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

Jun 2024

Project Reference Number

NIA_SHET_0047

Project Registration

Project Title

Non-Intrusive Foundation Testing

Project Reference Number

NIA_SHET_0047

Project Licensee(s)

Scottish and Southern Electricity Networks Transmission

Project Start

June 2024

Project Duration

1 year and 10 months

Nominated Project Contact(s)

Brant Wilson – Innovation Portfolio Manager

Project Budget

£570,000.00

Summary

Overhead line (OHL) foundation condition is difficult to assess without costly and disruptive excavation. Based on existing knowledge or previous data, non-intrusive techniques can be used and have been available for many years but are inadequately researched/developed for use in OHL foundations to base refurbishment and replacement decisions upon. The proposed solution will carry out the development, testing, and trial of a new method with an aim to achieve a reliable non-intrusive foundation assessment.

Third Party Collaborators

Xytecs Ltd

Nominated Contact Email Address(es)

transmissioninnovation@sse.com

Problem Being Solved

Foundations are a key component within the structural and mechanical support system for overhead line towers. It is challenging to accurately assess their condition without significant excavation works. An understanding of the condition is required for routine monitoring and to contribute to decisions about line refurbishment, upgrade, replacement and during the design of a refurbished or upgraded line. Without any further knowledge, often an arbitrary percentage of the foundations on a route are selected for intrusive investigations which incur high costs and disruption. There are techniques available that can non-intrusively assess foundations such as linear polarisation resistance (LPR), echo testing, soil resistivity testing, and ultrasonic concrete testing. Although these non-intrusive assessment techniques have been around for a few decades, they have been inadequately developed for accurate use in overhead line foundations, having largely been transferred across from other sectors where their use is more straightforward. The results are currently not reliable enough to base refurbishment and replacement decisions on.

Method(s)

The proposed solution will carry out the development, testing, and trial of a new method for achieving reliable non-intrusive foundation assessment. The identified limitations of the existing techniques will be investigated, including a survey of existing literature, evaluating the suitability of commercially available equipment through controlled testing in a small test environment that will assess different soil and backfill conditions. Varying steel sections will be inserted into the backfill and soils of varying types assessed, and the rate of corrosion will be predicted and then measured, to determine the reliability of the measurements. If sufficient then a procedure will be created to include the new learnings and allow users to generate measurements that are required to produce a reliable corrosion rate. Other activities include investigating soil resistivity contributions and echo testing waveform interpretation.

A mathematical model will be produced and then later a prototype tool that allows a test engineer to arrive on-site with a predetermined waveform of a theoretically perfect foundation. If the test engineers' results differ from the theoretical model, it will be possible to determine, in real-time, if there are any variations. If major variations are found, then other techniques could be used to further investigate the foundation.

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 ENIP document, the cumulative risk score is scored as 7 **= MEDIUM** from the sum of the risk thresholds below:

TRL Steps – 5 TRL Step – Medium (Score 2)
Cost – £500,000 - £1m – Medium (Score 2)
Number of suppliers – 1 – Low (Score 1)
Data – Assumptions known but will be defined within project – Medium (Score 2)

Scope

The scope of the project is broadly split into the following stages -

Stage 1 – Background data and test planning

• Comprehensive research of latest developments in LPR, Echo, and Resistivity testing relating to Overhead Line foundations and the science of the basic techniques.
• Carry out ultrasonic concrete measurements across SSEN projects where foundation intrusive investigations are currently ongoing. Other networks also where possible.
• Development of test plans and designs based on information gathered.

Stage 2 – Theoretical modelling and lab tests

• Mathematical modelling of echo testing.
• Small-scale modelling and development of LPR and Resistivity techniques.

Stage 3 – Full-scale controlled testing

• Testing each technique on full-size foundations and with varying backfill, conditions, and defects.

Stage 4 – Tool development

• Analyse investigation data - determine whether any further testing would be beneficial.
• Design a prescriptive methodology to include LPR, resistivity, and echo testing.
• Build a prototype tool which enables:

o Mathematical models to be constructed for foundation echo responses.
o imports and builds upon foundation information/records.
o Exports expected waveforms to validate on-site in real-time.
o Includes other on-site real-time environmental data.
o Imports test results and analyses against model expectations and other similar foundations in the database.

This tool will not be a final commercially-ready product, but it will be sufficient to prove the above works, ready for an end–user software tool to be produced outside of this project.

Stage 5 – Network validation

• Test and validate the methods and tool against existing excavations. Basic validation of the accuracy of the methods will have taken place already in previous stages so this will be a validation of the final output from the project, a working prototype tool.

Stage 6 – Implementation

• Integrate the outputs that will come from these techniques into network policies and systems including any training, debriefing, and demonstrations.

Financial benefits can be found in section 3.2.2.

Objective(s)

The project objectives are to:

• Investigate the current limitations in echo testing, LPR, and soil resistivity testing to determine whether they can be used for accurate and reliable OHL foundation condition assessment.
• Create a method and prototype tool for any non-intrusive foundation inspection techniques that prove to be reliable and draw them together into a clear methodology for future testing.

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 achieved.

Project Partners and External Funding

SSEN Transmission will partner with Xytecs Limited to deliver Non-Intrusive Foundation Testing using Network Innovation Allowance (NIA) funding.

Potential for New Learning

The outputs of this project include both theoretical and physical testing results for a range of non-intrusive foundation testing techniques that are currently unavailable for the application to OHL foundation inspection. This project, if proven successful, will create understanding and learning which would benefit the whole UK industry, including the first clear and transparent, scientifically supported information on the validity and accuracy of these techniques.

Learnings from the project will be disseminated via internal and external stakeholder event which will be conducted during the project. The learnings will also be shared within the annual project report and at relevant dissemination events such as the Energy Networks Innovation Summit.

Scale of Project

The project time frame is 18 months and is designed to get maximum learning for minimal cost and involves research, development, and demonstration. The project will begin with research into the latest developments in LPR, Echo, Resistivity testing and basic techniques related to OHL foundations followed by the development of test plans and designs based on the information gathered. The outputs of these activities will feed into, in a later phase, tool development followed by network validation and implementation.

Technology Readiness at Start

TRL2 Invention and Research

Technology Readiness at End

TRL7 Inactive Commissioning

Geographical Area

The project will take place in the Scottish Hydro Electric Transmission license 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 the future adoption of the learnings.

Indicative Total NIA Project Expenditure

The total NIA Expenditure for the project is £570,000, 90% (£513,000) 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:

As the network continues to grow over the coming years with the transition to net zero, more towers will be constructed that will later require inspection. In parallel, our responsibility to inspect our existing OHL foundation infrastructure to ensure network reliability and safety remains critical. Our current approach to foundation inspections is an intrusive approach that involves excavating the foundations. This project could lead to a better ability to predict higher-risk foundations reducing the chance of future foundationrelated incidents, allowing targeted maintenance/upgrade works and reducing unnecessary foundation upgrade works. Resources can then be better focused on building new infrastructure required to meet the energy system transition objectives and transition to net zero.

How the Project has potential to benefit consumer in vulnerable situations:

Not applicable.

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)

Not applicable.

Please provide a calculation of the expected benefits the Solution

This project has the potential to provide benefits for all Transmission network overhead line foundations and is likely to also be entirely relevant to distribution networks. The benefits are expected to be:

• Reduction of foundation intrusive exploration expenditure.
• Reduction of foundation upgrade works, with cost and time savings, and safety improvements through reducing construction works. This reduction will be justified through a better, more evidence-based understanding of residual risks, allowing policy adjustments to be made.
• Better ability to predict higher-risk foundations reducing the chance of future foundation-related incidents.
• Improve health and safety by removing damage to OHL/towers during foundation upgrades, hence, reducing the probability of risk events.
• Environmental impact – Reduction in materials and concrete required during foundation upgrades and reduction in access works.

An existing 132kV OHL with 193 towers of which 72 initial proposed foundation upgrades was examined to assess potential benefits for a single case.

Cost Benefit Analysis

The CBA Model is based on some assumptions below:

• The CBA model incorporates the project cost as part of the development cost.
• Due to the uncertainty and low level of TRL, an assumption that this project has a 40% probability of success has been made to estimate the low-level benefits.

• The capitalisation rate is 90% which is based on the current versus non-current cost.
• The number of foundation upgrades required will reduce by 40% when intrusive and non-intrusive testing method are employed.
• In the current approach, the percentage of foundations tested intrusively is 5% to 10% per line, and this rate is factored into the base case for this analysis.

• 50% of total foundations are tested non-intrusively, and 2% of total foundations are tested intrusively to validate non-intrusive findings. This approach is considered as a preferable option.

Summary of Benefits

Preferable option: Combining both non-intrusive and intrusive foundation testing.

• For a single case, the estimated saving is £1.4m discounted in 2018 real price. The benefit of this project will realise in 2029.
• For scaled benefits, it is estimated £2.3m discounted in 2018 real price. For £1 spending in this project, it can return £1 in cost saving by T3 or £5.9 through the lifetime of all eligible projects. (Annualised ROI: 15.2%).
• Due to uncertainty of this technology, the probability of success for this project is assumed to be 40%, which leads to the low benefits estimated at £915k in 2018 real price for the scaled benefits.
• In addition to a potential saving in CAPEX, there are also social impacts and other savings due to risk reduction. The total risk benefit saving is estimated at £132k.

Breakeven point analysis:

• For a single case, this innovation will need to achieve at least an 8% reduction in the number of foundation upgrades or 6 towers to break even and be considered a feasible investment.
• If not accounting for the development cost, this innovation project will reach break-even point if it can reduce 1 foundation upgrade compared to the initial number of foundation upgrade proposed in a single case.

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

The learnings which are of interest is not limited to Scottish Hydro Electric Transmission, all transmission and distribution network operators across GB could benefit from this research work.

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

This research project is at low TRL level, consequently the costs for rolling out the method across GB network are not fully defined. If this project is successful, then there is the potential to use the outputs of the project to support roll out non-intrusive foundation assessments across GB. The costs would be dependent on the proven solution and on-site requirements.

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 outputs of this project include both theoretical and physical testing results for a range of non-intrusive foundation testing techniques that are currently unavailable for the application to OHL foundation inspection. There is potential for other TOs and our distribution colleagues to make use of the outputs of the project as each sector/company has OHL foundation towers that currently employ intrusive foundation assessments. To date, both National Grid Electricity Transmission and SSEN-Distribution have indicated an interest in the outcome of this project.

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

Not applicable.

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.

There have been projects previously investigating the non-intrusive inspection techniques associated with foundations. Other projects (NIA_SPT_1607) have looked at vibration and ground penetrating radar and (NIA2_HGET0010) ultrasonic guided wave retrospectively. IFI 0620 has investigated similar techniques as this proposed project, however, this project was completed over 14 years ago and technology has progressed since then. Following this assessment, a combination of appropriate techniques will be determined, and a method, prototype and clear methodology will be established for future testing.

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

Not applicable.

Additional Governance And Document Upload

Please identify why the project is innovative and has not been tried before

Although these non-intrusive assessment techniques have been around for a few decades, they have been inadequately developed for accurate use in overhead line foundations, having largely been transferred across from other sectors where their use is more straightforward. The results are currently not reliable enough to base refurbishment and replacement decisions on. This project will assess a range of techniques for their suitability to carry out successful OHL foundation inspections accurately and reliably. The outcome of this project is likely to prove that a combination of techniques is appropriate, the combination is the innovative aspect that this project aims to prove.

Relevant Foreground IPR

Any new intellectual property which are completed as part of the NIA project will be made available to other relevant networks licensees. No background IPR is required.

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

NIA has been deemed the best method of supporting the delivery of this project. Development projects funded by NIA give suitable financial support to investigate areas for potential development that could not be funded by BAU as no allowance was made in the RIIOT2 settlement.

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

As noted in the NIA guidance, certain projects are speculative in nature and yield uncertain commercial returns. This is the case with this project. There is a commercial risk that the solution trialled in the project is not adopted at the end of the project into BAU due to the uncertainty and low level of TRL lowering the likelihood of success within the business. If this project is proven as successful it could lead to a better ability to predict higher-risk foundations reducing the chance of future foundation-related incidents and reducing unnecessary foundation upgrade works.

This project has been approved by a senior member of staff

☑ Yes