NIA Project Registration and PEA Document

*Notes on Completion: Please refer to the NIA Governance Document to assist in the completion of this form. Please use the default font (Calibri font size 10) in your submission. Please ensure all content is contained within the boundaries of the text areas. The full-completed submission should not exceed 10/12 pages in total.*

1. Project Registration

|  |  |  |
| --- | --- | --- |
| Project Title (*This cannot be changed once registered*) |  | Project Reference |
| Power System Oscillation Characterisation using Wavelets and Trilateration |  | NIA2\_NESO059 |
| Funding Licensee(s) |  | Project Start Date |
| NESO |  | May 2024 |
| Nominated Project Contact(s) |  | Project Duration |
| David Gregory (NESO) |  | 18 Months |
| Contact Email Address |  | Project Budget |
| [innovation@nationalgrideso.com](mailto:innovation@nationalgrideso.com) |  | £450k |

**Project Summary (125 words limit)**

Sources of oscillations on the transmission system can be determined by investigating the transfer of oscillation energy in the network. Following the direction of the energy flow on the system allows the source of the oscillations to be traced.

These methods have limitations: it requires good coverage of power management units (PMUs) across the system, determining the time period for calculating the energy flow requires some manual intervention and some oscillation source will absorb energy at certain frequencies, meaning that the energy method cannot be used.

This project aims to explore potential improvements to energy methods, investigating the application of signal processing techniques to improve accuracy with limited PMU coverage, remove the need for manual intervention and to replace the energy flow direction calculation.

**Benefits Summary (125 words limit)**

**Lead Sector**

|  |  |
| --- | --- |
| Electricity Distribution | Gas Distribution |
| Electricity Transmission | Gas Transmission |

**Other Sectors**

|  |  |
| --- | --- |
| Electricity Distribution | Gas Distribution |
| Electricity Transmission | Gas Transmission |

**Research Area**

|  |  |
| --- | --- |
| Net zero and the energy system transition | Optimised assets and practices |
| Flexibility and Commercial Evolution | Whole Energy System |
| Consumer Vulnerability | Energy System Transition |

**Development steps**

|  |  |
| --- | --- |
| Technology Readiness Level (TRL) at Start | TRL at Completion |

1. Project Details
   1. Problem(s)

This should outline the Problem(s) which is/are being addressed by the Project. This cannot be changed once registered.

Forced oscillations can occur, undetected, on the transmission system, with no information available concerning their source. As a worst case, they can cause cascading outages and present a risk to the stable and secure operation of the system. Due to the increasing penetration of Inverter Based Resource (IBR) connecting to the transmission system over the coming years, their prevalence is likely to increase.

Detection and source location methods have been proposed, though require extensive Phasor Measurement Unit (PMU) coverage, and they have limitations.

* 1. Method(s)

This section should set out the Method or Methods that will be used in order to provide a Solution to the Problem. The type of Method should be identified where possible, eg technical or commercial.

For RIIO-2 projects, apart from projects involving specific novel commercial arrangement(s), this section should also include a Measurement Quality Statement and Data Quality Statement.

The approach to solving the problems will be delivered through three work packages:

* WP1 (Technical) will investigate existing energy based methods for oscillation source detection and the use of the dissipating energy flow (DEF) method on the GB Transmission System. This work package will also look at the use of trilateration to minimize the use of PMUs and an automatic method for calculating the energy using time-frequency plots of PMU data
* WP2 (Technical) will derive a new method of oscillation source localisation using the wavelet arrival time of the mode of interest
* WP3 (Technical) tests the use of the new methods derived in WP1 and WP2 in different models and the GB network. It will also compile the final report of the project and prepares slides/videos for dissemination

In line with the ENA’s ENIP document, the risk rating is scored Low.

TRL Steps = 1 (2 TRL steps)

Cost = 1 (£500k)

Suppliers = 1 (1 supplier)

Data Assumptions = 2

Total = 5 (Low)

* 1. Scope

The scope and objectives of the Project should be clearly defined including the net benefits for consumers (eg financial, environmental, etc). This section should also detail the financial benefits which would directly accrue to the GB Gas Transportation System and/or electricity transmission or distribution.

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
  1. Objectives

This cannot be changed once registered.

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.
  1. Consumer Vulnerability Impact Assessment (RIIO-2 projects only)

Details of the expected effects of the Method(s) and Solution(s) upon consumers in vulnerable situations. This must include an assessment of distributional impacts (technical, financial and wellbeing-related). For RIIO-1 projects please add “Not Applicable”

The 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.

* 1. Success Criteria

Details of how the Funding Licensee will evaluate whether the Project has been successful. This cannot be changed once registered.

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
  1. Project Partners and External Funding

Details of actual or potential Project Partners and external funding support as appropriate.

Durham University will be carrying out the work. No external funding required*.*

* 1. Potential for New Learning

Details of what the parties expect to learn and how the learning will be disseminated.

This project applies the energy method to localise forced oscillation for the first time in GB, and will further develop new energy methods that are custom-designed for the GB network using as few PMUs as possible and automatic oscillation period recognition for high accuracy.

It also aims to improve reliability and generality of source detection with new methods using the arrival time of the mode of interest.

These new methods will allow the network operator to identify what and who has caused the forced oscillation completely from the network side without any extra information or report from third parties.

Learnings from the project will be disseminated through the publication of academic papers, and also through presentation material developed in WP4.

* 1. Scale of Project

The Funding Licensee should justify the scale of the Project – including the scale of the investment relative to the potential benefits. In particular, it should explain why there would be less potential for new learning if the Project were of a smaller scale.

The project spans six months with one project partner. The project consists of desk-based research, tool development and workshops with the relevant NESO teams (including network and wider teams).

* 1. Geographical Area

Details of where the Project will take place. If the Project is a collaboration, the Funding Licensee area(s) in which the Project will take place should be identified.

We will be based upon the GB ESO area of operations.

* 1. Revenue allowed for in the current RIIO settlement

An indication of the funding provided to the network licensee within the current RIIO settlement that is likely to be surplus to requirements as a result of the Project.

None

* 1. Indicative Total NIA Project Expenditure

An indication of the total Allowable NIA Expenditure that the Funding Licensee expects to reclaim for the whole of the Project (RIIO1).

An indication of the Total NIA Expenditure that the Funding Licensee expects to reclaim for the whole of the Project (RIIO2).

£450,000

1. Project Eligibility Assessment

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).

* 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:

* + 1. How the Project has the potential to facilitate the energy system transition:

The project is meant to develop methods of locating sources of forced oscillations on the GB transmission system. Occurrences of oscillations in the system will increase due to the energy system transition, driven by the increase in IBR on the system. By developing methods to understand how oscillations occur and their sources, higher fractions of renewables can be accommodated without compromising the security of supply – to manage oscillations in realtime, typically renewable energy sources need to be curtailed. This will facilitate net zero transition while ensuring secure and affordable supply for the customers.

* + 1. How the Project has potential to benefit consumer in vulnerable situations:

NESO does not have a direct connection to consumers, and therefore is unable to differentiate the impact on consumers and those in vulnerable situations. The project's objectives include improving the overall stability and efficiency of the power system by providing advanced tools for identifying oscillations, ultimately leading to a more reliable and cost-effective operation of the system.

* 1. 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.

* + 1. ~~Please provide an estimate of the saving if the Problem is solved (RIIO-1 projects only~~
    2. Please provide a calculation of the expected benefits the Solution

This is for Development or Demonstration Projects, not required for Research Projects. It should be (Base Cost – Method Cost, Against Agreed Baseline) and include a description of the recipients of the benefits.

Currently, oscillations in the GB power system are detected by NESO monitoring the damping ratio on the GridMetrix tool. However, these events cannot be detected in advance, which makes the implementation of defensive actions highly complex when oscillations occur. The cost associated with an oscillation event entirely depends on how quickly and effectively defensive actions are taken in real time. Unfortunately, the current situational awareness of the GB power system does not allow NESO to develop effective and economical defensive strategy to counteract these events. Consequently, some oscillations events may lead to the tripping of generating units, which in turn potentially lead to further cascading tripping of generating units and eventually a blackout if not promptly addressed.

NESO has implemented a defensive strategy to mitigate oscillations based on actions that have proven to be effective in previous events. This defensive strategy incurs a cost of spinning certain generating units during specific system conditions to enhance the robustness of the system when oscillations are more likely to occur. However, the experience points out that there are no specific actions that damp out all oscillations. Therefore, having a more detailed insight of the system’s behaviour may help to develop more effective and reliable defensive actions.

The outcome of this project will provide improved detection and source location methods, enabling a better comprehension of the system’s behaviour and identification of the root causes of the oscillations studied. These findings will contribute to the establishment of a more effective defensive strategy. This will enable real-time operators to respond to oscillation events more effectively and make informed decisions to maintain the GB power system security.

* + 1. Please provide an estimate of how replicable the Method is across GB

This must be in terms of the number of sites, the sort of site the Method could be applied to, or the percentage of the Network Licensees system where it could be rolled-out.

The project will investigate oscillations in standard IEEE reference systems and data from real events on the GB transmission system. This should ensure that the method is replicable across GB..

* + 1. Please provide an outline of the costs of rolling out the Method across GB.

The output of the project is subject to uncertainty and therefore no cost for GB roll out can be given. If successful a cost of scaling the solution for the whole of GB can be calculated and assessed against other pavailable solutions.

* 1. Requirement 3 / 1 – involve Research, Development or Demonstration
     1. RIIO-1 Projects

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 systems and 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 GB electricity transmission or distribution systems |  |
| A specific novel commercial arrangement |  |

* + 1. RIIO-2 Projects

A RIIO-2 Project must involve the Research, Development or Demonstration of at least one of the following:

|  |  |
| --- | --- |
| 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 |  |

* 1. Requirement 4 / 2a – develop new learning

A Project must develop new learning that can be applied by Gas Transporter and/or Electricity Transmission or Electricity Distribution licensees. For RIIO-1 Network Licensees may wish to address challenges specific to their network.

Please answer one of the following:

* + 1. Please explain how the learning that will be generated could be used by relevant Network Licenses
    2. This outcome of this project would be:

1. This project applies the energy method to localise forced oscillation for the first time in GB
2. It further develops new energy methods that are custom-designed for the GB network using as few PMUs as possible for and automatic oscillation period recognition for high accuracy
3. It also aims to improve reliability and generality of source detection with new methods using the arrival time of the mode of interest.
4. These new methods will allow the network operator to identify what and who has caused the forced oscillation completely from the network side without any extra information or report from third parties

The next steps will depend on the trajectory of the project, though it is intended that any developments in oscillation localization techniques could allow the development of tools for deployment by the relevant network licensees

* + 1. Or please describe what specific challenge identified in the Network Licensee’s innovation strategy is being addressed by the Project (RIIO-1 only)
    2. Is the default intellectual Property Rights (IPR) position being applied?

This cannot be changed once registered.

|  |  |
| --- | --- |
| Yes | No |

If “no”, the following questions must be answered:

* + - 1. Demonstrate how the learning from the Project can be successfully disseminated to Network Licensees and other interested parties:

* + - 1. Describe how any potential constraints or costs caused, or resulting from, the imposed IPR arrangements:

* + - 1. Justify why the proposed IPR arrangements provide value for money for customers:

* 1. Requirement 5 / 2c – be innovative

A Project must be innovative (ie not a business-as-usual activity) and have an unproven business case entailing a degree of risk warranting a limited Research, Development or Demonstration Project to demonstrate its effectiveness. This could include Projects which are untested at scale, or in relation to which there are risks, which might prevent the widespread deployment of the equipment, technology or methodology.

* + 1. Why is the project innovative?

RIIO-1 projects must include description of why they have not been tried before.

This project applies the energy method to localise forced oscillation for the first time in GB, and further develops new energy methods that are custom-designed for the GB network using as few PMUs as possible and automatic oscillation period recognition for high accuracy.

It also aims to improve reliability and generality of source detection with new methods using the arrival time of the mode of interest.

These new methods will allow the network operator to identify what and who has caused the forced oscillation completely from the network side without any extra information or report from third parties.

* + 1. Why is the Network Licensee not funding the Project as part of its business as usual activities?

Due to the nature of the project and that it is researching potential future impacts to the grid based largely on assumptions, this does not fall into current business as usual (BAU).

* + 1. Why can the Project can only be undertaken with the support of NIA?

This must include a description of the specific risks (e.g. commercial, technical, operational or regulatory) associated with the Project.

* The project is in a complex area of power systems, and the TRL of the overall framework is low. 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.
* The relationship between the electrical distances of branches and the energy may be difficult to obtain in a practical network. Such relationship exists but depends on other factors as well. This poses risk on the trilateration method aiming to reduce the number of PMUs
* The energy flow may not be monotonically changing with the direction of oscillation energy transfer due to the internal dynamics. This will increase the localisation error for certain frequencies

* 1. Requirement 6 / 2d – 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.

* + 1. Please demonstrate below that no unnecessary duplication will occur as a result of the Project.

There are a number of projects addressing this problem at the time of writing. However, the proposed approach to solving the problem is unique and is not being considered by the other projects. It will also help to improve the understanding of the phenomena and techniques that can be used to locate sources of oscillations.

A number of the other projects in this area also require detailed system models to determine oscillation modes and sources and are intended for use in planning the transmission system. The proposed solution will only require measurement data and will be targeted at real time operational use.

* + 1. If applicable, justify why you are undertaking a Project similar to those being carried out by any other Network Licensees.

The problem being addressed by this project is an active area of research and as such is being looked at by a number of network licensees. It is considered appropriate to carry out similar work as it is unclear which method(s) will be most appropriate to address the challenge and therefore investigating multiple approaches is considered to be appropriate. ￼

Here are some of the previous projects with various approach:

* [Oscillation and regional RoCoF monitoring](https://smarter.energynetworks.org/projects/nia2_ngeso052/)
* [Data-Driven Online Monitoring and Early Warning for GB System Stability (DOME)](https://smarter.energynetworks.org/projects/nia2_ngeso049/)
* [WI-POD- Wind turbine control Interaction with Power Oscillation Damping control approaches.](https://smarter.energynetworks.org/projects/nia_nget0188/)
* [Detection and control of inter-area oscillations (DACIAO)](https://smarter.energynetworks.org/projects/nia_nget0161/)
* [RealSim: Real-Time Phasor-EMT Simulations](https://smarter.energynetworks.org/projects/nia2_ngeso045/)
* [Power System Oscillation Damping with HVDC (POD) - Feasibility Study](https://smarter.energynetworks.org/projects/prj_1410/)
* [Smart Grid Oscillation Management for a Changing Generation Mix (Psymetrix)](https://smarter.energynetworks.org/projects/prj_1096/)
* Automated Identification of Sub-Synchronous Oscillations (SSO) Events

**Relevant Foreground IPR**   
*Please provide a list of the relevant foreground IPR that will be generated in the course of the project e.g. reports, models, tools etc.*

**Data Access Details** *(standard ESO response - please do not edit)*

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:

1. A request for information via the Smarter Networks Portal at [https://smarter.energynetworks.org](https://smarter.energynetworks.org/), to contact select a project and click ‘Contact Lead Network’. NESO already publishes much of the data arising from our innovation projects here so you may wish to check this website before making an application.
2. Via our Innovation website at [Innovation | National Energy System Operator](https://www.neso.energy/about/innovation)
3. Via our managed mailbox [innovation@nationalenerygso.com](mailto:innovation@nationalgrideso.com)

Details on the terms on which such data will be made available by National Grid ESO can be found in our publicly available “Data sharing policy relating to NIC/NIA projects” at [80797503.1](https://www.neso.energy/document/168191/download)

1. PEA approval

The senior person (RIIO-1) or senior network manager (RIIO-2) responsible for implementing RIIO-2 NIA Projects must approve the PEA. It must then be published on the Project Registration page of the Smarter Networks Portal.

|  |  |
| --- | --- |
| **Please confirm this project has been approved by a senior member of staff** |  |