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

Jul 2024

Project Reference Number

NIA2_NGESO052

Project Registration

Project Title

Oscillation and regional RoCoF monitoring

Project Reference Number

NIA2_NGESO052

Project Licensee(s)

National Energy System Operator

Project Start

February 2024

Project Duration

2 years and 1 month

Nominated Project Contact(s)

innovation@nationalgrideso.com

Project Budget

£295,000.00

Summary

This project will provide monitoring capabilities, observing two dynamic phenomena in the GB power system – oscillatory behaviour and regional Rates of Change of Frequency (RoCoF) trends. It will utilise data from high resolution eXtensible Measurement Unit (XMU) devices, combined with analytical capabilities to provide insights into the behaviour of the transmission system. It is a desktop study that will use data gathered from the XMU devices and historic events to provide insights into the two dynamic phenomena and will allow us to assess the effectiveness of XMU devices in monitoring system behaviour.

Preceding Projects

NIA2_NGESO018 - Automated Identification of Sub-Synchronous Oscillations (SSO) Events

NIA_NGET0161 - Detection and control of inter-area oscillations (DACIAO)

NIA_NGET0188 - WI-POD- Wind turbine control Interaction with Power Oscillation Damping control approaches.

Third Party Collaborators

Durham University

Nominated Contact Email Address(es)

box.so.innovation@nationalgrid.com

Problem Being Solved

As more inverter-based resources (IBRs) such as wind farms, solar PV, and interconnectors are connected to the power grid, there is a risk of increased oscillations occurring. These oscillations can cause a loss of generation and system security issues. Currently, the ESO does not have a reliable way to identify the risks and root cause of oscillations and has limited insights (only post event data through TO PMU devices) into this system behaviour. In addition, the ESO has little insight into regional RoCoF across the system and how large frequency changes propagate across the system.Regional frequency data will be analysed from historic large system losses and used to identify and estimate the occurrence of distributed generation RoCoF trips associated with large generation losses.For oscillatory behaviour, a pre-agreed definition of oscillation characteristics will be defined and used to study the network, identifying potential areas for further exploration.

Method(s)

This project aims to provide insights into two significant operational challenges for which the ESO currently does not own or have detailed data access to address effectively. This data gap hinders informed decision-making regarding appropriate mitigation actions.
The project will provide ongoing analysis and monitoring over a two-year period, providing the ESO with core frequency dynamic performance data and high-resolution data from Reactive Technologies XMU's to provide additional insights into how the power system is operating. The monitoring will use existing XMU devices across Great Britain. This project will consist of the following Work Packages (WPs) as listed below:

WP1: RoCoF event monitoring and reporting
The project will analyse data from large RoCoF events on the transmission system and study the impact on regional frequency. It will estimate the occurrence of distributed generation RoCoF trips. This will allow the ESO to understand the risk of LoMP tripping at a regional level, which in turn will help understand the system's behaviour as a whole and assess the risk from residual un-changed RoCoF protection devices that may still require change.
The ESO will provide public reports that contain the data of large RoCoF events on the transmission network. Reactive technologies will use the RoCoF value and their inertia estimation to estimate the MW size of the event from which any secondary RoCoF trips can be identified using the MW size on the transmission level.

Deliverables:

- Historic report reviewing previous 18 month period, quantifying the general location (DNO region) and residual size (MW estimate) of RoCoF trips as a result of large RoCoF events on the system.
- Ongoing quarterly report for a period of 24 months to assess large events and impact on regional RoCoF.

WP2: Oscillation and harmonic monitoring and reporting
Oscillatory behaviour is becoming an increasing phenomenon on the GB transmission system. Identification and analysis of these phenomena will assist the ESO in assessing the stability and robustness of the network and help identify stability issues before they become significant.

In line with WP1, this work package will deliver a monitoring service for specific oscillation events and provide a regular, ongoing report for a period of 24 months. Oscillation events will be selected based on damping ratio minima calculated from regional frequencies and from the RMS voltage of a single selected XMU from each region.

Deliverables:

- Quarterly report for national and regional oscillatory behaviour seen in each region of the system. Top 40 events will be selected and analysed. Initial split proposed is half the events from Scotland and the other half from the rest of GB but this can be adjusted as required.
- Specific shorter-term turn around report for oscillation events identified by ESO (up to five events per quarter). This report will include frequency and time domain analysis of the dominant oscillation and the in-depth analysis linking the time of the event to the timing information of grid events shared by ESO.

In line with the ENA's ENIP document, the risk rating is scored Low.
TRL Steps = 1 (2 TRL steps)
Cost = 1 (£350k)
Suppliers = 1 (1 supplier)

Data Assumptions = 2
Total = 5 (Low)

Scope

This project will provide monitoring capabilities, observing two dynamic phenomena in the GB power system – oscillatory behaviour and regional RoCoF trends. It will utilise data from high resolution XMU devices, combined with analytical capabilities to provide insights into the behaviour of the transmission system. It is a desktop study that will use data gathered from the XMU devices and historic events to provide insights into the two dynamic phenomena and will allow us to assess the effectiveness of XMU devices in monitoring system behaviour.
Potential benefits of this project will be determined by the insights gathered, however could include:

- Greater understanding of regional frequency variations, supporting future product developments or operating policies.
- Insights of actual vs. modelled Loss of Mains (LoM) risks could allow the ESO to reduce operational response and reserve holding (reducing consumer cost without increasing risk).
- Development of preventative strategies to mitigate system oscillations.
- WP2 will provide greater understanding of the GB power system and investigations into the root causes of oscillation events. Increased and timely insights will allow the ESO to identify any areas of the system at risk of instability issues, and the root cause of this.

Objective(s)

The primary objective of this project is to investigate whether the data insights available to the ESO through XMU devices can provide sufficient, detailed insight into how the GB transmission system is operating. It will enhance the situational awareness of the GB power system, complementing the insights that ESO has from existing PMUs.

- Evaluate whether high resolution XMU data can provide new insights into GB system operation that have previously been unavailable to the ESO.
- Assess if the resolution of the results is specific enough to allow the ESO to make changes to operational conditions (if deemed economic and/or relevant).
- Determine if data can be used to enhance the situational awareness currently provided by the SCADA system and PMUs to make more informed decisions to maintain the stability and reliability of the GB power system.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

The ESO 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 below.

Success Criteria

The success of this project will be determined by its ability to demonstrate the value of data insights provided by XMU technology into how the power system is operating. The project's success will be measured by its ability to achieve the objectives

- Project delivers on time and within specified budget.
- Conclusions can be drawn from the datasets to summarise results and findings.
- Clear understanding around whether resolution of the results is specific enough to allow the ESO to make changes to operational conditions (if deemed economic and/or relevant).
- Data can be used to enhance the situational awareness currently provided by the SCADA system and PMUs to make more informed decisions to maintain the stability and reliability of the GB power system.

Project Partners and External Funding

Reactive Technologies will be carrying out the work, no external funding is required.

Potential for New Learning

The specific learnings of this project are unknown due to the use of new technology to monitor the behaviour of the GB transmission system. However, the purpose of the project is to develop new learnings and insights into these characteristics of the system which are currently unknown. Some examples of this could be:
Insights into regional system frequency that have never been analysed before
Determine system imbalances at locational resolutions not used before
More accurate insights into the Loss of Mains (LoM) risks using analytical approaches rather than forecasted, which is the current approach.

Increased insights into the causes of system oscillations to create preventative strategies, rather than corrective actions.

Scale of Project

This project will provide monitoring capabilities, observing two dynamic phenomena in the GB power system – oscillatory behaviour and regional RoCoF trends. It will utilise data from high resolution XMU devices, combined with analytical capabilities to provide insights into the behaviour of the transmission system. It is a desktop study that will use data gathered from the XMU devices and historic events to provide insights into the two dynamic phenomena and will allow us to assess the effectiveness of XMU devices in monitoring system behaviour.

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Technology Readiness at Start

TRL3 Proof of Concept

Technology Readiness at End

TRL5 Pilot Scale

Geographical Area

The project will be based upon the GB ESO area of operation.

Revenue Allowed for the RIIO Settlement

None

Indicative Total NIA Project Expenditure

£295,000

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:

As we move to an IBR dominated electricity system, there is a risk of increased oscillations occurring. The detection of oscillations in the power grid is an important step towards creating a more reliable and stable grid, which is essential for the net-zero energy transition. Oscillations in the grid can occur due to a variety of reasons, such as fluctuations in demand, changes in supply, and faults in the system. These oscillations can result in voltage and frequency variations that can disrupt the operation of power systems and cause blackouts.

By detecting these oscillations, the ESO can take proactive measures to mitigate them and prevent power outages. This will help create a more reliable, efficient system as we continue to drive the net-zero transition

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

Currently, oscillations in the GB power system are detected by ESO 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 the ESO 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.

The ESO 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 a post-event analysis, 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.

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

The methodology developed in this project is designed to detect and locate power system oscillations and regional RoCoF trends across the entire Great Britain (GB) transmission system, based on the location of XMU devices.

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

The method will be run for GB based on existing locations of XMU devices. Once results are analysed, a CBA will be conducted to identify whether continued monitoring is required and/or the installation of additional XMU devices is of benefit to the ESO.

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

- While the ESO will primarily benefit from the results of this project, it is important to note that the insights gained will also have positive implications for Network Licenses. DNOs will be able to update their LoM RoCoF settings, leading to reduced consumer costs without compromising on risk. TOs, on the other hand, will experience the advantages of implementing more effective defensive strategies against oscillations. This will result in longer availability of certain transmission assets that could be impacted by oscillations if not promptly addressed.
- A final report will be provided at the end of the project, summarising the findings and assessment of XMU technology. This will be accessible for all Network Licensees.

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 proposed project ensures that there is no unnecessary duplication with any existing projects. Specifically, the Oscillations Guard Pro project developed by Reactive Technologies does not overlap or duplicate any requirements or outcomes of this project. While the Oscillations Guard Pro project focuses on developing an online monitoring tool for detection of oscillations, the proposed project is an offline desktop study. Its objective is to analyse post-event oscillations to identify the root causes that triggered such oscillations. This project aims to increase the situational awareness of the system, which in turn enables the ESO to establish more effective mitigation strategies that can be implemented in real-time when oscillations are detected by the Oscillations Guard Pro tool. Hence, there is no unnecessary duplication between the proposed project and other ongoing initiatives.

The below innovation projects are considering oscillations at transmission level but using installed PMU equipment. This project is providing an assessment of system conditions using monitoring techniques enabled by XMUs that has not been used before at the transmission level. Therefore, this is a new approach being covered by any of the below projects.

- (NIA2_NGESO049) Data-Driven Online Monitoring and Early Warning for GB System Stability (DOME): Injecting a small high frequency signal at optimal locations on the GB system, to identify the root cause of oscillations and mitigate potential risks
- (NIA2_NGESO018) Automated Identification of Sub-Synchronous Oscillations (SSO) Events – This project will explore, develop, and test a combination of novel frequency domain methodologies and machine learning techniques to identify potential system operating conditions which can lead to Sub-Synchronous Oscillations (SSOs) and implement an automated control interaction studies framework.
- (UKRI10079053) – INSIGHT - Innovative Network Status Intelligence Gathered by Holistic use of Telemetry - The Project seeks to understand, classify, predict, and define actions to manage potential new forms of instability (e.g., oscillations in voltage, power, and/or frequency) on a system dominated by power electronic sources (such as wind generation, HVDC converters, STATCOMs.).

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

The technology being utilised through this project has not been tested before to provide the specific insights proposed by this project. XMU technology will provide new insight to the ESO which has otherwise been unavailable, or that the ESO have relied on third party (transmission owners) to provide the data.
The project will enhance the situational awareness of the GB power system, complementing the insights that ESO has from existing PMUs.
If successful, the results of this project will provide detailed data to the ESO and facilitate improvements to system operating conditions, create savings for consumers and increase the detail with which the ESO can assess the behaviour of the transmission system.

Relevant Foreground IPR

The following foreground IPR is expected to be generated in the course of the project:

- Data insights from XMU devices that can provide sufficient, detailed insight into how the GB transmission system is operating.
- Technical reports on regional RoCoF behaviour and the regions where secondary trips took place following large RoCoF events on the transmission system. This will provide insights on the risk of RoCoF LoMP trips.
- Technical reports for national and regional oscillatory behaviour seen in each region of the system.
- A technical report on how many measurement points are needed to identify adequately the modes of a region of the GB transmission system or indeed the whole system. A set of results verifying the work of WP1 and WP2.

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 Grid ESO 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 https://www.nationalgrideso.com/future-energy/innovation
- Via our managed mailbox 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 https://www.nationalgrideso.com/document/168191/download.

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

As this project will be assessing methods not previously demonstrated in an electricity system operation environment with high levels of uncertainty and risk, this would not fall into BAU activities.

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 TRL of the overall framework is relatively low. Therefore, innovation funding is more suitable for exploring the project's potential and increasing the TRL before transferring into BAU activities.
- Conducting this project with NIA funding will ensure that the project findings can be shared more widely with other interested network licensees in TO/DNO, as the oscillations in the network affect multiple users of the power system.

This project has been approved by a senior member of staff

☑ Yes