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

Jun 2016

Project Reference Number

NIA_NGET0186

Project Registration

Project Title

Condition Monitoring of Circuit Breakers - iCASE

Project Reference Number

NIA_NGET0186

Project Licensee(s)

National Grid Electricity Transmission

Project Start

June 2016

Project Duration

2 years and 1 month

Nominated Project Contact(s)

Carl Johnstone

Project Budget

£169,500.00

Summary

This research project looks to address National Grids ambition to balance the capability to increase insight into the condition of a circuit breaker whilst minimizing the need to remove it from service during the conditional monitoring activity. The scope of work for this project will be developed in three key phases.

Phase 1 - Software package for processing acoustic signals and showing their chromatic values and tested on a circuit breaker in the lab under a range of fault currents.

A report will be available. By the end of Year 1 the sensor types will be known and preliminary software for analysing the signal.

Phase 2 - New acoustic sensors will be deployed on two selected circuit breakers with supporting electronics, data capture and communications systems. Data being analysed from the circuit breakers and operational behaviours are beginning to be defined.

A report will be produced. By the end of Year 2 some monitoring systems will have been deployed on site. By the end of Year 3 a method for determining the Health Index for gas filled switchgear will be produced.

Phase 3 - From the site data and information extraction units, a health index for the switchgear is embodied in to the software and can be demonstrated on operational switchgear as well as in the lab. A report will also be produced. Process and strategy for deployment into the business if proved viable.

The key outputs of this work include:

· A successful method of applying sensors to circuit breakers while still in operation in an high voltage environment.

· A system that can be temporarily used for routine measurements and an alternative system for long term fixed monitoring

· Validation of a methodology using the chromatic method

· Software that is deployable by a utility to centralize all the data and be used as part of asset management

· Delivery of a PhD thesis, with additional data analysis and final report with recommendations.

Nominated Contact Email Address(es)

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Problem Being Solved

The principle of condition monitoring is to keep up to date on the condition of an asset in order to mitigate maintenance outages and asset failure of High Voltage circuit breakers.

Conventional condition monitoring systems involve temporarily embedding sensors to the circuit breaker in order to capture direct performance measurements such as contact travel, gas and hydraulic pressures. During this activity, the asset must be removed from service to ensure safe working conditions. This can result in relatively long outages, which are difficult to secure and impact on network availability, costs and resources.

For enclosed circuit breakers in insulation, such as oil or SF6, with multiple breaks in series there is a requirement for increased outage times, with similar impacts on the network as mentioned above. Whilst conventional sensors offer the asset manager a measure of performance, they do not always detect defect symptoms present in a circuit breaker which may lead to an impact on the function or the integrity of the circuit breaker.

At present, there is no cost effective, non-intrusive condition monitoring system for high voltage circuit breakers that can indicate a range of possible faults during normal switching operations. This project will look at the development of a new sensor system, and associated diagnostic software, to gain an indication of the health index of the different circuit breakers using non-intrusive methods. The non-intrusive system would require an operation rather than a maintenance system outage. In order to achieve this aim, a new approach to conventional measurement and condition monitoring must be developed and tested on a selected population of switchgear.

Method(s)

The approach for this project is to research and develop a monitoring system that would utilise a limited number of non-intrusive acoustic sensors that will provide a holistic view of switchgear condition. It is anticipated that this new monitoring system would enable emerging faults to be detected; which previously haven't been detected at such an early state when using conventional methods (via the chromatic method). Once the new system is developed it will firstly be used in the lab based testing before being deployed onsite at various suitable substations. The working environment trials will monitor the static and dynamic operational behavior of switchgear.

The chromatic methodology has been used successfully elsewhere in the utility sector, such as condition monitoring of tap changers/selectors within distribution networks. The chromatic method has proven to be particularly successful in extracting latent information from complex signals. It can detect known faults but also small changes related to the emergence of faults which statistically have a low probability of occurring. This project is interested in taking the lessons learned in other sectors to develop the chromatic methodology in the area of circuit breaker recognition. The method necessary to develop the methodology into a circuit breaker monitoring systems includes the following:

· Sensor selection to enable non-intrusive measurement.

· Build and test a condition monitoring systems in the lab using gas filled switchgear.

· Induce faults on a model circuit breaker, under laboratory conditions, to assess the sensitivity of the approach to detect and discriminate single faults as well as multiple failure modes.

· Deployment of condition monitoring systems for continuous monitoring of high voltage circuit breakers at selected substations that have circuit breakers that meet the projects needs and minimise impact to normal operations. With some monitoring systems being installed temporarily and others on a longer term basis. These units will not interfere with the operation of these breakers.

· Apply chromaticity principles to monitor the condition of high voltage circuit breakers to detect obvious (e.g. reduced hydraulic pressure etc) and emergent conditions that could lead to an operational fault.

· Analysis software to automatically process signals detected by the monitoring.

Scope

This research project looks to address National Grids ambition to balance the capability to increase insight into the condition of a

circuit breaker whilst minimizing the need to remove it from service during the conditional monitoring activity. The scope of work for this project will be developed in three key phases.

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The key outputs of this work include:

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Objective(s)

Develop a monitoring system that requires a limited number of non-intrusive sensors in order to provide a holistic view of switchgear condition. The aim is to provide the industry with an improved ability to understand the asset health of circuit breakers. If successful, this would increase network availability and decreases the risk of outages and failures on the assets.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

n/a

Success Criteria

The success delivery of the key project outputs, as listed in the Scope. Including the provision of additional data analysis and a final report with recommendations for viability of deployment onto the transmission network.

A non-invasive solution (sensor, hardware, and software) that can be adopted for wider use the network.

Project Partners and External Funding

n/a

Potential for New Learning

n/a

Scale of Project

The initial research element of this project will be undertaken at a university research facility. The second half of the project will involve deployment of monitoring units on site to test two different types of switchgear in a working environment. The equipment needs to be trialed for an extended period of time to collect sufficient data. During testing, a selection of monitoring units will be relocated to multiple sites, in order to widen the data sample collection. It is envisaged that at minimum 30 circuit breakers will be monitored during the field trials, focused on a family/type of circuit breakers.

Technology Readiness at Start

Technology Readiness at End

TRL3 Proof of Concept	TRL5 Pilot Scale

Geographical Area

The initial development phase is desk based. Following on from that, data collection and trails will be undertaken at appropriately selected sites. Where possible the team will look in the North West areas on National Grid's network.

Revenue Allowed for the RIIO Settlement

NGET's RIIO T1 business plan identified the need for approximately £1.3bn to be invested from 2013 to 2021 related to switch gear breaker replacement, refurbishment and reconditioning. The aim of this project is to provide tools and techniques that could help reduce the amount that needs to be spent on these assets.

Indicative Total NIA Project Expenditure

£100,000 (excludes EPSRC iCase Award contribution of £69,500 directly to the University)

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)

The principle of condition monitoring is to avoid maintenance outages and asset failure. The cost of a catastrophic circuit breaker failure is in the region of ~£2.5m, therefore if the condition monitoring solution for circuit breakers provides data to save even 1 asset, it is anticipated that this cost of ~£2.5m will be avoided.

Please provide a calculation of the expected benefits the Solution

Not applicable – research project.

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

The non-invasive chromatic method developed during this project could be applied to circuit breakers on the GB electricity transmission and distribution networks. The information and assessment index methodology will enable network operators to perform maintenance and plant asset replacement on a more evidenced base methodology and with a greater understand of time to failure and failure mechanism.

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

For roll out of the condition monitoring solution for circuit breakers, it is estimated that costs for design and installation of sensors on targeted circuit breakers which have been identified with potential asset health issues will be ~£2.1m. National Grid is not in a position to articulate how other transmission and distribution licensees will take this technology forward within their networks.

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

The development of this new non-invasive condition monitoring system will be applicable to other electricity transmission network licensees for use their electricity network.

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

This project fits within the Managing Assets value area of the Electrical Transmission Owner Innovation Strategy.

☑ 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