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_0046

Project Registration

Project Title

High Temperature Low Sag Conductors (HTLS) Non-Destructive Inspection Device

Project Reference Number

NIA_SHET_0046

Project Licensee(s)

Scottish and Southern Electricity Networks Transmission

Project Start

June 2024

Project Duration

0 years and 9 months

Nominated Project Contact(s)

Brant Wilson – Innovation Portfolio Manager

Project Budget

£65,000.00

Summary

There is a need to utilise High Temperature Low Sag (HTLS) conductors within our network as it increases the capacity of overhead line (OHL) conductors with no need for further reinforcement. Due to the composite nature of the core of HTLS conductors, traditional non-invasive inspection methods are not applicable and there is currently no method to inspect or monitor the condition of the conductor post installation. The proposed solution is to use guided wave inspection, by means of a prototype device, which works through a single transmitter/receiver where an energy wave reflection is analysed to detect defects. The prototype device will be demonstrated and aims to provide a definitive answer as to whether the inspection methodology is applicable to HTLS conductors.

Third Party Collaborators

Full Matrix Ltd

Northwards Ltd

Nominated Contact Email Address(es)

transmissioninnovation@sse.com

Problem Being Solved

HTLS conductors are a relatively new type of conductor which have structural cores composed of composite materials (many are carbon fibre based) and can be operated at temperatures exceeding 150°C. The increased operating temperature allows for greater current flow and greater power transfer. SSEN-T's network currently has approximately 60km of Aluminium Conductor Composite Core (ACCC) conductors manufactured by CTC, which is composed of a single stranded carbon fibre core encased in a glass fibre epoxy sheath. SSEN-T plan to install further HTLS conductor on our network as part of the Accelerated Strategic Transmission Investment (ASTI) programme and it is estimated the need will continue to increase by 30km of HTLS conductor per year. HTLS conductors have many benefits, such as being a solution for uprating existing tower lines without having to do major structural works.

However, as these conductors are a relatively new technology there are significant issues and knowledge gaps surrounding inspection and maintenance procedures. Due to the composite nature of the core, traditional non-invasive inspection methods are not applicable and there is currently no method to inspect or monitor the condition of the conductor post installation.

Method(s)

The proposed solution is to use guided wave inspection, which works through a single transmitter/receiver where an energy wave reflection is analysed to detect defects. A laboratory prototype Electromagnetic Acoustic Transducer (EMAT) transmitter and receiver device is to be developed as part of the project to excite and receive guided waves in an ACCC conductor. The EMAT tool will measure the noise levels in the conductor and, by calibrating against models of the conductor with different defects, assess the detection capability. This tool will then be demonstrated at an SSEN-T test site. This project aims to prove whether the inspection methodology is applicable to the ACCC conductor.

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 5 **= LOW** from the sum of the risk thresholds below:

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

Scope

A laboratory prototype transmitter and receiver EMAT will be produced to be tested on an 8m to 12m length of ACCC conductor. Electronic equipment will then be used to excite and receive low frequency sound waves in the conductor. The signals received will be analysed and the noise level assessed.

In parallel, more sophisticated finite element models will be generated. The experimental measurements will be used to guide the development of and validate these finite element models. Once validated, the models will then be used to study several different postulated defects in the conductor. By referencing to the experimental noise level measured, this will enable a predicted detection capability for the ACCC conductor to be established.

Additionally, the experimental work will provide an estimate of the maximum range of the inspection that could be achieved in practice since the decay in amplitude of the waves as they reflect back and forth inside the short length of conductor will be representative of a continuous length.

Finally, the laboratory prototype will be demonstrated on ACCC conductor at an SSEN-T’s test site.

Financial benefits can be found in section 3.2.2.

Objective(s)

The project objectives are to:

• Design, develop and build prototype EMAT transmitter and receiver devices, in the laboratory, to excite and receive guided waves in an ACCC conductor.
• Use the prototype EMAT tool to measure the noise levels in the conductor and, by calibrating against models of the conductor with different defects, assess the detection capability.
• Demonstrate the laboratory prototype EMAT device at a SSEN-T site.

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 Full Matrix Limited to deliver High Temperature Low Sag Conductors (HTLS) Non-Destructive Inspection Device using Network Innovation Allowance (NIA) funding.

Potential for New Learning

The outputs of this project include both theoretical and physical testing results for a laboratory prototype EMAT transmitter and receiver device to inspect ACCC conductors, which currently there is no method of inspection. This project aims to prove whether the inspection methodology is applicable to the ACCC conductor. This is a benefit to the whole UK industry where there is currently no known capability to inspect these conductors.

Learnings from the project will be disseminated via internal and external stakeholder events 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 7 months and is designed to get maximum learning for minimal cost. At the end of the project, the method, experimental and modelling results, and conclusions on the potential capability of the EMAT system will be provided in a final report. If the developed system proves to be a viable approach to inspection of HTLS conductors then additional work, out with this project scope, will be required to progress the prototype into a working, commercial device.

Technology Readiness at Start

TRL4 Bench Scale Research

Technology Readiness at End

TRL5 Pilot Scale

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 £65,000, 90% (£58,500) 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, Transmission networks may take up the option to install HTLS conductors, such as Aluminium Conductor Composite Core (ACCC) conductors, to futureproof the network. Given the demand for increased ratings, HTLS conductors are a favourable conductor, allowing existing OHL assets to be maximised to increase ratings without the need for additional/new infrastructure. There is no current method to inspect the ACCC conductors which creates an inherent risk in their use and deters Networks from employing them. As a result, the energy system transition may miss out on the benefits that these types of conductors could bring. This new method will reduce lengthy outages and allow for non-destructive inspections which ultimately will allow resources to be better focused on building new infrastructure required for the transition to net zero and carrying out targeted maintenance/upgrade works.

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

The potential benefits identified are listed below.

• Offers a non-intrusive means of assessing the condition of the existing carbon cored, HTLS conductor on the Transmission network. A capability that is not known to exist within the UK or globally.
• Improve estimates on the end-of-life of conductors and the ability to assess the level of damage to the conductor following incidents, such as tree strike. This could reduce repair time and avoid unnecessary repair work.
• Enables the future use of carbon cored, HTLS conductors on the transmission system due to addressing the current concern that these conductors cannot be assessed.
• Carbon cored conductors have been installed in over sixty countries in over 1,100 different projects. With no current diagnostic tool on the market, there would be high potential for commercialisation/licence of the tool.
• If testing is successful, the new method will reduce lengthy outages following unplanned disruptive events and full section replacement costs as conductors will be non-destructively inspected and repaired, if needed, rather than replaced.
• Less conductor replacements could also reduce their environmental impact by minimising manufacturing and procurement of new conductors as well as mobilisation of equipment and staff required for their replacement.
• Developing this prototype will enable learnings to be shared so all HTLS conductors can benefit from this innovation.

Note, to achieve the above benefits a second project would be required to convert the lab-based prototype into a conductor mounted field unit.

Cost-Benefit Analysis (CBA)

Assumptions

Our CBA model and methodology was used to estimate the benefit value of this project. The model is based on the following assumptions:

• The operational cost (OPEX) was distributed over 45 years, which is the standard transmission asset life, to mitigate cost fluctuations.
• Annualised the capital expenditure (CAPEX) because of the uncertainty around the timings of conductor replacements during their lifetime.
• All values are expressed in 2018 real as per previous Ofgem models' base year.
• Planned maintenance cost was assumed to be one third of the cost of unplanned outages. Both the costs of outages and minor conductors' replacements were factored in to cover any issues identified during planned inspection.
• Assumed the device cost for commercial stage is £3960 (discounted by 10%) and used this to estimate the scaled benefit.
• The successful device development involves three stages: lab testing (current stage), demo (live SSENT site testing), and wider deployment to our network (60 km scaled benefit analysed). The lab testing is planned to be carried out at an 8m - 12m conductor to improve knowledge on the design, so no financial benefits are expected at this stage.
• Assumed the cost of the demonstration on live SSENT site testing is twice that of the lab testing, factoring in resourcing, contingency and a 50% probability of success. This is a highly conservative approach to reflect as the benefit value estimated considers all the development risks from prototype until final deployment.
• Assumed the efficiency of the device is 70%, potentially reducing 70% of unplanned issues.

Results

This analysis focuses on the assessment of the scaled benefits of EMAT transmitter device (60km conductor length).

• If the lab testing is successful, further demonstration will be required to validate the outcomes. The innovation will be tested in a live SSENT site to assess its capabilities. The scaled benefit of this project was estimated to approximately £280k over lifetime.

• However, due to the low TRL and high uncertainty, a risk assessment was conducted to account for the potential costs and risks of applying this technology to the eligible part of our network. The minimum risk-adjusted scaled benefits estimated to £91k over lifetime (approximately £1,530 per km).
• The Benefit-Cost ratio (BCR) was estimated then to 3.6, which means that for every £1 of project development spend, this innovation has the potential to return £3.6 by the end of the asset lifetime.

The scaled benefit will be revised once (and if) this project is successful at the demonstration testing and before progressing to the next stage of deployment.

Sensitivity analysis:

• Due to the high uncertainty of the device's efficiency, a sensitivity analysis was carried out assessing its impact on the potential scaled benefits. The minimum efficiency level of the device is 34% for this project to be considered as viable.
• The inspection duration and frequency have high impact on the potential benefits of this project. It is assumed that the conductors will be inspected once every 7 years, as such, the estimated benefit values reduced by 23%. If inspection lasts 2 days every 7 years, the project still results in financial benefits, but the benefit value will be reduced significantly by 91%.

Key Risks:

• The project requires further development to be used widely to inspect conductors in the whole SSEN Transmission Network.
• Due to the unknown period of time from development until becoming BAU, the costs of producing an actual final device could increase or be adversely affected by any future market fluctuations.

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 proven, then there is the potential to develop this prototype for use in all types of HTLS conductors which would be a benefit across GB.

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 conductor that will be testing using the prototype is made exclusively by CTC, which all other Transmission Network Operator's (TNO's) & Distribution Network Operators (DNO's) use. If this project proves successful it will offer a non-intrusive means of assessing the condition of the existing carbon cored, HTLS conductor on SSEN's network. A capability that is not known to exist within the UK or globally. There is potential for other TOs and our distribution colleagues to make use of the outputs of the project should the prototype be made commercially available in the future. Further funding would be required to transform the prototype into a device which is able to be used on site.

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.

To the best of our knowledge, there haven't been any existing projects that have explored this inspection technique. A previous project (NIA_SHET_0021) trialled a different way of testing ACCC conductors. The previous technology was deemed to be unsuitable due to the high development cost and low TRL level of a conductor travelling device/robot which would inspect the length of installed conductors. The technology used in the previous trial required the conductor measuring device to be in an absolute fixed distance which is unachievable in field conditions.

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

Globally there is no known method to non-destructively test the ACCC conductors. Through developing technologies from different industries, the project is looking to create a non-destructive inspection device.

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 a solution to testing HTLS conductors. If the project is successful, this will provide a definitive answer as to whether the inspection methodology is applicable to the ACCC conductor.

This project has been approved by a senior member of staff

☑ Yes