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

Jul 2022

Project Reference Number

NIA2_NGET0022

Project Registration

Project Title

Switch Oil Markers

Project Reference Number

NIA2_NGET0022

Project Licensee(s)

National Grid Electricity Transmission

Project Start

August 2022

Project Duration

0 years and 10 months

Nominated Project Contact(s)

Gordon Wilson (Box.NG.ETInnovation@nationalgrid.com)

Project Budget

£95,000.00

Summary

This project will support transformer reliability and condition assessment by identifying when fault gas migration from a switch compartment to another part of a power transformer has taken place. Eliminating this as an unambiguous source of fault gas in a transformer main tank or selector can be difficult while carrying out expensive and time-consuming fault-finding activities. The project will look at methods as part of a feasibility study.

Third Party Collaborators

The University of Manchester

Mynas Limited

Nominated Contact Email Address(es)

box.NG.ETInnovation@nationalgrid.com

Problem Being Solved

Power transformers are filled with transformer oil which is routinely sampled for the presence of dissolved gases. One of the gases that is checked is acetylene which is only produced as a result of processes involving significant amounts of energy. The presence of acetylene in the main tank or tap-changer selector compartment of a transformer is therefore an indication of a serious problem in need of investigation. When the problem cannot be readily identified, it can lead to a transformer being switched out for internal inspection and potentially replacement, especially if the acetylene concentration shows an increasing trend.

In the transformer tap-changer switching compartment, the diverter, frequent arcing during normal operation generates high levels of acetylene. The diverter is isolated from both the main tank and selector compartments to avoid gases such as acetylene from migrating into these areas and being misdiagnosed as a fault. NGET has experienced, on occasion, leaks from the diverter to the

main tank and/or selector through the barrier in older transformers. This has led to lengthy and expensive investigations and transformer unavailability. Although leaks have been suspected they are difficult to prove and leave lingering doubts about the transformer's condition.

Method(s)

This feasibility project is aimed at reducing this uncertainty through use of an identification marker that can be used in diverter switch oil to make it easier to detect when acetylene-contaminated oil has migrated into the main or selector tanks through, for example, a leaking barrier board.

Following an innovation call for solutions, two potential methods are to be explored whereby markers could be introduced into the divertor compartment. These markers can then be detected at low concentrations in either the main tank or selector as evidence that the acetylene has migrated from the diverted rather than being produced by a fault.

- One of the proposed markers is known to be stable and suitable for use in diverters, but methods for trace detection in transformer oil needs to be developed
- The second proposed marker is known to be detectable at very low levels, but the suitability for use in electrical equipment has not yet been established.

Data Quality Statement (DQS):

- The project will be delivered under the NIA framework in line with OFGEM, ENA and NGGT / NGET internal policy. Data produced as part of this project will be subject to quality assurance to ensure that the information produced with each deliverable is accurate to the best of our knowledge and sources of information are appropriately documented. All deliverables and project outputs will be stored on our internal Sharepoint platform ensuring access control, backup and version management. Relevant project documentation and reports will also be made available on the ENA Smarter Networks Portal and dissemination material will be shared with the relevant stakeholders.

Measurement Quality Statement (MQS):

- The methodology used in this project will be subject to our supplier's own quality assurance regime. Quality assurance processes and the source of data, measurement processes and equipment as well as data processing will be clearly documented and verifiable. The measurements, designs and economic assessments will also be clearly documented in the relevant deliverables and final project report and will be made available for review.

Risk Assessment

TRL Steps = 1

Cost = 1

Suppliers = 1

Data Assumption = 1

Assessed risk score 4 - Low

Scope

The project will investigate two methods as part of a feasibility study into the introduction of an additive into a diverter switch compartment without having any negative impacts on its performance. The assumption being that if there is some migration of oil from the diverter switch to either the selector or main tank which results in acetylene being detected in those compartments it would be possible to then test for the additive as proof that this is the source of the acetylene.

One workstream will investigate the ability to find synthetic ester in mineral oil at low concentrations. The addition of ester to the switch compartment will have no negative impact but there is a need to identify the best solution for reliably measuring its concentration at low levels in mineral insulating oil.

A second workstream will investigate a tracer chemical that has been used in other industries and can be detected at low levels and determine whether this could be added to the diverter without affecting its performance.

In the event that acetylene is picked up during routine dissolved gas analysis testing (DGA) the condition of a transformer is considered to be suspect. If the acetylene is confirmed and appears to be increasing the transformer could be considered at risk of failure and switched out. Further investigation will not easily identify that the acetylene has come from the diverter although this may be a consideration. Rather than engage in testing and internal inspections requiring outages and oil handling until the issue is resolved,

application of the results of this research will enable the migration from the switch compartment to be confirmed one way or the other.

Objective(s)

The objective of the project is to develop and evaluate two alternative chemicals for use in a diverter that can be detected at low concentrations if they migrate with oil and acetylene into other transformer compartments.

It will determine the best technique for measuring ester at low concentrations.

It will determine whether there are tracer chemicals that can be used safely in a diverter switch.

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 a neutral impact on customers in vulnerable situations as it as feasibility project that will impact on availability and the assessment of condition of transmission power transformers.

Success Criteria

This feasibility project will be considered successful if at least one of the chemicals investigated is both safe to use in transformer switch compartments and readily detectable at trace levels in mineral oil.

Project Partners and External Funding

Not applicable

Potential for New Learning

It is expected that the new learning derived from this project will be an assessment of the most likely analytical techniques for detecting ester in mineral oil at trace levels. The limits of detection and quantification will be determined for at least one technique and depending on these levels other techniques will be considered.

There will be additional learning about the impact of tracer chemicals used in other industries on the dielectric performance and stability of mineral insulating oil.

Learning will be disseminated through defined project progress and completion reports. In addition, opportunities to share the learning through industry conferences will be sought.

Scale of Project

The project is going to take two techniques from relatively low levels of TRL for this application and assess whether they could be useful as markers for switch oil migration. The project will not assess the ability of either marker to migrate inside transformers, no field trials will be conducted at this time. A larger project for one of the techniques would be required, it would not be considered sufficiently beneficial to take both chemicals through this process until their feasibility is proven. The project scale could have been smaller with only one technique but given the inherent overhead associated with any project, it was deemed more efficient to consider both techniques at this stage to increase the probability of success of at least one chemical proving suitable.

Technology Readiness at Start

TRL3 Proof of Concept

Technology Readiness at End

TRL5 Pilot Scale

Geographical Area

Laboratory studies to be carried out at the innovation providers' facilities.

Revenue Allowed for the RIIO Settlement

Not Applicable

Indicative Total NIA Project Expenditure

£85,500

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 through the efficient return to service of transformers where a potential fault is identified through routine DGA but where the fault gas has migrated through from a diverter. Acetylene is considered to be an indicator of a serious fault and, where it appears to be increasing, can result in the transformer being switch on fault and may not return to service for a period of months while investigations are undertaken. Ruling out migration can be very difficult and where it occurs the transformer may be returned to service where migration is considered the only remaining option. Electrification of other industries will increase the required resilience of the transmission network. Increasing transformer availability, especially where outages are unnecessary will increase network resilience.

How the Project has potential to benefit consumer in vulnerable situations:

Not applicable

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)

Not applicable

Please provide a calculation of the expected benefits the Solution

This is a research project and assessment of feasibility for two techniques that may be further developed. The number of transformers where acetylene is believed to have migrated from switch compartments is relatively rare but it can be an onerous task to eliminate every other possibility. Should either technique prove successful a more detailed assessment of benefits will be carried out ahead of further development.

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

It is anticipated that either technique could be applied to any transformers where the diverter switch tank is oil filled and not expected to be in communication with other oil-filled compartments that are routinely assessed for condition by DGA.

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

Both of the techniques are assessed as being relatively inexpensive to apply and the actual cost would depend on the network's own labour costs. The materials are commercially available and would have to be used based on the learning from this project. Laboratory costs should be relatively inexpensive, it is intended that the techniques will be relatively common in most commercial laboratories.

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

Other networks would be able to use the learning directly if they have similar issues related to the migration of gases from switch compartments in transformers to other oil filled compartments such as the selector or main tank. Both solutions being evaluated use commercially available chemicals, testing should be available at commercial laboratories and the process of doping and sampling should be achievable using in house capability or from a number of oil handling service companies.

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.

This project does not duplicate any work that NGET is aware of, no similar innovations were proposed as part of the innovation call.

If applicable, justify why you are undertaking a Project similar to those being carried out by any other Network Licensees.

Not applicable

Additional Governance And Document Upload

Please identify why the project is innovative and has not been tried before

This project was developed following a public innovation call looking for solutions to this problem. Existing solutions for the same purpose were also requested, nothing similar was proposed.

Relevant Foreground IPR

The foreground IPR will be the test method developed for detecting trace levels of ester in mineral insulating oil and the results of testing on a chosen tracer chemical. The method and the test results will be published. The Background IP around the exact chemical formula for the ester and the tracer may not be shared as they are commercial products protected by their suppliers, neither of whom is involved in the project.

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 project is a feasibility study into whether either method will deliver the required solution. There is a reasonable risk that neither solution will work and if either is successful further work will still be required to demonstrate that it will work in a real world scenario i.e. a project involving testing in a transformer may be required.

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

There are technical risks associated with any innovation project as the proposed solution may not work. If the initial laboratory work proves unsuccessful the project will need to be revised or further work will have to stop, this would be the case for either solution.

At this stage the commercial benefits have not been evaluated. The challenge the project is addressing is one that arise rarely but causes significant problems when it arises. It is expected that the benefit will be achieved over a longer period of time than any commercial organisation would consider reasonable for business as usual investment.

This project has been approved by a senior member of staff

☑ Yes