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 2024

Project Reference Number

NIA_SHET_0051

Project Registration

Project Title

SETTLE

Project Reference Number

NIA_SHET_0051

Project Licensee(s)

Scottish and Southern Electricity Networks Transmission

Project Start

January 2025

Project Duration

3 years and 0 months

Nominated Project Contact(s)

Brant Wilson – Innovation Portfolio Manager

Project Budget

£1,187,416.00

Summary

A real-time alert and control system for the system operator to reduce system stability risks by monitoring, detecting, interpreting, and mitigating different types of power network oscillation events.

SETTLE bridges earlier SIF work carried out under the INSIGHT project (Discovery Phase and Alpha Phase) and its potential Beta Phase by delivering clear oscillating tracing, categorisation, measurement and modelling that provides the foundation for new control and planning tools to be developed and demonstrated in Beta.

Preceding Projects

UKRI10051585 - INSIGHT (Innovative Network Status Intelligence Gathered by Holistic use of Telemetry and Simulation)

UKRI10079053 - INSIGHT - Innovative Network Status Intelligence Gathered by Holistic use of Telemetry

Third Party Collaborators

University of Strathclyde

Imperial College London

BVM Systems

Nominated Contact Email Address(es)

transmissioninnovation@sse.com

Problem Being Solved

Inverter-based resources (IBRs), e.g. wind and solar, introduce new dynamics compared to traditional fossil fuel-driven synchronous generation. System instabilities that manifest as power system oscillations have occurred, presenting a severe threat to the security of the system.

The current method of managing oscillations is to increase the strength of the system by changing the generation dispatch and/or restricting the taking of major system outages. There is a requirement to reduce the need to restrict generation output to isolate and manage oscillations, resulting in lower balancing mechanism costs associated with stability.

Method(s)

Use modelling software to develop an approach which both defines a frequency dependent network equivalent of the passive elements of the equivalenced system (i.e. a frequency dependent impedance behind a limited voltage source) together with then folding synchronous generation representation within that frequency dependent impedance behind a voltage source. Power electronic sources to be further represented as frequency dependent impedance (exploring use of current source representation to provide suitable voltage dependency where relevant).

Using provided measurement data, derive a small signal representation of an actual device to be then compared with the small signal analysis of the relevant electromagnetic transient (EMT) model by HVDC centre.

Consultant to be engaged to distil lessons learned into a proposed specification for frequency domain monitoring of steady state. Using the measurement data the project will test this specification with a programmable Phasor measurement unit (PMU). Further testing will be performed with the same specification and programmable PMU to replicate steady state performance responses via the replicas located at the National HVDC Centre.

Perform literature review on the existing classifications for non-classical device oscillation contributions to non-classical oscillation; what complements, damps and drives the oscillations. This will lead to new learning -

• based on the frequencies of oscillation and for each the tendency to be undamped
• from this derive acceptable damping ratios by frequency
• what factors that depends upon
• what alerts the operator to risk of insufficient damping; exploration of pre-state- post state trending via Bayesian/ AI learning approaches based on available event data.

Establish definitions relating to device/ network contributions to non-classical oscillation what complements the oscillation, what damps the oscillation, what drives the oscillation. Using event data establish techniques based on damping ratio assessment, assessment of actuation of oscillation using small signal and other non-classical mechanical approaches to power electronic device contribution to actuation. Assess tendency to undamping via sensitivity analysis to a range of operational actions in voltage step, angle, inertia change, frequency change that would be classified as small signal and then larger event triggers such as a fault.

In response to these learnings, propose a GB-centric adoption strategy and, where relevant within the time, develop a statistical framework to classify oscillation types based on Bayesian or AI approaches. In all cases identify linkages with PMU specification to feed into.

Test the practicality of these definitions in response to different event data and, in co-ordination with National HVDC centre model replication of these events in real-time simulation.

Propose a sequence of activities for -

• identifying the above oscillation classifications, the device effect and the most appropriate source of damping
• determining what influences the frequencies of that damping have and how those frequencies are applied
• the balance between active, reactive power or combination in effectively damping
• how to establish practical criteria for triggering the damping response and the disengaging of it.

Data Quality Statement (DQS):

The project will be delivered under the NIA framework in line with OFGEM, ENA and SSEN Transmission internal policy. Data produced as part of this project will be subject to quality assurance to ensure that the information produced with each deliverable is accurate to the best of our knowledge and sources of information are appropriately documented. All deliverables and project outputs will be stored on our internal SharePoint platform ensuring access control, backup, and version management. Deliverables will be shared with other network licensees through the closedown reports on the Smarter Networks Portal.

Measurement Quality Statement (MQS):

The methodology used in this project will be subject to supplier's own quality assurance regime. Quality assurance processes and the source of data, measurement processes and equipment as well as data processing will be clearly documented and verifiable. The measurements, designs and economic assessments will also be clearly documented in the relevant deliverables and final project report and will be made available for review.

In line with ENA's Energy Networks Innovation Process (ENIP) document, the cumulative risk score is scored as 8 = MEDIUM from the sum of the risk thresholds below:

TRL Steps – 1 TRL Steps – Low (Score 1)
Cost – >£1m – High (Score 3)
Number of suppliers – 3 – Medium (Score 2)
Data – Assumptions known but will be defined within project – Medium (Score 2)

Scope

The project scope is as follows –

The project focuses on the interpretation of network oscillation mechanisms in real-time and the associated modelling capabilities.

SSEN-Transmission

• Project Management.
• System Performance SME support across all work packages.

HVDC Centre

• SME support across all work packages.
• Internal supervisor for Imperial College PhD student.
• Host BVM Systems for modelling and characterisation work.

Imperial College London

• Definition of models including frequency dependent reductions.
• Creation of device models from monitoring data.
• Classification of existing inverter-based oscillations and literature review.
• Classification, analysis and early warning of future oscillations (PhD).

University of Strathclyde

• Investigate and implement generic IBR models with different control designs.
• Further development of the real-time network developed as part of INSIGHT SIF Alpha Phase.
• Investigation of analytical approaches and select the most suitable for SETTLE.
• Generate a range of oscillation test cases representative of different oscillation mechanisms.

BVM Systems

• Characterisation of its PQSensorTM to determine its frequency bandwidth.
• Identification and assessment of monitors suitable for power system oscillation monitoring including developing a specification.
• This work will allow the measurements going into the algorithm to be better understood to appreciate their limitations.

A Cost Benefit Analysis has been developed to estimate the financial benefits which can be linked to:

• Lower bills for Consumers: Reduced need to restrict generation output to isolate and manage oscillations, resulting in lower balancing mechanism costs associated with stability.
• Reduced environmental impact: Given balancing actions that manage oscillations can increase CO2 emissions as carbonbased sources of generation are often use for balancing.
• Better Network Stability: Lower risk of whole or localised network blackout due to an improvement in stability.
• A reduction in customer minutes lost due to outages, i.e., a positive societal impact.

Objective(s)

A real-time alert and control system for the system operator to reduce system stability risks by monitoring, detecting, interpreting, and mitigating different types of power network oscillation events.

SETTLE bridges earlier SIF work carried out under the INSIGHT project (Discovery Phase and Alpha Phase) and its potential Beta Phase by delivering clear oscillating tracing, categorisation, measurement and modelling that provides the foundation for new control and planning tools to be developed and demonstrated in Beta.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

An assessment of distributional impacts (technical, financial, and wellbeing related) for this project has been carried out using a bespoke assessment tool, which assesses the project as having a positive, negative, or neutral effect on consumers in vulnerable situations. To help inform the assessment, this tool considers the categories of consumers identified in the Priority Services Register. This project has been assessed as having a neutral impact, meaning that it does not have any effect on customers in vulnerable situations. This is because it is a Transmission project.

Success Criteria

The project will be deemed as successful if all items in the scope, objectives and learnings are met which can be used to increase the understanding of network behaviours.

Project Partners and External Funding

The project will be undertaken using NIA funding by Scottish Hydro Electric Transmission supported by the following partners -

University of Strathclyde: Department of Electronic and Electrical Engineering. Expertise in Power System and Power Electronics Modelling and Analysis.

Imperial College London: Department of Electrical and Electronic Engineering. Expertise in Power Systems and Power System Stability and System Stability Analytics.

BVM Systems: Small Medium Enterprise (SME) with power quality, harmonic and transient measurement expertise. Their PQSensorTM allows low and high frequency monitoring of power systems dynamics and transients.

Scottish Hydro Electric Transmission will also utilise the National HVDC Centre whose test facilities and expertise in detailed network modelling (‘replicas’) and grid integration and interactions will be leveraged.

Potential for New Learning

SETTLE bridges earlier SIF work carried out under the INSIGHT project (Discovery Phase and Alpha Phase) and its potential Beta Phase by delivering clear oscillating tracing, categorisation, measurement and modelling that provides the foundation for new control and planning tools to be developed and demonstrated in a potential Beta. The learning will be disseminated via publications and industry conferences such as the Energy Innovation Summit.

Scale of Project

This project is designed to get maximum learning for minimal cost. This scale of project expects to provide sufficient learning to further understand network behaviours and inform a potential future SIF project. Any smaller scale project would limit the ability to fully develop the learnings.

Technology Readiness at Start

TRL3 Proof of Concept

Technology Readiness at End

TRL4 Bench Scale Research

Geographical Area

The project will be undertaken in the Scottish Hydro Electric Transmission licence area in Scotland.

Revenue Allowed for the RIIO Settlement

No allowance has been made for this type of development within the RIIO-T2 settlement. No savings are expected during project implementation; future savings may be possible depending on the outcomes of the project and future SIF project.

Indicative Total NIA Project Expenditure

The total expenditure expected from the project is £1,187,416. 90% of which £1,068,675 is allowable NIA expenditure.

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:

The project has the potential to facilitate the energy system transition by developing and delivering a real-time alert and control system methodology for the system operator to reduce system stability risks by monitoring, detecting, interpreting, and mitigating different types of power network oscillation events.

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

As this project is low TRL (Technology Readiness Level), a cost-benefit analysis is not required at this stage to meet NIA criteria. However, a reasonable attempt to quantify the potential benefits has been made. A general risk adjustment, due to the low TRL, of 20% has been made.

No benefits are expected from the outputs of the NIA project. The outputs will inform a potential future SIF BETA project which will deliver the expected benefits.

• Network Operational cost saving (1%)
o Assumed SETTLE can help to reduce 1% of Balancing Mechanism (starts from 2032) and NOA Pathfinder (starts from 2036) due to network stability improvement.
o Lifetime saving: £259m
o Annual saving: £12.7m

• Risk Avoidance:
o Lifetime saving: £19.6m
o Annual saving: £0.44m

• Social Impact:
o Customer minutes lost is converted to value of lost load (approximately 165MWh)
o Lifetime saving: £4.55m
o Annual saving: £0.1m

Summary
Total lifetime saving:

£283.15m without risk adjustment, or
£226.52m price) risk adjusted.
Annual saving: £13.24m risk adjusted.

All values are demonstrated in 2018 real price and the figures do not consider discount rate.
Asset lifetime: 45 years

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

All GB Transmission owners can utilise the project outputs to enhance their existing network models.

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

Costs are dependent on each TO and cannot be confirmed as part of this NIA project.

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

SETTLE bridges the gap between the completed INSIGHT (SIF Discovery and Alpha Phase) projects and its potential future Beta Phase. SETTLE plans to deliver clear oscillating tracing, categorisation, measurement and modelling that provides the foundation for new control and planning tools to be developed and demonstrated in the Beta Phase of INSIGHT.

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.

SETTLE bridges the gap between the completed INSIGHT (SIF Discovery and Alpha Phase) projects and its potential future Beta Phase.

A review of the ENA Smarter Networks portal has concluded that there is no duplication with existing or past completed projects.

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 project leverages new technology to test the developed project learning. This includes the use of innovative equipment and methodologies that could benefit the industry if proven successful. By tackling theoretical novel systems, the project embraces risks that might deter more conventional initiatives. This willingness to explore uncharted territories is a hallmark of innovation, aiming for breakthroughs that could lead to significant advancements.

Relevant Foreground IPR

Any foreground IP created, and any background IP used will remain property of the creating party. Any IP generated by HVDC centre will remain property of SSEN-T. IP arrangements are as required of the NIA Governance.

Data Access Details

For information on how to request data gathered in the course of this project, see Strategic Innovation Fund (SIF) and Network Innovation Allowance (NIA) Data Sharing Procedure at https://www.ssen-transmission.co.uk/about-us/innovation/.

Additionally, data from this project and all other projects funded under the Network Innovation Allowance (NIA), Network Innovation Competition (NIC) or the Strategic Innovation Fund (SIF) can be found or requested in the ways listed below:

• Via the Smarter Networks Portal at: https://smarter.energynetworks.org. To contact select a project and click 'Contact Lead Network.' SSEN Transmission 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 - SSEN Transmission (ssen-transmission.co.uk)
• Via our managed mailbox: transmissioninnovation@sse.com

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

The Network Licensee (SSEN-T) is not funding the SETTLE project as part of its business-as-usual activities because the project involves a pioneering methodology that has not been previously tested. This innovative approach carries inherent risks and uncertainties, necessitating a Research, Development, or Demonstration phase to validate its feasibility and effectiveness. The project aims to address existing challenges in a more effective manner, leveraging cutting-edge technology and novel systems that require thorough testing before they can be integrated into standard operations.

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

This project can only be undertaken with the support of NIA due to the overall cost, risks and timescales required. There is also commercial risk that the project may not deliver the expected outcomes. NIA is the best mechanism to fund development projects such as this.

This project has been approved by a senior member of staff

☑ Yes