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NIA Project Registration and PEA Document

Date of Submission

Jul 2016

Project Reference Number

NIA_NGET0185

Project Registration

Project Title

Investigation of transient and safety issues in gas insulated systems

Project Reference Number

NIA_NGET0185

Project Licensee(s)

National Grid Electricity Transmission

Project Start

October 2016

Project Duration

4 years and 7 months

Nominated Project Contact(s)

Dongsheng Guo

Project Budget

£281,430.00

Summary

The R&D scope of work of this project will focus on a number of key aspects of GIS with emphasis on switching operations, in particular disconnector switching. The investigations will involve the following deliverables:

1. Extensive gathering of existing knowledge from published literature regarding transient voltages for GIS switching,
2. Study of GIS components, and the development of physical models to determine electric field distribution and circuits models of GIS components. and connected external circuit of air busbars and overhead lines,
3. Simulation of earthing systems at GIS sites and establish rigorous mitigation techniques to improve safety,
4. Develop measurement techniques to improve quantification of generated surges and potentials at GIS during switching
5. Establish solutions to mitigate fast surges and rise of earth potential.

Nominated Contact Email Address(es)

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Problem Being Solved

Gas insulated substations (GIS) offer significant benefits, including savings in substation footprint and their operation is not affected by weather conditions. However, because the voltage breakdown in SF6 is fast compared to air, many switching operations could result in very fast transient phenomenon being generated and propagated not only in the high voltage conductor systems but also in the 'earthed' enclosures.

The academic understanding of fast transient phenomena is not yet readily explored and acknowledged by network operators, which could lead to the situations where earthing and bonding arrangements are not optimally designed and/or installed at the project construction phase.

The population of GIS equipment on the network is growing quickly; this is in large part due to the many benefits that GIS presents. Gradual but steady changes to the electricity generation mix, and topology of the whole GB network, has meant the system operator is requesting operations of GIS with increasing frequency to achieve operational targets, such as voltage control and load flow control. An increase in operations will result in more occurrences of fast transient phenomena in GIS, which not only impacts the system operator but will impact on the maintenance activity undertaken by the transmission owner. Therefore, the appropriate and timely implementation of the findings from this research project will have a direct benefit to the GIS population as it continues to be subject to increasing stress. The aim is to mitigate any increasing stress and the resulting equipment faults and cost implications to the business and the industry a whole. This research project will address the need to carry out targeted studies to fully understand the major factors involved and how they impact on the magnitude of the fast transients in GIS. Equipped with the above knowledge, GIS asset owners could produce better specifications for future GIS equipment. As well as optimising operations to mitigate potential faults and failures.

Method(s)

This project will involve the study of GIS to gain in-depth understanding of phenomena appearing in gas insulated systems. These will include discharge activity, transient overvoltages during disconnect or switching, and line closing when connecting to overhead line circuits. Furthermore, earthing scenarios will be investigated to determine the need and requirements for high frequency earthing in such systems. Safety aspects of such configurations will be evaluated.

The models generated within the modelling and simulation task will be compared and verified with controlled experiments and on site testing. For the purpose of advanced measurements, new fast voltage transducers will be designed, built and tested to allow measurement of the fast transient overvoltages.

The method of research will focus on lab based modelling and measurement tasks undertaken by the students:

- Build both generic and specific installation models for electric field, transient and earthing investigations,
- Design and build transducers to test the measurement of transient overvoltages and earth potential rise in GIS during switching operations,
- Identify the phenomena occurring in GIS, and therefore the contributing factors to rapid voltage breakdown in SF6
- Establish procedures and solutions to mitigate fast surges and rise of earth potential in GIS during switching operations.

Scope

The R&D scope of work of this project will focus on a number of key aspects of GIS with emphasis on switching operations, in particular disconnect switching. The investigations will involve the following deliverables:

1. Extensive gathering of existing knowledge from published literature regarding transient voltages for GIS switching,
2. Study of GIS components, and the development of physical models to determine electric field distribution and circuits models of GIS components. and connected external circuit of air busbars and overhead lines,
3. Simulation of earthing systems at GIS sites and establish rigorous mitigation techniques to improve safety,
4. Develop measurement techniques to improve quantification of generated surges and potentials at GIS during switching
5. Establish solutions to mitigate fast surges and rise of earth potential.

Objective(s)

This research and development programme aims to achieve the following main objectives:

1. Completion of an extensive review of available literature on state of the art of GIS discharge phenomena and earthing approaches.
2. Develop suitable models of the GIS components and system to determine electric field and fast transient surge levels. Furthermore, develop procedures to reduce the magnitude and other effects of such surges.
3. Develop models of the earthing system to allow accurate determination of rise of earth potentials, and develop mitigation techniques to ensure safety of GIS earthing system.
4. Develop measurement techniques to allow comparison with modelling, improve understanding and allow future monitoring of the above phenomena in GIS.
5. Develop mitigation measures for fast surges and rise of earth potential.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

n/a

Success Criteria

The delivery of a successful innovation project is reliant on a number of deliverables to be achieved at the end of the project period. Comprising of the conclusion of a state-of-art review; provision of parametric modelling of switching operations in GIS; a quantification of the earth potential rises in GIS and the production of possible mitigation measures with recommendations; and the validation and verification of theoretical conclusions of the measurement techniques.

Project Partners and External Funding

n/a

Potential for New Learning

n/a

Scale of Project

This iCase award studentship spans over 4 years and is co-funded by EPSRC, which provides £81,430. This project is focused on investigating and mitigating the discharge phenomena and voltages generated during switching operations in GIS. The investigation work will comprise of desktop survey (of relevant international literatures), desktop modelling (alongside the established theories and practices), and site activities (to adjust and verify the studies). Each of the elements above will be crucial to the successful delivery of the output, i.e. the guidance on how transient in the earthed parts of GIS installations are generated and how to mitigate against the transients, from not only an operational but also a design perspective.

Technology Readiness at Start

TRL3 Proof of Concept

Technology Readiness at End

TRL5 Pilot Scale

Geographical Area

All the desktop elements are to be carried out in Cardiff University in south Wales. Site measurements will take place at several specified National Grid substations, with alternative sites identified in order to test the theories on a wider GIS population across multiple sites.

Revenue Allowed for the RII Settlement

None

Indicative Total NIA Project Expenditure

The total NIA project expenditure will be £200,000 (this excludes the EPSRC contribution of £81,430)

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 prevention of failures caused by discharges in GIS will provide savings in the avoidance of outage costs associated with repair work. Addressing these faults carry an estimated cost of more than £1m across a span of five years. This would include site attendance, investigations, system alteration, repair and restorations. Therefore is it anticipated that the avoidance of faults and associated outages as an output of this project, would result in an average savings of ~£200k a year.

Please provide a calculation of the expected benefits the Solution

N/A – research project.

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

All utilities use GIS, hence, this project will allow better understanding of techniques used to mitigate discharge/surges and optimise safety of GIS during switching operations. The better quantified effects and understanding of mechanisms will allow the proposed mitigation techniques to be deployed at all affected GIS sites.

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

The majority of benefit will be realised in the activity of updating associated policy and specification based on learnings derived from this project, which will influence changes and potential relevant limitations to operational sequences, therefore no direct cost is foreseen in the rolling out stage.

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 learning generated will allow all relevant network licensees to apply this mitigation of GIS discharges/surges and earthed potential rise in their systems, with the learnings published and disseminated via relevant technical reports/papers, forums, approved code of practices, and standards.

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 seeks to address the Corporate Responsibility and Managing Assets value areas within the Electricity 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