yet met the final objective of providing guidance and a detailed demonstration on the fast and accurate localisation of forced oscillation events in the UK network. Work is ongoing towards achieving this.

Success Criteria:
In relation to the original success criteria, the project is currently working towards the first criterion — improving the existing DEF method with limited PMU availability.
In this regard, two work packages have been delivered as listed below:
WP1: Report on existing localisation methods.
This report focuses on techniques used to localise the source of oscillations in power systems. These methods can be categorised according to the physical metrics used—such as energy, mode shape, travelling wave, and damping torque—or by the specific approaches applied, such as data-driven methods, machine/deep learning, and transforms. The principles of these techniques, along with their respective advantages and disadvantages, are discussed. Based on this report, recommendations are made for the NIA project on oscillation localisation. The report aims to provide a comprehensive review of the most widely reported techniques for oscillation source localisation in the literature, enabling researchers and engineers to identify the most appropriate method for their specific domain and application.
WP2: Report on dissipating energy flow-based method.
This report presents a thorough performance analysis of the energy flow method by examining incremental energy expressions over one period of the forced oscillation and exploring a wide range of oscillation frequencies. Frequencies of 0.66 Hz, 0.55 Hz, and 0.3 Hz, along with both well-damped and weakly damped conditions, are studied. Additionally, scenarios involving multiple oscillation sources

are considered.

The other criteria have not yet been started.

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

No modifications are required now. The proposed approach has proved feasible in our preliminary works.

Lessons Learnt for Future Projects

One key lesson is the importance of requesting real PMU data from the network operator as early as possible. The request was submitted for real event oscillation data several months ago, but no response was received. In the meantime, simulated PMU data is used.

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

A survey paper 'A Survey of Oscillation Localisation Techniques in Power systems' was published on 10, Feb 2025 in IEEE Access.

(This survey paper was an outcome of the first project aim to review existing methods. It focused on localizing the source of oscillation in power systems using different physical properties of the power system, including energy, mode shape, traveling wave, and damping torque, and different methods, including data-driven, machine/deep learning, and transforms.
A report on dissipating energy flow-based method was submitted in March 2025.
This report was an outcome of a more focused study on the mostly widely used existing methods based on dissipating energy flow. A thorough performance analysis of the energy flow method was conducted by examining the incremental energy expressions over one period of forced oscillation and exploring different inter-area oscillation frequencies (0.66 Hz, 0.55 Hz, and 0.3 Hz), sub-synchronous oscillation (SSO) frequencies (3 Hz, 6 Hz, and 9 Hz), and different damping ratios at well-damped and weakly-damped conditions.

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 works so far have focused on existing methods. The new method using limited PMU availability is still under development, so no foreground IPR has been produced yet.