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

Mar 2015

Project Reference Number

NIA_NGET0163

Project Registration

Project Title

SF6 Management and Alternative Gases

Project Reference Number

NIA_NGET0163

Project Licensee(s)

National Grid Electricity Transmission

Project Start

March 2015

Project Duration

6 years and 5 months

Nominated Project Contact(s)

Mark Waldron

Project Budget

£1,200,000.00

Summary

Leak Detection and Refilling

The aim of this work package is to develop automatic and more accurate leak detection techniques, for both outdoor and indoor use, to more efficiently manage GIS and SF6 filled equipment. Success in this area will allow utilities to move from reactive to proactive planning of resource by applying modern monitoring techniques to order equipment where bigger benefits would be delivered. By also developing improved and automated gas handling techniques, the level of SF6 used can be significantly reduced.

Leak Sealing and Repair

The aim of this work package is to identify ways of reducing leak rates in order to achieve a significant leak reduction through development of techniques for SF6 switchgear that are sustainable and long-lasting. This work package will investigate and develop new technologies and installation methods and test them on-site to analyse their performance.

SF6 Capture and Reuse

The aim of this work package is to identify a methodology for efficient gas capture which allows for gas cleansing and quality re-use of SF6. Initial work will involve the development and laboratory testing of the technology. If successful, the technology will be trialled on-site.

SF6 Alternatives

This work package is looking at two new gases both at different stage of development, G3, a novel gas composed of 4% NOVEC and 96% CO2, and CF3I mixtures. This programme is stage-gated and divided into three phases detailed below. This project will look at the first one.

Phase 1: Use of G3 on two-life gas insulated busbar sections terminating in cable-sealing ends. By trailing this initially in passive sections, implementation will be de-risked and practical experience gained.

Phase 2: Installation of G3 in a full substation on all assets except circuit breakers.

Phase 3: Trialling of G3 on active sections.

Phase 1

G3 is a new gas matches the dielectric strength of SF6 when operated at a higher pressure and reduces the global warming potential from 23,500 to 345.

This new gas has never been installed on life equipment and to do so, modification to the GIS wall sections and flanges need to be made. From an operational perspective, new gas-handling systems and parts need to be developed and tested. For this reason, in order to trial this new gas, the following steps will be taken:

1) Modification to the GIS-to-air bushings

2) Modification to the flanges

3) Installation of the two modified GIS busbar sections

4) Development and testing of gas-handling equipment and maintenance practices

5) Monitoring of the gas performance for a period of 3 years

The scope is limited to two busbar sections on a substation.

The second gas requires further development in order to understand whether it may be of use to the industry as a 400kV insulator based on CF3I gas. In order to develop this gas further, we are supporting an iCASE studentship to look at the properties of this gas and mixtures in gas insulated busbars on a laboratory demonstrator.

Nominated Contact Email Address(es)

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Problem Being Solved

Sulphur hexafluoride gas (SF6) is estimated to contribute about 0.2% of the global warming potential of the annual greenhouse gas emissions in the UK. SF6 is also the dominant insulation and interruption material in high voltage equipment with around 10,000 tonnes of it being used by electricity companies in the UK with an estimate emission rate of 15.6 tonnes (approximately 389,329 tonnes of CO2 equivalent). The possibility of reducing the amount of SF6 in the electricity network and hence the potential impact of the industry on global warming is therefore of great interest. Unfortunately, due to its unique capabilities SF6 has, until now, been very difficult to manage and substitute.

Due to its molecular structure, SF6 has a relatively high dielectric strength of nearly three times more than air at atmospheric pressure. However, this same characteristic provides it with an average life of about 3,200 years. This long life-time, added to its strong infrared absorption capability are the reasons for its extremely high global warming potential, which for a 100-year horizon is estimated to be approximately 23,900 times greater than CO2. There are hence several challenges addressing utilities looking at reduce their environmental impact in this area:

- Leak Detection and Refilling
- Leak Sealing and Repair
- SF6 Capture and Reuse
- SF6 Alternatives

This project comprise parallel work packages that address each of these, and builds on the work previously carried out by National Grid as well as projects undertaken by other networks and reported on the ENA portal.

The planned programme of work across all work packages has a duration of 5 years, however, recognising the signficance of the environmental benefits that success at any stage could offer, results that could enable others to accelerate the reduction of greenhouse gas emissions from SF6 will be shared with all GB licensees and electricity networks globally as soon as they are verified.

Method(s)

Addressing all the above challenges requires the development of various new innovative technologies, systems and methods. Trialling them under controlled, supervised conditions in order to learn and de-risk the decision to roll them out will be essential to developing solutions that can be implemented on the electricity networks.

Scope

Leak Detection and Refilling

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Objective(s)

Leak Detection and Refilling

This work package is aimed at delivering three key outputs:

- A technology capable of detecting SF6 leaks at various dew points and in indoor environments.
- A technology capable of automatically refilling leaks to maintain a constant pressure.
- An improved SF6 trolley to improve safety of handling staff.

Leak Sealing and Repair

This work package's objective is to investigate novel leak sealing and repair techniques capable of being used on two specific situations:

- On large leaks which require rapid curing of epoxy compound or valve to reduce pressure
- On porcelain/metal sections.

SF6 Capture and Reuse

This work package aims at investigating and developing a technology for capturing SF6 gas and, if necessary, filtering it to a stage where it could be re-introduced to the equipment for reused as insulating material.

SF6 Alternatives – Phase 1

G3: This new gas has never been installed before on any life equipment. The successful implementation will prove the potential of new gases to be successfully introduced into the electricity industry as alternative insulation.

CF3I: Mixtures based on this gas are still under development and its use for HV applications has not been proved. This area of work will look at key techniques for the characterisation of its insulating properties and will include preliminary investigations into the interaction of CF3I with key high voltage materials.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

n/a

Success Criteria

Leak Detection and Refilling

A successful outcome of this work package would see would see the three deliverables, described in the objectives above, successfully developed and tested.

Leak Sealing and Repair

If successful, this work package will develop a technology and/or compound capable of being used for large gases and for both porcelain and metallic interfaces.

SF6 Capture and Reuse

If successful, this work package will deliver a technology capable of capturing any leaking gas, filtering and if required, refilling the tank.

SF6 Alternatives – Phase 1

A successful project will see the modifications to the GIS equipment being performed without impacting the reliability of the whole substation as well as see the introduction of G3 into the system for a period of three years without faults. It will also see the development of a CF3I mixture capable of being used in transmission applications.

Project Partners and External Funding

n/a

Potential for New Learning

n/a

Scale of Project

Leak Detection and Refilling

This work package will be restricted to research and development. If successful, the technology will be tested in a range of locations, limited to 10.

Leak Sealing and Repair

This project will be limited to the development of one technology capable of tackling both challenges articulated. If successful in laboratory trials, 10 sites will be chosen for the technology to be installed and monitored during a period of 1 year to understand any degradation or failure mechanisms.

SF6 Capture and Reuse

This work package will be restricted to research, development and laboratory testing. Only in exceptional circumstances will site trials be involved.

SF6 Alternatives – Phase 1

The trial of G3 will be limited to two busbar sections on two feeder circuits at one substation.

The laboratory testing of CF3I will be conducted on decommissioned plant.

Technology Readiness at Start

TRL3 Proof of Concept

Technology Readiness at End

TRL7 Inactive Commissioning

Geographical Area

United Kingdom

Revenue Allowed for the RIIO Settlement

The G3 trial will be undertaken as an additional element to the construction of a bypass substation the underlying costs of which are allowed for under the RIIO settlement. The substation construction costs are based on using well established SF6 insulated busbars and is being funded as part of NGET's normal construction activities. Only the additional design and construction and monitoring costs required for trialling G3 on two of the circuits at the substation are being funded through the NIA. The current estimate of these additional costs is £1.189m.

Indicative Total NIA Project Expenditure

The indicative NGET NIA budget for the current phase of work, the trial of G3 on two gas insulated busbars is £1,200,000.

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

There are approximately 850 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 around 370,000 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 (CO2e of about 14,000 tonnes) representing a potential reduction of around 350,000 tonnes CO2e per year. Using DECC central projections for CO2e cost for 2030 of £70/tonne this equates to £25m savings per year. Using forecasts for 2050 (£200/tonnes CO2e) these savings rise to be greater than £70m per year.

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

There are approximately 850 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.

Due to the low TRL levels of some aspects of the work proposed, the roll out costs are difficult to calculate for some of the aspects described.

For the G3 trial, it is expected that new installations consisting of novel gases would be more expensive that SF6 insulated substations, not least because in the case of G3 the gas must be kept at a higher pressure than SF6. If the G3 trials are successful and the timescales are appropriate, National Grid will consider an application for Innovation Roll Out Mechansims (IRM) funding and will consult with stakeholder representatives to support an IRM application.

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

1. The developed leak detection and refilling techniques will be of use to all licensed network owners in the UK.
2. The leak sealing and repair techniques will be of use to all transmission owners in the UK. Minor modifications might allow the same technology to be used in distribution assets.
3. SF6 capture and reuse techniques will be of use to all transmission owners in the UK. Similarly to above, it is believed that only minor modifications will be required for distribution licensees to take advantage of the new learning in this area.
4. The learning generated will allow all relevant network licenses to request G3 insulation material on new GIS builds without the associated risks. Initial work in the area of CF3I has already allowed a distribution licensee spin-out work in this area for distribution assets. Output from the further work proposed here will allow the transmission industry to develop further confidence in this new gas as a possible alternative.

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

☑ 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.

n/a

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

n/a

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

n/a

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

n/a

This project has been approved by a senior member of staff

☑ Yes