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NIA Project Registration and PEA Document

Date of Submission

May 2018

Project Reference Number

NIA_NGTO002

Project Registration

Project Title

Long Term Stability Testing of Alternative Gases

Project Reference Number

NIA_NGTO002

Project Licensee(s)

National Grid Electricity Transmission

Project Start

January 2018

Project Duration

2 years and 4 months

Nominated Project Contact(s)

Amrit Sehmbi

Project Budget

£353,000.00

Summary

This project will investigate the stability of the new gas mixtures (Novec and other modified mixtures) in the presence of various materials and under different working pressures. Measurement of by-products of the gas subjected to electrical flashover and partial discharges will be carried out to understand their nature and their effect on the stability of the gas properties.

Nominated Contact Email Address(es)

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Problem Being Solved

Sulphur hexafluoride gas, SF₆, is unique in its electrical and thermal performances. However its Global Warming Potential, GWP, is very high at around 23900, compared to CO₂ which has a GWP of one. In addition, when released in the atmosphere, its life time is approximated to over 3000 years. Such negative impact on the environment led to the designation of the gas as a "Kyoto Gas", i.e. harmful to the environment and the Paris convention agreed to reduce the use of climate-damaging greenhouse gases. The leakage of SF₆ gas from pressurized gas insulated equipment worldwide is significant, and owners of such assets are now taking steps to reduce leakage (estimated to nearly 16 tonnes equivalent to almost 390,000 tonnes of CO₂ each year), and consider alternative insulation media for their equipment. In the UK, it is estimated that SF₆ contribute 0.2% of the annual greenhouse emissions.

In recent years, new gas molecules and mixtures of gases have been considered and tested. A number of candidates have been particularly studied. These include dry air, N₂ or CO₂, polyfluorinated gases especially Trifluoriodomethane (CF₃I), Perfluorinated Ketones, Octafluorotetra-hydrofuran, Hydrofluoroolefin (HFOs), and Fluoronitriles. National Grid has trials on the latter gas and its mixture with CO₂, known as the g3 gas.

National Grid has an ongoing NIA projects (NIA_NGET0163) that comprises of the following work packages:

- Leak Detection and Refilling

- Leak Sealing and Repair
- F6 Capture and Reuse
- SF6 Alternatives of g3 and CF3I

Scottish Power Transmission have also registered an NIA project (NIA_SPT1604) which is looking in detail at the handling and gas management implications for g3.

This project will investigate the stability of the new gas mixture (Novec and other modified mixtures) in the presence of various materials and under different working pressures. Measurement of by-products of the gas subjected to electrical flashover and partial discharges will be carried out to understand their nature and their effect on the stability of the gas properties.

Method(s)

A specialist stainless test rig will be used to conduct the tests. First, the effect of discharges and flashover in the gas mixtures will be measured in terms of by-products. Both short term and long term tests will be explored. An in-house technique employing a GCMS system will be used to analyze the gas by-products following incremental periods of time of discharges and number flashover events. A list of by-products will be developed for each mixtures tested in this programme and its correlation with severity of electrical discharge activity will be quantified.

Furthermore, for the above tests, comparison of Novec gas with its various mixtures with CO₂ and/or N₂ will be conducted (at 100%, 50%, 20%, and 4%). This will work will help to indicate if any health and safety studies of the gas mixtures are required.

The second major axis this work is to investigate the stability of the gas and its mixtures. Building on the previous work of by-product analysis, quantifying the impact of the gas and its mixtures on the surrounding materials will be necessary to determine the long term stability of the gas. In this case, various materials used in GIS technologies will be sourced (through National Grid) and investigated. Existing methods of life estimation for dielectrics will be considered and adapted for the gas mixtures in the presence of various materials and under various diverging electric field conditions. This work will determine the overall stability of the gas mixtures, their life expectancy and their reaction with the surrounding materials. Scanning electron microscopes (SEM) will be used to investigate the changes of surface properties of the various materials. This will form a solid platform for future detailed analysis of the gas long term stability, if required.

Scope

This project will focus on health and safety of the new gas mixtures based on the NOVEC gas. It will also give an initial indication of the gas mixtures stability and their interaction with the surrounding environment and materials. Gas by-products, due to varying levels of electrical discharge in the gas mixtures, will be analyzed by adopting a Cardiff in-house technique using a GCMS system. The interaction with surrounding material will be examined through surface analysis using SEM techniques.

Objective(s)

The ultimate aim of this work is to gain a better understanding of the recently proposed alternative gases and gas mixtures to replace SF₆ gas. This will reduce the environmental impact of the transmission network.

The particular objectives of this work are to:

- Determine the impact of electrical discharges and flashover on the dielectric properties of the gas mixtures
- Determine the by-products of the gas mixtures following flashover
- Determine the impact of the gas mixtures and their by-products on surrounding materials.
- Determine an indicator of gas mixture degradation and estimate long term stability.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

n/a

Success Criteria

Obtain a better understanding of the health and safety implications when using the newly proposed alternative gas mixtures, through the by-products analysis. Moreover, assess stability of new gas mixtures and their impact on surrounding equipment.

Project Partners and External Funding

This project will be delivered by Cardiff University.

Potential for New Learning

By-products details following electrical discharge in Novec gas mixtures are not known / published. This project will deliver this new knowledge. Furthermore, indicators of long term stability of new gas mixtures and their impact on surrounding materials will be assessed.

Scale of Project

This is a 2-year project. It will involve extensive laboratory tests and modelling.

Technology Readiness at Start

TRL2 Invention and Research

Technology Readiness at End

TRL4 Bench Scale Research

Geographical Area

The work will be carried out at Cardiff University. Linkage with other on- projects at National grid and Manchester will exploited.

Revenue Allowed for the RIIO Settlement

None

Indicative Total NIA Project Expenditure

£353,000

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:

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)

If all the problems are solved a significant reduction in SF6 leak rate can be achieved and the impact electricity companies have on the environment reduced. This would provide a paradigm change in terms of the the impact that electricity networks have on their scope 1 greenhouse gas emissions and result in the provision of more environmentally sustainable electricity to UK consumers.

Please provide a calculation of the expected benefits the Solution

It is not possible to quantify this yet as this is early research and we don't know the potential degree of environmental and cost advantage of a replacement gas until we find a mix that works.

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

There are approximately 100,000 tonnes of SF6 installed in the UK electricity network with total emissions estimated to be around 15.6 tonnes a year - with a CO2 equivalent impact of between 370,000 and 400,000 tones. Successful outcome of this work could see the total amount of SF6 used by electricity utilities in the future reduce significantly as new-builds and replacement assets are filled with new gases. The total emissions could be reduced significantly to an estimated 0.6 tonnes a year.

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

The direct cost of making a policy or procedure change could range from as little as ten thousand to hundreds of thousands of pounds depending on the complexity of the change implications. The wider cost implications arising from such changes will be dependent on the specific outcomes generated from the project and typically will be subject to further stages of demonstration prior to roll out. Further information regarding roll out costs can be provided prior to demonstration stage.

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

Currently, Scottish Power and other DNOs are considering alternative insulation gases to SF6. This project output will be informative and of value to their future choices.

Or, please describe what specific challenge identified in the Network Licensee's innovation strategy that is being addressed by the project (RIIO-1 only)

Managing Assets and Corporate Responsibility

Has the Potential to Develop Learning That Can be Applied by all Relevant Network Licensees

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.

By participating in collaborative projects through EPRI National Grid can ensure that unnecessary duplication with other projects under NIA is avoided.

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

A number of alternatives to SF6 have been considered and Novec gas mixtures have only recently been proposed as an alternative and, therefore, NGTO would now like to conduct investigative research to better understand its properties.

Relevant Foreground IPR

n/a

Data Access Details

n/a

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

The nature of a research programme means it inherently carries a risk that the research may be unsuccessful and/or identify unforeseen barriers to implementation and National Grid is unable to consider research of this scale as business-as-usual. The NIA funding offers the most appropriate route for NGTO to evaluate this potential alternative to SF6 and share this learning with the industry.

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 inherent risk of the project is detailed above and the learning from the project will be directly relevant to all Network Licensees. For this reason, NGTO believe this project is appropriately funded through NIA.

This project has been approved by a senior member of staff

Yes