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

Feb 2023

Project Reference Number

NIA_SPEN_0081

Project Registration

Project Title

Innovative Monitoring of GIS Cable Terminations

Project Reference Number

NIA_SPEN_0081

Project Licensee(s)

SP Energy Networks Transmission

Project Start

March 2023

Project Duration

3 years and 1 month

Nominated Project Contact(s)

Gurbagh Singh, Watson Peat

Project Budget

£400,000.00

Summary

There are GIS cable terminations which may not have been adequately secured mechanically into the GIS. The perceived risk is that large and relatively fast load reductions could cause the cable conductor to contract along its length, causing the conductor and possibly insulation to pull back out of the rest of the termination. If that was to occur, it is feasible that the connection between cable and GIS would have high resistance, generating heat and arcing across the loose connection. after deterioration as a side-effect of heat and arcing, the termination insulation may become compromised leading to partial discharge activity.There is no way of non-intrusively testing the terminations in situ to find out if they are secure. A monitoring system would detect the effects of cable contraction using sensors that can be applied to the outside of the cable, termination or GIS, linked to an alarm system to alert staff to the hazard of a termination that has suffered from cable contraction.

Third Party Collaborators

Prysmian Group

Nominated Contact Email Address(es)

innovate@spenergynetworks.co.uk

Problem Being Solved

Cable terminations for 132kV GIS depend for their integrity on a spring-loaded pin securing the termination when it has been sufficiently inserted. After installation this can only be checked through destructive testing which is both very costly and disruptive to the network. At a specific 132kV substation operated by SPT a disruptive failure occurred and 6 terminations were subsequently found to be defective through destructive testing. There are 18 remaining cable terminations on the Gas Insulated Switchgear (GIS) switchboard which may not have been completely secured. The risk is that large and relatively fast load reductions could cause the

cable conductor to contract along its length, leading to the conductor (and possibly insulation) pulling out of the rest of the termination. If this were to occur, it is likely that the connection between cable and GIS would have high resistance, therefore generating heat and arcing across the loose connection. In cases of severe cable contraction, or after deterioration as a side-effect of heat and arcing, the termination insulation may become compromised leading to partial discharge activity.

The terminations may well continue to operate with no ill effects until such time as a sudden load change causes cable contraction, at which point deterioration would be initiated. The speed and severity of deterioration is uncertain and would depend, to a large degree, on the amount of movement that is experienced and the severity of the high resistance in the connection.

There is currently no non-intrusive way of testing the terminations in situ to determine if they are mechanically secured. An intrusive inspection to examine the terminations would result in permanent damage to the equipment and require new lengths of cable to be spliced in and terminated. The expense of an intrusive inspection would be disproportionate to the perceived risk and would lead to lengthy circuit outages. This option has therefore been rejected by the network.

Method(s)

In developing a solution to this problem, the following measurements are relevant in order of importance:

1. Temperature. Internal movement of the fitting will change the contact resistance, ultimately generating heat. To be useful as an alarming measurement, this heating anomaly must be distinguishable from the normal loading heat generation less heat losses. Thermal modelling of HV assets is now a mature and accurate technology and expertise exists within the UK University sector to perform a relevant study. We propose to commission a study to determine a suitable measurement approach to identify the thermal anomaly. This will be more cost-effective, but no less accurate, than performing HV laboratory tests.

2. Partial discharge (PD). Elimpus has extensive experience in the measurement and interpretation of PD, including results from high resistance joints and CSEs before failure. PD measurements are highly correlated with the problem, and should be included. However, our experience is that a wide variation exists in the PD emissions from CSEs: it is possible (although by no means certain) that significant PD is only emitted in the immediate period before failure of the CSE. In this respect, PD is regarded as a secondary measurement to the temperature. Note that attempts to replicate PD effects on HV equipment in laboratories are notoriously unreliable and we do not recommend any tests to prove that PD accompanies CSE defects.

3. Shock, or vibration, sensing. Any movement of the cable end fitting in the CSE receptacle is likely to be in the form of a ‘shock’ or sudden impulse, rather than a smooth motion, which potentially could be measured on the exterior of the CSE. In view of many arbitrary factors – such as contact surface finish, presence of grease etc - that influences the nature of this motion, it is highly unlikely that any modelling, either computer-based or physical, will provide any meaningful insight into the level of vibration measurable on the cable surface. However, the marginal cost of adding a shock sensor to the solution is modest and we recommend this is included and informed by site experience.

Scope

The scope is on the following:

- Material determination & Thermal Modelling
- Analysis of stage 1 modelling & Product Development
- Manufacture
- HV Lab Testing dependent on Stage 1 outputs (optional)
- Installation on site
- Monitoring and optimising of site equipment
- Evaluation of project outcomes

Objective(s)

The objectives are on the following topics:

- Collect all mechanical and material information in order to establish the requirements for thermal modelling. Commission University to perform modelling exercise.
- Carry out thermal modelling and review the results
- Determine if the thermal fault detection is possible
- Design a monitoring system that can measure required parameters
- Design sensors and agree where they can be fitted

- Manufacture monitoring system
- Manufacture sensors
- In-house testing of a modelled CSE to show correct operation
- Install system on site, with full data upload capability
- Monitor the result for 2 weeks and adjust as necessary to avoid nuisance alerts
- Long term monitoring

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

This project has been assessed as having a neutral impact on customers in vulnerable situations.

This is because it is a transmission project.

Success Criteria

The delivery of the above objectives, within budget and within agreed timelines, as is reasonable depending on the knowledge at this stage of the development phase.

The project will be managed within SPEN applying due diligence and best practices where appropriate.

Project Partners and External Funding

This project will run as a partnership with Elimpus and a University in the UK who will be carrying out the analysis, development, installation and commissioning of the monitoring system. Elimpus and the selected University will be working in collaboration, each completing a set of tasks. The selected University will focus on thermal analysis and Elipmus will follow with the development of the devices, the installation and commissioning of the monitoring system.

Potential for New Learning

The potential to develop an innovative non-intrusive moinitioring system that can be used by Business and Usual.

Scale of Project

The scale of the project is currenlty bounded to one substation. (This is the substation we have chosen to trial)

Technology Readiness at Start

TRL3 Proof of Concept

Technology Readiness at End

TRL8 Active Commissioning

Geographical Area

Central and Southern Scotland

Revenue Allowed for the RIIO Settlement

0

Indicative Total NIA Project Expenditure

£400,000

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:

- Ensuring assets can continue to operate into the future and preventing disruptive failure
- Operate effectively into the energy system transition and reduce unplanned outages.

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

- Reducing the potential for power cuts from 132kV equipment on the network.
- Power cuts at this level can affect great numbers of vulnerable customers.
- Preventing power cuts and outages will provide a benefit to consumers.

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

- Cost of replacing one GIS termination estimated ~ £135k
- Fault and disruption costs ~ £250k.
- Project aims to ensure these costs are avoided by alerting early detection of issue with GIS cable termination.

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

All DNOs have 132kV GIS cable terminations, therefore the mointoring system developed could be used across GB.

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

The cost of rolling out the method across GB will have similar estimated cost to the project per 132kV substations with the same number of GIS cable termination.

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

Applicable to any other Licensees that have same switchgear to undertake similar monitoring.

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.

To the best of our knowledge we are unaware of any similar projects, particularly in relation to non-intrusive differential temperature monitoring of cable terminations on this type of switchgear.

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

As far as we are aware this is the first time non-intrusive techniques have been trialled to detect potential defective terminations in 132kV.

Relevant Foreground IPR

N/A

Data Access Details

Access to this data must be requested by contacting SPInnovation@spenergynetworks.com Please provide the following information in your request:

Affiliation, position and contact details of requesting party

- Relevant project and type of data required
- Reasons for requesting this data and evidence that this data will be used in the interest of the UK network electricity customers
- How data will be shared internally and externally by the requesting party

Any data request deemed unsuitable for sharing will be highlighted to the appropriate requesting party. After receiving the request we will provide the estimated date for completing the data provision based on other requests and our team workload at that time. All requested data remains the property of SP Energy Networks.

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

The reason for the requirement of NIA funding is due to the unproven technique of monitoring the cable terminations at 132kV.

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

There is a technical risk that the project will not succeed therefore can only be undertaken with the support of NIA.

This project has been approved by a senior member of staff

☑ Yes