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 2023

Project Reference Number

NIA2_NGET0046

Project Registration

Project Title

CrystalClear - Lifecycle Analysis of SF6 Alternative Technologies and Crystal Formation Impacts

Project Reference Number

NIA2_NGET0046

Project Licensee(s)

National Grid Electricity Transmission

Project Start

September 2023

Project Duration

1 year and 7 months

Nominated Project Contact(s)

Gordon Wilson

Project Budget

£500,000.00

Summary

NGET is investigating alternatives to SF6 for use in gas insulated electrical switchgear. Two areas of investigation are combined within this project to further the understanding of alternative technologies.

The project will consider how lifecycle analysis of new technology options may be approached and conducted. This will provide understanding of the relative merits of different technologies and the potential benefits of selecting one over another

A second workstream will involve testing the dielectric strength of fluoronitrile based gas mixtures in the presence of crystalline materials to understand whether they pose a risk to the function of assets.

Third Party Collaborators

The University of Manchester

Electric Power Research Institute

Nominated Contact Email Address(es)

box.NG.ETInnovation@nationalgrid.com

Problem Being Solved

SF6 has the highest known global warming potential (GWP) with a long atmospheric lifetime. In the UK, it is estimated that the combined SF6 installed volumes in both transmission and distribution networks is approximately 1,500 t or 35 MtCO2e, with an annual SF6 leak of 0.5 MtCO2e from 2015 to 2018. National Grid has pledged to reduce SF6 emissions to 50% by 2030; long term emission reduction will only be achieved through inventory reduction and NGET has an ambition to reduce SF6 inventory to zero by 2050 which depends on having suitable alternatives to SF6 technology instead. This project brings together two independent

workstreams investigating alternative technologies.

Method(s)

NGET is investigating alternative technologies as replacements for SF6 at transmission voltages and has identified that there is a need for independent benchmarking of the overall environmental impacts of the different products available. In addition, one of the technologies already in service requires investigation of an issue reported by other researchers.

We will investigate the environmental impact of SF6 alternative technologies through comprehensive independent life cycle analysis. This will enable NGET to evaluate the best alternatives to SF6 to select under different scenarios.

Other investigators have noted the presence of crystals forming in gas mixtures based on C4F7N and this has been replicated in other laboratories but producing them in sufficient quantity to understand their significance to asset integrity has been difficult. This project will synthesise crystals in a chemical laboratory. The impact of these crystals on dielectric strength of the gas mixture can then be evaluated.

Scope

Equipment that contains SF6 can develop leaks over time resulting in loss of SF6 to the atmosphere. SF6 emissions have an impact on global warming over a period of thousands of years because it is very stable as well as having the highest known GWP. The scope of this project is to support decision making about alternative technologies to replace SF6 and this requires an understanding of all possible and environmentally friendlier solutions. The total environmental impact of the different technologies over their lifetime will be assessed, this will attempt to take into account the future technology landscape and compensate for lack of operational experience with the new technologies. One of these new technologies has been reported to produce solid materials in crystalline form during laboratory testing. These have proved difficult to produce in large quantities in realistic conditions but this may happen in service. To understand the materiality of such products, this project will generate them synthetically to enable electrical testing to be carried out.

Objective(s)

This project seeks to understand the environmental impact of different technologies proposed as alternatives to SF6 for switchgear.

This project also aims to understand the potential damaging effects of producing crystalline by-products in certain gas mixtures proposed as an alternative to SF6.

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 over the long term as a result of reducing costs associated with early life failures and remediation as a result of adoption of new technology.

Success Criteria

The project will be successful if the following are true:

- An independent environmental lifecycle assessment is carried out comparing different alternative technologies to SF6 (using SF6 as a benchmark) that is considered to be impartial and technically acceptable
- Appropriate crystalline byproducts are produced and tested to evaluate their impact on operation performance of GIS equipment

Project Partners and External Funding

The project is supported by both Scottish and Southern Electricity Networks Transmission and Scottish Power Energy Networks. Both supporting networks will cover the cost of their own involvement with the project.

Potential for New Learning

The project will deliver a report for each workstream. The reports will describe the work carried out and the results that are achieved. The reports will focus on novel and independent findings in the following areas:

- Lifecycle impacts of SF6 and SF6 alternatives for GIS

- End of life options for new technologies and their impact
- Potential lifespan of SF6 alternatives
- Consideration of potential for obsolescence on lifecycle analysis
- Methods for production and testing of crystalline solid by-products from C4F7N based gas mixtures

Learning will be disseminated through defined project progress and completion reports. Learning will also be shared through conference presentations and an open dissemination event, e.g. a webinar, on completion.

Scale of Project

One workstream will be a desk-based study carried out by a National Grid strategic innovation partner. The second will take place in the laboratory at a university.

Reducing the scale of the project would reduce the scope of the project deliverables.

Technology Readiness at Start

TRL2 Invention and Research

Technology Readiness at End

TRL7 Inactive Commissioning

Geographical Area

Desk based study in a UK based laboratory. The results will be applicable to all UK based networks regardless of geographical location.

Revenue Allowed for the RIIO Settlement

N/A

Indicative Total NIA Project Expenditure

£450,000

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:

The project will enable the energy system transition through facilitation of the use of eco-friendly alternatives to SF6 through investigation of environmental impacts and a particular failure mode of one alternative technology. The replacement of SF6 may be slower if there are concerns about the rapid introduction of new technology.

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)

N/A

Please provide a calculation of the expected benefits the Solution

This is a research project and a cost benefit analysis has not been conducted but should be considered along with the analysis that was conducted for NIA2_NGET0028 "Identification and quantification of C4F7N gas arcing by-products and their implication for GIS operation" which indicated potential cost savings up to £9.7m. The cost of this project should be balanced against those costs. The results of the lifecycle analysis piece of work should highlight the potential benefits of different technologies enabling a better assessment of the project benefits on completion.

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

The project will be applicable to both distribution and transmission assets.

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

The project will develop knowledge to support networks in their decision making for replacing SF6 filled assets and will not have an implementation cost as such.

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 research is being conducted to understand environmental impacts and potential issues with the use of SF6 alternative technologies for GIS. It is therefore learning that may be directly applied to other networks installing similar assets at similar voltages. The disseminated results will be shared with all licensees so that the reasons for the conclusions may be understood. It will be the responsibility of others to determine to what extent it applies to other equipment types and different voltages but the underlying work from this project is likely to help.

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.

NGET has shared the project details with SSEN Transmission and SPEN to confirm that all the transmission owners believe this project is necessary, beneficial and does not duplicate other research projects.

Any residual risk of duplication will be addressed through dissemination of progress with other licensees and being open to co-operate with licensees working in this space.

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

While Life Cycle Assessments (LCAs) have been performed in the industry for a wide range of scenarios, the application of LCAs for SF6 Alternatives is highly innovative and technically challenging owing to the newness of switchgear employing SF6-free technologies and there being little operational experience.

The evaluation of the crystal complexes is innovative as we are exploring an issue that has only recently been identified. The original research group that has identified that crystal formation occurs is no longer investigating the phenomenon and has provided any remaining samples to us for testing. Others have been investigating crystal formation but as yet the testing of the gas in the presence of these by-products is untested.

Relevant Foreground IPR

NIA funding enables the development of new approaches, in this case to LCA methodology and synthesis of chemical compounds, which de-risks their application to business as usual activities.

Data Access Details

Data for this project and all other projects funded under the Network Innovation Allowance (NIA), Network Innovation Competition (NIC) or the new Strategic Innovation Fund (SIF) can be found or requested in a number of ways:

- A request for information via the Smarter Networks Portal at https://smarter.energynetworks.org, to contact select a project and click 'Contact Lead Network'. National Grid 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 https://www.nationalgrid.com/uk/electricity-transmission/innovation

- Via our managed mailbox box.NG.ETInnovation@nationalgrid.com

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

This is a research project that will lead to knowledge that may underpin future decisions about replacement of SF6-filled assets on the network with alternative insulating arrangements where cost comparisons would not favour the use of technology with a shorter proven track record of performance. Investigation of these technologies is most appropriately supported through NIA as no allowance for such investigations were made in the RIIO-T2 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

NIA funding enables the development of new approaches, in this case to LCA methodology and synthesis of chemical compounds, which de-risks their application to business as usual activities.

This project has been approved by a senior member of staff

☑ Yes