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

Feb 2024

Project Reference Number

NIA2_NGET0059

Project Registration

Project Title

Anticipating Gas Insulation Leaks from Electrical assets – AGILE

Project Reference Number

NIA2_NGET0059

Project Licensee(s)

National Grid Electricity Transmission

Project Start

March 2024

Project Duration

2 years and 2 months

Nominated Project Contact(s)

Gordon Wilson

Project Budget

£475,000.00

Summary

This project will use machine learning techniques to improve forecasting capability for SF6 circuit breakers taking nameplate, environmental and operational factors into account. Building on existing work the following will be undertaken:

- Understand the performance of the existing model when applied to NGET assets
- Develop the model taking NGET assets into account and then test to determine accuracy
- Collect online density monitoring data and use it to improve the forecasts
- Demonstrate how forecasting may be used to automate planned interventions.

Nominated Contact Email Address(es)

box.NG.ETInnovation@nationalgrid.com

Problem Being Solved

Maintaining SF6 gas pressure in gas filled circuit breakers is critical to their function, reduced pressure owing to leaks can prevent it from operating or returning to service when it is opened. Loss of SF6 is also an environmental issue owing to its high global warming potential.

Addressing SF6 leaks is primarily a reactive matter – when assets lose gas at an abnormal rate it will trigger an alarm to let the asset owner know that a top-up is required. Although, over time, leak rates may be determined, it is not normally possible to schedule top-ups and repairs effectively until a number of top-ups have been carried out.

Method(s)

Efforts have already been made by others to employ machine learning (ML) models for predicting when SF6 may be lost from specific assets based on their nameplate and environment with some success but the required level of reliability has not yet been achieved. By

adding NGET's data and making use of data from on-line pressure gauges this project will refine the model with the intention of yielding greater accuracy.

The solution will make use of the existing ML model (Python) and using an 'ensemble' type regression model to map asset covariates such as age, tank size, corrosion zone, distance from sea etc. onto leak rates calculated from SF6 top up data recorded during asset maintenance. The modelling will be enhanced with live SF6 density data installed specifically for this project.

Scope

An existing machine learning model written in Python and using an 'ensemble' type regression model will be used to map asset covariates such as age, tank size, corrosion zone, distance from sea etc. onto leak rates calculated from SF6 top up data from circuit breakers recorded during asset maintenance. This model has already been benchmarked on other TO circuit breakers and will initially be run on NGET assets to gauge accuracy. An NGET specific model will then be developed. This will entail selecting the optimal inputs for predicting future SF6 loss. A model learned from a combination of all 3 TO's assets will then be tested against a held out portion of assets from across the GB transmission network. Part of this proposed project will run concurrently with a further iteration of development with SSEN and SPEN (funded separately). Incorporating understandings from online monitored assets will be unique to this project and will help refine the predictive model functionality to take seasonal and diurnal effects into SF6 leakage rates.

The project will consider how predictive analytics can change operational decision support through their incorporation into planning tools the form in which this decision support will take.

Objective(s)

This project will deliver against four objectives:

- Development of a software model based on gas monitoring data for predicting short term SF6 escapes for inclusion in a longer term general SF6 escape model
- Application of leak prediction model to NGET assets detailing performance against individual families of circuit breakers
- Development, testing and reporting of a new predictive escape model with combined UK TO data
- Proof of concept for an automated maintenance planning driven by predictive analytics.

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 SF6 leaks.

Success Criteria

The project will be successful if a model is developed that is able to predict SF6 leaks from assets with acceptable accuracy.

Project Partners and External Funding

SSEN Transmission and Scottish Power Energy Networks will be actively involved in the project. This builds on their previous work.

Potential for New Learning

The project will deliver reports for each of the workstreams within the overall work package. 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:

- Analysis of online SF6 monitoring (density) data and specification of a model for short term SF6 leaks
- Analysis of SF6 top-up data to infer and predict leak rates of unmonitored SF6 circuit breakers using pre-existing model
- New SF6 escape predictor model
- Software demonstrator using predictive analytics to schedule maintenance activities

Learning will be disseminated through defined project progress and completion reports. In addition there will be a webinar to share learnings and a CIGRE conference paper.

Scale of Project

The project will largely be conducted as a desktop exercise. Density monitoring and connectivity to enable remote access to data will be installed on three circuit breakers at two sites. The locations have not been selected but one will be coastal and the other inland.

The project has been scaled with the intention of delivering efficiently and with reasonable expectation of success. When creating models, probability of success is increased with increased data acquisition, but comes at a cost. The amount of density monitoring is expected to support development. Less data may reduce the cost but may prove to be insufficient for the purpose.

Technology Readiness at Start

TRL4 Bench Scale Research

Technology Readiness at End

TRL6 Large Scale

Geographical Area

The project will be carried out at a university facility, monitoring data will come from two sites not yet determined. The results will likely be applicable to all UK based networks regardless of geographical location.

Revenue Allowed for the RIIO Settlement

N/A

Indicative Total NIA Project Expenditure

£423,000

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:

This project supports the energy transition to a net zero network by reducing direct, Scope 1 emissions of SF6. Reducing SF6 losses has a direct impact on transitioning to a low carbon network.

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

Leak modelling should enable SF6 top ups on circuit breakers to be a planned activity rather than causing unplanned outages and emergency call-outs. Better understanding of likely SF6 leak rates going forward will support timely interventions such as palliative coating of assets, maintenance, and leak repairs. It has been estimated that the improvement in overall SF6 management that may result from a successful project will provide an NPV of £2m between the end of the project and 2040.

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

The project will be applicable to transmission assets, as indicated by the interest in the project from SSEN Transmission and SPEN.

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

At the completion of the project further work may be required to achieve further improvements in modelling or in implementation of the results but those costs cannot be estimated at this time.

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

Results will be shared with all licensees and they may be applicable to all owners of SF6-filled circuit breakers. Although NGET will focus on transmission assets the model has already been developed for higher distribution voltages (132 kV). It will be the responsibility of others to determine the extent to which the models might be directly applicable to not only their assets but their asset management approach to managing this type of equipment.

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 having SPEN and SSEN Transmission involved with the project.

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

There are technical risks associated with any innovation project as the proposed solution may not work. The project is anticipated to generate sufficient benefit to justify the expenditure over 15 years so the success of the project will only become apparent over a longer period of time.

Relevant Foreground IPR

NIA funding enables innovative work that is not part of the business-as-usual activities for network utilities, in this case research into predicting SF6 leaks from assets based on their design, location and service history using modelling tools that will be supplied by an academic partner.

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

NGET has created models for understanding the likely SF6 losses of the fleet of SF6 filled assets as part of business of usual activities. This work is an extension and somewhat speculatively considers that the addition of gauge data will provide improvements to the model. This project may not deliver benefit, especially in the longer term but it is appropriate to undertake efforts in this regard to accelerate understanding of what may be achieved through modern machine learning techniques in meeting future SF6 emission reduction targets.

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 innovative work that is not part of the business-as-usual activities for network utilities, in this case research into predicting SF6 leaks from assets based on their design, location and service history using modelling tools that will be supplied by an academic partner.

This project has been approved by a senior member of staff

☑ Yes