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 2023

Project Reference Number

NIA_SHET_0041

Project Registration

Project Title

Autonomous Inspection & Monitoring of High Voltage Assets (AIM High)

Project Reference Number

NIA_SHET_0041

Project Licensee(s)

Scottish and Southern Electricity Networks Transmission

Project Start

June 2023

Project Duration

1 year and 5 months

Nominated Project Contact(s)

Brant Wilson

Project Budget

£454,556.00

Summary

High Voltage Direct Current (HVDC) valve halls are inaccessible to staff due to the hazardous environment. Monitoring of the equipment is currently performed using static cameras however these do not provide full visibility of equipment, particularly monitoring gauges and floor level machines. Because of these restrictions condition monitoring and maintenance is performed on a periodic timeframe (annually) and requires a shutdown of the system.

This project proposes to install an autonomous robot within the confined space of a HVDC valve hall to monitor equipment status and need for maintenance. This innovation would allow for any faults or need for maintenance to be identified without causing unplanned downtime of the system and allowing for engineers to perform condition-based maintenance.

Third Party Collaborators

Ross Robotics

Nominated Contact Email Address(es)

transmissioninnovation@sse.com

Problem Being Solved

HVDC converter halls are inaccessible to personnel due to the hazardous environment. Monitoring of the equipment is currently performed using static cameras however these do not provide full visibility of equipment, particularly monitoring gauges and floor level machines. Because of these restrictions only planned maintenance is performed on a periodic timeframe as this requires a shutdown of the system. Condition based maintenance is therefore not possible and therefore any faults not observed during the periodic shutdown need to be managed using a forced shutdown. Additionally, the inability to visually monitor the condition of certain equipment may cause further unnecessary degradation that requires increased time and cost to complete the repair.

Method(s)

Installation of an autonomous robot within the confined space of a HVDC converter hall or similar location, to monitor equipment status and need for maintenance. This innovation would allow for any faults or need for maintenance to be identified without causing unplanned downtime of the system. The solution will be developed and tested at a suitable switching station location for proof of concept before being deployed for pilot trial at a HVDC converter hall.

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 6 = LOW from the sum of the risk thresholds below:

TRL Steps – 3 TRL Steps – Medium (Score 2)

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

The scope and objectives of the Project should be clearly defined including the net benefits for consumers (eg financial, environmental, etc). This section should also detail the financial benefits which would directly accrue to the GB Gas Transportation System and/or electricity transmission or distribution.

To be developed and trialled at a DC switching station then deployed at an HVDC valve hall. All future HVDC valve halls could incorporate the device into the design. Further uses could be DC switching stations, and other remote unmanned facilities. The technology could be used by other Licensees.

Work Package 1

- Purchase of a single platform and initiation with project team
- Integration of additional acoustic and UV sensors
- Deployment of prototype in a DC Switching Station and testing of equipment

Work Package 2

- Testing and monitoring of prototype in HVDC Converter Hall
- Production of platform for deployment
- Deployment of platform at HVDC Converter Hall

Financial benefits can be found in section 3.2.2.

Objective(s)

The main objective of the project is to develop an autonomous robot and assess if it can be used to accurately and efficiently provide monitoring services that would otherwise not be possible using the current asset monitoring design.

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 an overall positive impact on consumers in vulnerable situations. The assessment has identified that this project will look to reduce the costs for households and reduce the occurrence and duration of supply interruptions. Other considerations including the projects impact on supply, immediate health and safety in the home have been made in carrying out this assessment.

Success Criteria

The project will be deemed as successful if all items in the scope, objectives and learnings are achieved. It is expected that new learning will be generated with regards to the use of autonomous robots and the sensor types in a high EMF environment whilst proving a new cost-effective and reliable alternative to current asset monitoring design.

Project Partners and External Funding

SSEN Transmission will partner with Ross Robotics to deliver Autonomous Inspection & Monitoring of High Voltage Assets using NIA funding.

Potential for New Learning

The development of the autonomous robot monitoring technology will inherently develop new learning. Principally, this will be in the areas of asset monitoring, and specifically around:

- Increasing the understanding and confidence in the use of autonomous robots within the confines of an HVDC asset
- Most suitable configuration of an automated asset monitoring device
- Communication and reporting of monitoring data

The new learning will form part of the final report, which will be shared with all relevant parties and will also be presented in post-project dissemination sessions. The technology could be utilised by other licensees.

Scale of Project

The project is designed to get maximum learning for minimal cost. Estimates indicate potential cost savings of £6,275,000 per installation (over lifetime, 2072).

If the AIM Hi innovation can provide information that will allow for accurate monitoring of assets and avoid the need for unplanned outages then the solution could be installed at all HVDC valve halls as well as other locations that require either accurate monitoring, are remote or with limited ease of access.

Any smaller scale project would not allow the learning outcomes to be achieved.

Technology Readiness at Start

TRL5 Pilot Scale

Technology Readiness at End

TRL8 Active Commissioning

Geographical Area

The project will take place in SSEN Transmission's 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 £454,555, 90% (£409,100) 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 SSEN Transmission network moves towards greater reliance on HVDC technology it is imperative that we monitor and maintain the facilities appropriately. Being able to monitor the equipment proactively will allow for planned condition-based maintenance with the expectation that this will reduce the number of faults and unplanned shutdowns.

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

The project has been assessed as having an overall positive impact on consumers in vulnerable situations. The project will look to reduce the costs for households and reduce the occurrence and duration of supply interruptions.

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

If the system can reduce the number of unplanned maintenance outages, then this will have a saving to the consumer in the form of reduced costs. By monitoring SF6 gauges, leaks can be observed earlier meaning less loss of SF6 to the environment and reduced penalty charges. The analysis considers only robot use on converter stations where restricted areas exist and each converter station, irrespective of its capacity and size, will be able to be served by one robot if the charging station can be installed within the halls.

Based on the use of a robot calculated to reduce the O&M cost by up to 61% until 2072, reaching an identified benefit of £6.28m per single converter pilot station, an analysis of the scaled benefit was conducted to reflect the innovation at more stations. Indicative costs were used for the purpose of the Cost Benefit Analysis (CBA) with an assumption that a further nine stations may benefit from installation of an autonomous robot considering site placements by 2032. There is no need to consider substations without restricted areas as these can be accessed by technicians freely. The base case included remote inspection using installed cameras only. The potential benefits have been calculated as follows –

Single robot install at single pilot site:

- Base cost for converter station maintenance at pilot site: £10.33m
- Method cost with robot installed at pilot site: £4.06m

· Lifetime Saving per single pilot site: £10.33m - £4.06m = £6.28m

Scaled cost savings from additional projects are as follows -

Base cost for converter station maintenance at ten sites: £72.38m
Method cost with one robot installed at each of the ten sites: £23.28m
Saving up to 2072: £72.38m - £23.28m = £49.11m

These projects will be carried out through the asset life of the substations (45 years), and we used as estimation's cut-off year 2072 following a consistent methodology for our analysis. The capital budgeting method of Net Present Value (NPV) is used to account for the time value of money and expressed in 2018 real values based on Ofgem's CBA template. The initial investment cost for purchasing the robots for these projects is £1.26m and cost savings as expected to start after 2030. The short-term cost savings on key regulatory milestones is estimated as below for the ten substations identified as long as a long-term saving until 2072.

· RIIO-T2 (FY 2025/26): - £9,685

· RIIO-T3 (FY 2026/27 – 2030/31): - £11,501

Long term (up to FY 72/73): £49.11m

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

As the number of HVDC assets on our network increases to manage the huge increase in offshore wind this innovation could be replicated across the SSEN Transmission network. The base learning, equipment specification and monitoring platform could be replicated across GB.

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

The costs of replicating the AIM Hi solution across the rest of GB are not fully defined. Initial investigation as part of the Cost Benefit Analysis suggests that the costs associated with rolling out the method would be considerably lower than those attached to this innovation project as development and testing costs would be removed. However, the roll out cost would be dependent on the size of the asset as well as the need for upgrading for any structural alterations (such as air lock).

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

Installation of a mobile robot within an HVDC system has not been attempted before and learning will be generated on how the system performs, completes activities, tolerates the environmental conditions, and relays data back to a monitoring system to be recorded and reported.

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.

The ENA Smarter Networks portal has been reviewed to confirm that there is no duplication.

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

This will be the first time that an autonomous robot has been deployed in an HVDC environment. It is not yet proven that the robot will be able to withstand the hazardous environment or that the visualisation tools will provide accurate and clear data. There is a risk that the system will not meet the requirements of the user.

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. The suppliers historical and current background IP may be used or referenced as part of the project.

Data Access Details

See Strategic Innovation Fund (SIF) and Network Innovation Allowance (NIA) Data Sharing Procedure for Transmission Innovation Projects at: https://www.ssen-transmission.co.uk/globalassets/documents/innovation-at-work/pr-net-gov-521-data-sharing-procedure-for-innovation-transmission-r2.pdf

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

This is a new monitoring solution that is yet unproven and needs to be better developed and validated before it can be introduced as business as usual. There are certain risks associated with the acquisition, utilisation, and the overall usefulness of the proposed technology and techniques in the scope which need to be tested first. Due to the TRL and risks associated with this project, NIA funding is the correct mechanism rather than BAU delivery.

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. This could be because some of the assumptions around the usefulness of the autonomous robot solution and the predicted accuracy of the sensors. If the project is successful, it will have proven a technical and novel solution that can be adopted in existing and future assets design reducing need for unplanned maintenance and cost to customers.

This project has been approved by a senior member of staff

☑ Yes