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

Aug 2022

Project Reference Number

NIA_SSEN_0059

Project Registration

Project Title

CageCapture™ ™ SF6 Paint Detection

Project Reference Number

NIA_SSEN_0059

Project Licensee(s)

Scottish and Southern Electricity Networks Distribution

Project Start

September 2022

Project Duration

2 years and 1 month

Nominated Project Contact(s)

Tim Sammon, Innovation Delivery Manager at SSEN

Project Budget

£437,219.00

Summary

CageCapture™ 'Detection' solution will improve the speed of response to reduce sulphur hexafluoride (SF6) emissions by enabling early detection and location of SF6 leakage points in assets. The project will deliver a leak detection coating that can be applied to switchgear pipework and flanges for the detection of SF6 leaks, indicated by exhibiting an Ultraviolet fluorescence or colour change. Stage 1 will validate the proof of concept in a suitable test environment; Stage 2 will evaluate application of the product to switchgear on the distribution networks.

Nominated Contact Email Address(es)

fnp.pmo@sse.com

Problem Being Solved

A net zero future promises reduced greenhouse gas emissions driven by a shift towards electrification. Electricity networks are expanding to connect wind and solar power to the grid and offer an infrastructure of Electric Vehicle (EV) charging points, but equipment containing (SF6) as a dielectric medium presents the risk of significant greenhouse gas emissions in the event of a leak. However, as the network expands, so does the installed base of SF6, which is expected to grow by 75% between 2019 and 2030. Network Operators are supporting switchgear manufacturers in the development of alternative dielectric materials to SF6, but it will be several years before fully type tested products are available across the voltage range. Even when all new products are SF6 - free, Network Operators will have to manage the installed SF6 bank for the remainder of the life of the associated assets.

SF6 is a man-made gas and highly effective insulator used in gas insulated switchgear (GIS). As one of the most potent greenhouse gases, current estimates suggest SF6 is responsible for 0.8% of CO2-equivalent modelled global warming, and more than 80% of the SF6 produced is used by the electricity industry. While in principle SF6 is contained within switchgear, leaks occur as assets age and are regularly exposed to the environment. Aging electrical equipment is a significant contributor to these emissions. In transmission and distribution networks, the leakage rate is estimated to be 1.29% and 0.40%, respectively (Widger, P.; Haddad, A. "Evaluation of SF6 Leakage from Gas Insulated Equipment on Electricity Networks in Great Britain", Energies 2018, 11, 2037).

Leak detection is challenging, and a reactive approach is used to locate leaks which often occur at flanges or connections points. The use of SF6 ‘sniffers’, and more recently SF6 cameras, have improved leak detection but are not effective in all scenarios, e.g. if the gas is lost in short bursts as gaskets contract during cold evenings.

Method(s)

The project is initially a research project followed by a real world trial to deliver a leak detection coating that can be applied to switchgear pipework and flanges to provide visual indication of leak points (either a fluorescence that can be seen with a UV torch or a change in colour visible to the naked eye). The application will provide an easy-to-deploy solution to accelerate leak detection and reduce total emissions. Further, early leak detection will prevent damage to assets caused by moisture entering the switchgear, hazards relating to SF6 contamination and facilitate timely repair or replacement of assets.

Scope

Stage 1 Proof of concept SF6 detection coating developed and tested in relevant lab environment.

Stage 2 Evaluate the performance of SF6 detection coating applied to nine circuit breakers in service on the distribution networks. Trial sites will preferably be in three different locations to provide the typical range of UK environmental conditions including coastal and higher altitude locations.

As detailed in section 3.2 the project has the potential to deliver up to £11m in financial benefits to GB distribution customers based on early detection of leaked SF6 gas.

Objective(s)

Stage 1:
Proof of concept detection with CageCapture™ material. Quantifiable detection results will be undertaken to measure the success of the CageCapture™ detection proof of concept.

Stage 2:
Prototype testing of the coating. Evaluation of coating function in real world environment, measured by real world testing results.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

Not applicable.

Success Criteria

Minimum success criteria (Must and should)
Measure
Must be applicable to welds, metal pipework, resin and flanges. Should be applicable to existing coatings with simple surface preparation.
Consideration in coating formulation results in successful deployment
Must be durable and resilient to environmental conditions
Evaluation in real environment testing validates performance
Minimal conductivity
Lab based testing validates property
Reapplication possible
Evaluation in lab and real environment testing shows viability
Desirable criteria (Could)
Measure
Detection coating with visual indicator
Successful candidates are identified as part of work programme in Stage 1
Easy to use
Evaluation in real environment testing results in positive feedback

Project Partners and External Funding

CageCapture™ Ltd, EIC – Energy Innovation Centre, UK Power Networks, Northern Powergrid and SP Energy Networks

Potential for New Learning

Network Operators hope to learn of an innovative method of detecting SF6 from switchgear to facilitate prompt remedial action or asset replacement. The learning will be disseminated through the publication of NIA reports and opportunities will be taken to present

to stakeholders such as the ENA Switchgear Assessment Panel.

Scale of Project

This project is designed to develop learning, the scale of the project is sufficient to understand the specific issues associated with SF6 detection by an applied coating. The scale of the project allows application to several circuit breaker designs which are also likely to exhibit differing leak rates. It might be the case that the solution is more successful in some applications over others. The project will demonstrate if SF6 detection by an applied coating is possible in the real-world environment and if it is successful, the solution is easily scalable. This project is sufficient in scale to inform future decisions on the application of SF6 leak detection technology.

Technology Readiness at Start

TRL3 Proof of Concept

Technology Readiness at End

TRL7 Inactive Commissioning

Geographical Area

Scottish Hydro Electric Power Distribution
Southern Electric Power Distribution
London Power Networks
South Eastern Power Networks
Eastern Power Networks
Northern Powergrid (Northeast)
Northern Powergrid (Yorkshire)
SP Distribution
SP Manweb

Revenue Allowed for the RIIO Settlement

No revenue was allowed for this activity.

Indicative Total NIA Project Expenditure

The total expenditure expected from the project is £437,219.
SSEN £148,711
UK Power Networks £157,000
Northern Power Grid £131,508

90% of which is allowable NIA Expenditure (£393,497).

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:

N/A

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)

The detection technology would allow operatives to target areas of the network requiring remedial works. The other key areas where financial benefits can be derived from the project are:
Health and Safety – better SF6 detection mechanisms would result in fewer leakage incidents on site.
Environmental – Reduction in SF6 emissions due to early detection of leakages.
Customers – Costs associated with the replacement of leaked SF6 plant would be reduced which would reduce energy cost for customers.
Carbon Reduction – Allows timely maintenance of assets to prolong operational life whilst reducing SF6 emissions.

Total Number of Customers in GB 30,091m
Total Number of Customers in trial 16,187m
Total Base Cost CO2e lost over 5/years/ £12,774,840
Cost per customer £0.78 Total Base cost of CO2e over 5 years all DNOs £23,747,796
Method reduction leak rate / 20%
Total Base Cost CO2e lost over 5/years/ £2,544m (over DNOs in Trial)
Method cost of CO2e lost over 5 years £4,749m (Savings to GB customers based on customer numbers)
Base Cost minus Method Cost £18,998m

Assumptions
Carbon values and sensitivities 2020-2100 for appraisal, 2020£/tCO2e
GWP for SF6 for ED2 *22,800
Assumed up to 20% reduction on leakage based on feedback from CageCapture™
Assumed trial DNOs was representative of all DNO leakage rate.
No data on execution of CageCapture™ application for method cost

Please provide a calculation of the expected benefits the Solution

Project assumptions
The benefits realised are due to the assumed reduction in SF6 emissions and calculated using traded carbon prices 2020/21. Deferring asset replacement has not been included. The detection coating will reduce the time to locate SF6 leaks. Once the coating has been applied it will fluoresce allowing the equipment to be checked. Where a leak exists no fluorescence or colour change will be

seen. This will help detect low rate leaks that are difficult to identify, before large volumes have been released. Assumed 20% reduction in leakage rate.

SSEN Base Cost
Current SF6 Bank = 29,115kg (Assume SF6 remains constant to 2027/28)
Leakage rate = 0.0059%
SF6 Leakage per year = 0.59% * 29,115 = 171kg per year = 855kg (5 years)
2023-2027 average carbon value £260 *table 3 green book
171kg per year = 171*5 = 855kg (5 years)
GWP for SF6 for ED2 and T2 periods as 22,800 so effectively cost per kg of SF6 = £5,928
SF6 855kg for 5 years = 855kg*£5,928= £5,068m

SSEN Method Costs
Assume 20% reduction in leakage over 5 years
20% £5,068 = £1,013m (minus installation cost)

Base costs minus method costs
£5,068m - £1,013m = £4,054m

Assumption
Carbon values and sensitivities 2020-2100 for appraisal, 2020£/tCO2e
GWP for SF6 for ED2 *22,800

UKPN Base Cost
Current SF6 Bank = 125,000kg raising to 129,000kg over ED2
Leakage rate = 0.15%
SF6 Leakage per year = 0.15% * 125,000 = 187kg average per year, Equivalent to 952kg over ED2 £5.542m

UKPN Method Costs
Assume 20% reduction in leakage
20% £5,542m = £1,108m (minus installation cost)

Base costs minus method costs
£5,542m - £1,108m = £4,434m

Assumption
Carbon values and sensitivities 2020-2100 for appraisal, 2020£/tCO2e
GWP for SF6 for ED2 *22,800
Assumed up to 20% reduction on leakage based on feedback from CageCapture™
No data on execution of CageCapture™ application for method cost

Northern Powergrid
Current SF6 Bank = 36,300kg (Assume SF6 remains constant to 2027/28)
Leakage rate = 0.20%
SF6 Leakage per year = 0.20% * 36,300 = 73kg per year = 365kg (5 years)
2023-2027 average carbon value £260 *table 3 green book
73kg per year = 73*5 = 365kg (5 years)
GWP for SF6 for ED2 and T2 periods as 22,800 so effectively cost per kg of SF6 = £6,110
SF6 855kg for 5 years = 365kg*£6,110= £2,163mm

NPg Method Costs
Assume 20% reduction in leakage over 5 years
20% of £2,163 = £432kmm (minus installation cost)

Base costs minus method costs
£2,163m - £432km = £1,739m

Assumption
Carbon values and sensitivities 2020-2100 for appraisal, 2020£/tCO2e
GWP for SF6 for ED2 *22,800
Assumed up to 20% reduction on leakage based on feedback from CageCapture™

No data on execution of CageCapture™ application for method cost

https://www.gov.uk/government/publications/valuing-greenhouse-gas-emissions-in-policy-appraisal/valuation-of-greenhouse-gas-emissions-for-policy-appraisal-and-evaluation

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

It is expected that the project will be equally applicable to all 14 DNO licence areas. Assuming benefits will be constant for all licence areas.

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

At this stage of the research project a method cost has not been calculated for roll out across the UK. The project will determine if an outage is required and the other associated costs of using the detection.

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 new learning generated by this project can be applied and is of relevance to all Electricity Distribution Network Licensees, new solutions for SF6 detection could be applied by all DNOs across the UK.

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.

There is currently no other project looking at SF6 detection with this technology.

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

This technology has never been trialled by a DNO. The technology currently has only been demonstrated in a small-scale laboratory environment. The project will seek to develop this and trial in an operational environment.

Relevant Foreground IPR

The Relevant Foreground IPR will be knowledge and reporting. The project will conform to the default IPR position under the NIA governance.

Data Access Details

For information on how to request data gathered as part of this project see Network Innovation Competition (NIC) and Network Innovation Allowance (NIA) Data Sharing Procedure at https://ssen-innovation.co.uk/wp-content/uploads/2022/04/Network-Innovation-Competition-NIC-and-Network-Innovation-Allowance-NIA-Data-Sharing-Procedure-PR-NET-ENG-020.pdf
To view UK Power Networks' Innovation Data Sharing Policy, please visit here.

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

There are significant unknowns about how the technology will behave in the operational environment the project will undertake research and real-world trials to de-risk a potential BaU deployment.

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

The current operational risks and unknows of this technology would stop the project being undertaken without the support of NIA.

This project has been approved by a senior member of staff

☑ Yes