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_0058

Project Registration

Project Title

CageCapture™ SF6 Flange Guard

Project Reference Number

NIA_SSEN_0058

Project Licensee(s)

Scottish and Southern Electricity Networks Distribution

Project Start

September 2022

Project Duration

1 year and 6 months

Nominated Project Contact(s)

Tim Sammon

Project Budget

£439,611.00

Summary

CageCapture™ 'Capture' solution will improve the speed of response to reduce sulphur hexafluoride (SF6) emissions by enabling early capture of SF6 leakage from assets. The project will deliver a leak capture solution that can be applied to switchgear pipework and flanges for the capture of SF6 leaks. 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.

Third Party Collaborators

University of Liverpool

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 EV charging points, but equipment containing SF6 as a dielectric materials presents the risk of significant greenhouse gas emissions in the event of a leak. Network Operators are supporting switchgear manufactures 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. The installed base of SF6 is expected to grow by 75% between 2019 and 2030. 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 electrical 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).

There are no current technologies deployed in the electricity grid for SF6 capture. Leaks are targeted for repair, or if repair is not possible or cost effective, asset replacement is brought forward. In the interim the replacement of the asset may take over 12 months, during which time the asset may be required to remain in service to provide network security, in which case the switchgear may require frequent topping-up resulting in significant SF6 loss to the atmosphere.

Method(s)

CageCapture™ Ltd. are experts in porous materials, commercialising a technology platform built at the Materials Innovation Factory, Liverpool. They have developed a nano-porous technology that exhibits the highest reported SF6 absorption at room temperature and atmospheric pressure which is critical to tackling emissions in the environment they occur – from predominantly outdoor infrastructure of the electricity transmission and distribution networks. The patented material, named CageCapture™ SF6, is claimed to have a 36% absorption capacity by weight which is hundreds of times more than traditional absorbents. It is solution-processible meaning it can be applied onto a variety of substrates. These properties make CageCapture™ SF6 flange guards a viable tool for tackling SF6 emissions.

The proposed application of the technology is flange guards to capture SF6 leaking from flanges. The application will provide an easy-to-deploy solution for SF6 capture and reduce total emissions. Further, SF6 can be recovered from CageCapture™ SF6 and recycled through pressure or temperature desorption reducing through-life costs and minimising future production of this environmentally damaging gas.

The intellectual property is protected under patent and owned by the University of Liverpool with no encumbrances and has been licensed to CageCapture™ on an exclusive basis.

Scope

Stage 1 We will develop prototype flange guard for SF6 capture and recovery developed and tested in relevant lab environment.

Stage 2 We will install up to 9 prototype flange guards for SF6 capture and recovery tested in real world environments (up to 3 locations, preferably in different environments i.e. near the coast, city, etc).

As detailed in section 3.2 the project has the potential to deliver up to £4m in financial benefits to GB distribution customers based on capture of leaked SF6 gas.

Objective(s)

Objectives
Measure
Stage 1
Produce CageCapture™ absorption
Produce the CageCapture™ absorption at scale and carry out analytical tests of the material produced.
Proof of concept SF6 recovery
Analytical tests of recovered SF6 will be undertaken to demonstrate the success of the CageCapture™ device.
Assembled prototypes
Up to 40 prototype devices will be produced in the laboratory environment.
Stage 2
Deploy prototype for testing
Successful installation and real world testing of up to 9 CageCapture™ devices.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

Not applicable.

Success Criteria

The project will be deemed successful if a prototype coating for SF6 capture is developed with real world environment testing results.
Minimum success criteria (Must and should)
Measure
Flange guards must fit on different infrastructure types
Multiple, flexible designs are produced

Flange guard media must capture SF6
Capture capacity determined and tested, with a target to capture up to 10% of leaked SF6 per device
Recovery of SF6 possible from media
Tests for recovery produces positive results
Easy to deploy
Evaluation of up to 9 installs with subject matter experts in real world environment testing results in positive feedback
Resilience to environment (water, hydrocarbons, temperatures up to 60° C, salinity)
Lab tests and real environment testing
Desirable criteria (Could)
Measure
High capture capacity
Successfully capture up to 80% of leaked SF6 per device
In situ SF6 recovery possible from DNO assets
Evaluate factors in lab and real environment testing to demonstrate performance based on lab results and feedback from asset teams.

Project Partners and External Funding

CageCapture™, Energy Innovation Centre (EIC), UK Power Networks (UKPN) and Northern Powergrid (NPg)

Potential for New Learning

Network Operators hope to learn of an innovative method of significantly reducing loss of SF6 to atmosphere from identified leaks before a permanent repair can be undertaken or the asset can be replaced. The learning will be disseminated through the publication of NIA annual 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 capture technologies. 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 capture is possible in the real world environment and if it is successful, the solution is easily scalable.

Technology Readiness at Start

TRL4 Bench Scale Research

Technology Readiness at End

TRL7 Inactive Commissioning

Geographical Area

The project will be undertaken across the following licence areas:
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)

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 £439,612
SSEN £161,152
UK Power Networks £149,000
Northern Power Grid £129,460

90% of which is allowable NIA Expenditure (£395,650).

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:

The project has the potential to enable Network Operators to achieve their net zero goals.

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 capture 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 capture mechanisms would result in fewer leakage incidents on site.
Environmental – Reduction in SF6 emissions due to the capture of leakages.

Total Number of Customers in GB 30,091,831
Total Number of Customers in trial 16,187,541
Total Base Cost CO_2e lost over 5/years/ £12,774m
Cost per customer £0.78 Total Base cost of CO_2e over 5 years all DNOs £23,747m
Method reduction leak rate / 10%
Method cost of CO_2e lost over 5 years £2,374m
Base Cost minus Method Cost £21,373m

Assumptions
Carbon values and sensitivities 2020-2100 for appraisal, 2020£/tCO_2e
Global Warming Potential (GWP) for SF6 for ED2 *22,800
Assumed up to 10% 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 SF6 emissions and calculated using traded carbon prices 2020/21. Deferring asset replacement has not been included. 10% reduction in leakage rate will result from the Flange guard capturing SF6 and prevent it from being released into the environment. The captured SF6 can be recovered, reducing the overall emission rate.

SSEN Base Cost
Current SF6 Bank = 29,115kg (Assume SF6 remains constant to 2032/33)
Leakage rate = 0.0059%

SF6 Leakage per year = 0.0059% * 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)
Global Warming Potential for SF6 for ED-2 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 10% reduction in leakage over 5 years
10% £5,068 = £506km (minus installation cost)

Base costs minus method costs
£5,068m - £506km = 4,561m

Assumption
Carbon values and sensitivities 2020-2100 for appraisal, 2020£/tCO2e
GWP for SF6for ED2 *22,800

UKPN Base Cost
Current SF6 Bank = 125,000kg raising to 129,000kg by 2027/28)
Leakage rate = 0.15%
SF6 Leakage per year = 0.15% * 125,000 = 187kg average per year = 952kg (5 years) = £5,542m over 5 years.

UKPN Method Costs
Assume 10% reduction in leakage over ED2
952kg * 10% = £554k (minus installation cost)

Base costs minus method costs
£5,542m - £554km = £4,988m

Assumption
Traded Carbon Price in 2020/21 prices (£/t.CO2e)

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= £2,163m

NPg Method Costs
Assume 10% reduction in leakage over 5 years
10% of £2,163m = £216k (minus installation cost)

Base costs minus method costs
£2,163m - £216k = £1,947mm

Assumption
Carbon values and sensitivities 2020-2100 for appraisal, 2020£/tCO2e
GWP for SF6 for ED2 *22,800
Assumed up to 10% reduction on leakage based on feedback from CageCapture™
No data on execution of CageCapture™ application for method cost

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 constant for all licence areas.

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

The estimated cost of the flange guard is £400 – the project will determine if an outage is required and the other associated costs of

installation and removal.

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 Network Licensees, new solutions for SF6 capture could be applied by Electricity Companies 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 trailed by a DNO. The technology currently only exists in a laboratory 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 is 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 unknowns about 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