SIF Discovery Round 2 Project Registration

Date of Submission

Aug 2023

Project Reference Number

11061098; NGET/SF6 Whole Life Strategy/SIFIESRR/Rd2_Discovery

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Project Title

SF6 Whole life strategy

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11061098; NGET/SF6 Whole Life Strategy/SIFIESRR/Rd2_Discovery

Project Licensee(s)

National Grid Electricity Transmission

Project Start

Apr 2023

Project Duration

3 Months

Nominated Project Contact(s)

Prem Ranjan

Project Budget

£132,899.00

Funding Mechanism

SIF Discovery - Round 2

SIF Funding

£119,607.00

Strategy Theme

Net zero and the energy system transition

Challenge Area

Improving energy system resilience and robustness

Lead Sector

Electricity Transmission

Other Related Sectors

Funding Licensees

NGET - National Grid Electricity Transmission, SSEN-T - Scottish and Southern Electricity Networks Transmission

Lead Funding Licensee

NGET - National Grid Electricity Transmission

Collaborating Networks

Scottish and Southern Electricity Networks Transmission

Technology Areas

Asset Management, Carbon Emission Reduction Technologies, Electricity Transmission Networks, Environmental, Green Gas, High Voltage Technology, Substations

Equality, Diversity And InclusionSurvey

Yes

Project Summary

The project seeks to develop an economic, efficient, and holistic strategy for delivering an SF6-free electricity system that will support GB's ambition to deliver a net-zero, resilient energy system.

The potency of SF6 released into the earth's atmosphere has a significant effect on global warming. It is estimated that there are over 960 tonnes of SF6 currently insulating gas insulated switchgear (GIS) apparatus in GB substations. The SF6 in GIS switchgear continuously leaks into the atmosphere throughout its lifecycle and requires periodic top-ups and cleansing to maintain satisfactory insulating properties.

SF6 leakage contributes the second highest greenhouse gas emissions from transmission networks, after network losses. The transmission networks must develop a roadmap to being SF6-free by 2050. To understand how to achieve this, whilst deriving best-value to consumers, we propose to develop a strategy for the retrofill of existing switchgear apparatus with alternative lower-carbon-footprint insulating gases, programmes for reducing leakage in existing apparatus, and direct replacement of apparatus where it would not provide optimal value to retrofill with an alternative gas. The strategy would define the broad principles of decision-making for profiles of apparatus (age, scale, future planning requirements, footprint, leakage rates, etc.) across GB's entire transmission system.

This project will analyse the current regulatory frameworks that govern the use of SF6 and lower-carbon alternative gases and deliver a desk-top study of proposed changes to the regulatory landscape, to deliver a strategy that is future-proof by assessing the techno-economic performance of each option. The overall strategy will be refined over the project lifecycle, and will comprise an exploratory analysis during Discovery phase, testing of solutions at Deeside Innovation Centre during the Alpha phase, and strategy development and deployment during the Beta phase.

The lead partner is National Grid Electricity Transmission (NGET) supported by the following project partners in the Discovery phase:

- SSEN Transmission as a transmission licensee.
- University of Manchester as an academic partner and expert in HVAC switchgear technologies and alternative lower-carbon-footprint insulating gases.
- DNV as project manager and techno-economic assessment experts.

In the Alpha and Beta phases, we anticipate additional partners would join the project, including:

- 3M as provider of alternative low-carbon gas solutions
- DILO as specialist in gas handling, including reconditioning, mixing and recovery of gases.

Each project partner has an interest in driving innovation and supporting the efficient roll-out of new infrastructure and delivering a resilient energy system which is net-zero ready.

Project Description

The potency of SF6 released into the earth's atmosphere has a significant effect on global warming. It is estimated that there are over 960 tonnes of SF6 currently insulating gas insulated switchgear (GIS) apparatus in GB substations. The SF6 in GIS switchgear continuously leaks into the atmosphere throughout its lifecycle and requires periodic top-ups and cleansing to maintain satisfactory insulating properties.

This project will develop an economic, efficient and holistic replacement strategy of SF6 that will realise GB's ambition to deliver the energy system transition for a net-zero, resilient future.

The outcomes of the project will be a review of the current regulatory frameworks that govern the use of SF6 and lower-carbon alternative gases and a strategy for replacing SF6 that is future-proof by assessing the techno-economic performance of each option and understanding the additional evidence required to show that solutions are operationally safe.

Third Party Collaborators

The University of Manchester

DNV

Nominated Contact Email Address(es)

box.NG.ETInnovation@nationalgrid.com

Project Description And Benefits

Applicants Location (not scored)

National Grid Electrcitiy Transmission PLC

National Grid House,

Warwick Technology Park,

Gallows Hill, Warwick, CV34 6DA

Project Short Description (not scored)

To develop an economic, efficient and holistic replacement strategy of SF6 that will realise GB's ambition to deliver the energy system transition for a net-zero, resilient future.

Video description

www.youtube.com/watch?v=wGS83TT94Eg

Innovation justification

Our energy system is undergoing a radical transformation. Government targets of 40 GW of offshore wind generation by 2030 and net zero emissions by 2050 present challenges to deliver the infrastructure needed to support increasing amounts of renewable energy and to facilitate a nationwide rollout of electric vehicles. The continued electrification of heat and transport will increase further demand on the electricity network. This will require an extensive uprating of existing electricity network infrastructure where power-dense gas-insulated substations (GIS) have an increasingly vital role to play. SF6, a gas with the highest known global warming potential (25,200 times greater than CO2), is the main insulation medium used in GIS because of its dual qualities of electrical insulation and arc interruption. Existing SF6 technology has provided industry with the ability to install compact high-voltage substations that occupy a volume as low as 5% of air-insulated substations at equivalent voltage level.

The SF6 inventory is expected to drastically increase in the coming years given the growth in renewable generation and uprating of existing electricity infrastructure. Some commercial equipment utilizing non-SF6 based solutions developed by manufacturers has been deployed, but user experience remains limited since the first installation at Sellindge in 2016, so there are many technical unknowns that require urgent further investigation. As the industry accelerating the development of SF6-free technology, we introduce a new challenge in the end-of-life treatment and eventual disposal of many thousands of tonnes of SF6. The current method of high temperature incineration of SF6 contained in its storage container is energy intensive and not carbon neutral. All these issues will inherently delay the Net Zero transition and introduce uncertainty into the safe operation of our energy systems.

This project focuses on developing a viable long-term strategy around (a combination of) the following possible solutions:

1. new-build replacement for substations at the tail end of the asset lifetime;
2. retrofilling existing SF6-designed equipment at the middle or early stage of their lifetime;
3. effective seal mitigation techniques applied on ageing assets to minimise direct SF6 release to atmosphere; and
4. effective end-of-life treatment and disposal of SF6.

This work will drive the changes necessary to transform our energy system towards a sustainable SF6-free electricity grid that is reliable and affordable for consumers.

Benefits Part 1

Environmental - carbon reduction – direct CO2 savings per annum against a business-as-usual counterfactual
Financial - cost savings per annum for users of network services
Financial - future reductions in the cost of operating the network

Benefits Part 2

The principal benefit of this project is the facilitation of a net zero power system at the minimum achievable cost to the consumers, giving significant environmental and financial benefits:

Environmental benefits: Direct environmental benefits can be tracked through the quantity of SF6 removed from assets and SF6 annual emission reductions. Following the alpha and/or beta phase, the findings of the project will inform the replacement of possibly several tonnes of SF6 as the procedures recommended by the holistic SF6 replacement strategy move into BAU. If a conservative estimate of 10 GISs across GB identified by the holistic strategy could be retrofilled/replaced with SF6-free alternatives before 2035, this alone would result in an abatement of 1050 kg of SF6 emissions in the following 15 years assuming 700 kg of SF6 is removed from each GIS and a 1% leak rate. This is equivalent to more than £6bn in environmental savings using 2021 HMRC Green Book carbon costs, and is a low estimate for savings as the vast array of other SF6 assets excluding GISs is not considered.

Financial benefits: Financial benefits to consumers manifest through savings in the long-term overall cost of removing SF6 up to 2050 over current strategies, which for RIIO-2 are focussed on refurbishment and replacement with further SF6 equipment and do not consider retrofilling as a commercially available alternative. Exact savings will be quantified as the strategy develops and optimal strategies can be compared in terms of cost to the current strategy of leak reduction and replacement. However, considering the previously mentioned example future scenario, replacing 10 GISs with current new-build options for GISs would cost around £1.5bn, whereas retrofilling solutions would be estimated to cost an order of magnitude less at roughly £150m. This would result in a reduced cost of around £1.35bn to consumers, and would be in addition to significant time savings. Rapidly bringing these solutions to commercial availability through this SIF-funded project is therefore paramount. The holistic SF6 replacement strategy, and its associated techno-economic feasibility studies, will expedite the large-scale rollout of SF6-free options and optimise the choice of solution from all available options, not just retrofilling, for a varied profile of assets. This will echo recent stakeholder sentiment; a 2019 survey revealed that 60% of consumers would like National Grid to reach net zero ahead of the promised 2050, further encouraging the accelerated path to decarbonisation that is offered by this project.

Project Plans And Milestones

Project Plan and Milestones

The project will be delivered in three work package:.

WP1 Replacement Strategy

Develop and assess options available for replacing SF6 use across all network assets. This study will include retrofilling with alternative gases and new build solutions and will identify typical profiles of assets to enable the recommendations to be applied across the UK's transmission networks. This work package will also describe SF6 end-of-life considerations that are required to develop a holistic replacement strategy, including the reuse of reconditioned SF6. Finally, we will undertake a review of the regulations and assess future changes (e.g., EU F-gas regulations). The objective of this work package is to develop the knowledge base from which to develop replacement strategies in the Alpha phase.

WP1 lead – University of Manchester

Support from – NGET, DNV, SSEN

WP2 Roadmap to Implementation of Solutions

Develop a high-level plan of the testing that is required to validate the replacement strategies that are recommended. This will involve the testing of alternative gases at the Deeside Innovation centre that will be undertaken in the Alpha phase. The objective of the testing is to provide valuable evidence that the solution is operationally safe in addition to the pass/fail styled IEC type tests.

WP2 lead – NGET

Support from – UoM, DNV, SSEN

WP3 Techno-economic Analysis

Undertake a cost benefit analysis of the options available for replacing SF6 gas. A techno-economic study will be conducted to inform the choices for what replacement strategy is recommended. As well as the costs, this work package will monetize the reduction in carbon emissions and estimate the benefit to networks of addressing SF6 emissions in advance of any regulatory requirements.

WP3 lead – DNV

Support from – NGET, UoM

The project plan Gantt chart can be found in the appendix. It shows the 3 key milestones of the project, which are aligned to the 3 review meetings during which the project progress, risks and findings will be assessed against the plan. Regular progress meetings will be held between the core team every two weeks.

The project will be managed by DNV, who has extensive experience delivering innovation, research and development projects through network funding mechanisms, including strategic change, technology policy and systems roadmap development. As Lead-Partner, NGET will be responsible for providing regular control and support to the day-to-day project management that DNV will deliver.

Regulatory Barriers (not scored)

The EU F-gas regulations control the use of F-gases, including SF6 and some alternatives, in the EU. Equivalent regulations also exist in GB. The EU F-gas regulations are currently under review. As part of the Energy Networks Association (ENA), transmission operators are engaged with potential changes in GB. In general, tighter controls, and, in time, bans, on the use of SF6 are expected and broadly welcomed. However, it is not foreseen that these would be barriers to embedding outcomes into business as usual.

There is legislative push to restrict/ban the use of SF6 as well as SF6 alternatives with high global warming potential (GWP). The current F-gas regulation proposal has instilled clear dates where the sale of new SF6 switchgear will be banned. It also states that the use of new solutions with GWP between 10 to 2000 will be restricted. This introduces a significant risk that some of existing solutions could be restricted, which leads to the undesirable scenario of air being the only solution for the end users with comparatively larger substation footprint than SF6 required. The final version of F-gas regulation could be pending further changes as it will not be ratified until the end of 2023, and it is not known for certain how the updated EU regulations will impact the equivalent regulations in GB.

Commercials

Route To Market

To ensure the proposed solution is relevant, effective, safe, and cost-efficient, we have proposed three work packages split across partners to elicit robust requirements that are fit for purpose. This project will involve a multidisciplinary team including experts from network owners (NGET and SSEN), academic partner, consultancy, and low carbon gas providers joining at later stages of the project. Close collaboration with a wide range of partners ensures the outputs of the trial are not only successful at reducing SF6 emissions but also easily scalable and applicable to multiple sites across all electricity networks.

By the end of the Discovery phase, the project will have an informed understanding of options based on the techno-economic comparison, including their environmental impact. The evidence generated in this analysis will feed into future investment strategies developed by networks that will incorporate one, or a combination of, solutions based on their asset profiles. These solutions are:

- Retrofilling gas insulated electricity transmission assets (non-switching applications) with a more environmentally friendly replacement gas;
- Strategies to reduce leakage in existing assets; and
- Replacement of assets not eligible for retrofilling with alternative gas solutions.

The project will further create a high-level plan for testing at a selected site, and review current and future regulatory climate.

The results of the Discovery phase will feed into the testing of the solution at Deeside and assessing its effectiveness. Following a successful proof of concept at one site, a strategy will be created to roll out this solution at other eligible sites, incorporating any lessons learnt and providing confidence to networks to implement these projects into business as usual. A plan to disseminate the findings with other network owners and operators will also be developed to further increase adoption rates.

This project will inform development of the commercial strategy and any relevant regulatory changes for SF6 management. The results will directly contribute to the NGET's SF6 Incentive through reduction of carbon footprint and ultimately feed into the roadmap to Net Zero. The consumer value proposition generated throughout this work, as well as the potential for knowledge sharing across the industry will create necessary conditions for investment.

Intellectual property rights (not scored)

Foreground IPR produced by the project, such as the findings from testing that is carried out on SF6 replacement strategies at Deeside, will be communicated in the Discovery Phase reporting in sufficient detail to enable others to benefit appropriately from the learning delivered by this project. Confidential details of IPR will not be disclosed, however sufficient information will be provided to enable other licensees to understand the technology being developed and its applicability to their own networks. This is in the interests of all project partners as it is hoped that the solutions can be demonstrated to be technically and commercially viable so wider licensee understanding of the new technology could lead to additional network development activity and economic benefits for the supply chain, including project partners from industry.

Project compliance with the IPR arrangements as defined in Chapter 9 of the SIF governance document will be assured via the contractual arrangements which will be put in place between NGET and each of the project partners.

Costs and value for money

An innovative strategy for the replacement of SF6 in networks will underpin the network-specific roadmaps that transmission owners will seek to deliver in their respective business plans for subsequent price control periods (RIIO-T3, T4, etc.). It is important that a common strategy is developed to deliver the necessary efficiencies and establish the optimal approach to SF6 replacement that can be applied across transmission networks. This value of these cost-efficiencies will be realised in business plans through lower future tariffs for consumers.

In the Discovery Phase, the work will primarily be a desk-top exercise including literature review, attendance at collaborative meetings, techno-economic modelling and drafting reports, this will incur professional fees on a 'day rate' basis. There are no 'costs for assets' envisaged to be required in the Discovery Phase.

The overall costs to deliver the Discovery Phase at £132,899, with the following cost breakdown between project partners:

National Grid Electricity Transmission (NGET) (WP1, WP2,WP3): £19425 total, £17482 of funding sought with a 10% self-contribution of £1943.

Scottish & Southern Electricity Networks (SSEN) Transmission (): £3182 total, £2863 of funding sought with a 10% self-contribution of £319.

University of Manchester (WP1, WP2): £51,305 total, £46,174 of funding sought with a 10% self-contribution of £5131.

DNV (WP3 & Overall PM*): £58,987 total, £53,088 of funding sought with a 10% self-contribution of £5899.

*We propose that approximately 10% of the project budget would be required for overall project management services: £13,700

Document Upload

Documents Uploaded Where Applicable

Yes

Documents:

10061098 - SF6 Whole Life Strategy - Discovery Project Direction.pdf

2023-06-30 SIF Discovery Show and Tell - SF6 Whole Life Strategy.pdf

SF6 Whole Life Strategy - SIF Discovery Application Submitted 23-11-22.pdf

SF6 Whole Life Strategy Project Management Book.xlsx

SF6 Whole Life Strategy Updated Risk Register.pdf

SIF SF6 Whole Life Strategy Discovery Phase Report.pdf

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This project has been approved by a senior member of staff

☑ Yes