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

Nov 2018

Project Reference Number

NIA_SPEN_0035

Project Registration

Project Title

Transient Recovery Voltage Investigation

Project Reference Number

NIA_SPEN_0035

Project Licensee(s)

SP Energy Networks Distribution

Project Start

December 2018

Project Duration

1 year and 7 months

Nominated Project Contact(s)

Watson Peat

Project Budget

£200,000.00

Summary

The overall aim of this project is to quantify the potential range of TRV requirements at different voltage levels (33 kV, 132 kV, 275 kV and 400 kV) by considering the characteristics of the SPT, SPD, SPM, SHET and SHEPD networks. Based on the outcome, standard TRV requirements can then be established. Also, guidance will be formulated on how to identify cases where this standard TRV capability is insufficient and how to remedy the situation.

Third Party Collaborators

Energy Innovation Centre

Trilliant Networks Operations Ltd

Nominated Contact Email Address(es)

innovate@spenergynetworks.co.uk

Problem Being Solved

Transient Recovery Voltage (TRV) can be defined as the voltage which appears across a circuit breaker's terminals upon interruption of the current resulting from a switching operation. The TRV which occurs at the circuit breaker terminals depends on the source side network inductance and capacitance and the location of a fault. When specifying circuit breakers, designers are often unsure about the TRV requirements that should be requested, particularly when switching e.g. series reactors or transformer circuits. This leads to a number of potential problems, namely:

- Circuit breakers with a voltage rating above the rated network voltage are selected unnecessarily at additional cost.
- Additional TRV studies are required, leading to additional project cost and possibly delays.

· Circuit breakers with “special” TRV ratings are specified unnecessarily at additional cost.

The UK electricity industry has long-established circuit breaker standards, often based on IEC 62271-100 or its predecessors. However, there are concerns:

· Are the TRV requirements in these standards still appropriate for present and future networks?

· Do these standards offer a good balance between TRV capability and cost for SPEN and SSEN networks?

The aim of this project is therefore to quantify the potential range of TRV requirements at different voltage levels (33 kV, 132 kV, 275 kV and 400 kV) by considering the characteristics of the SPT, SPD, SPM, SHET and SHEPD networks. Based on the outcome, standard TRV requirements can then be established. Also, guidance can be formulated on how to identify cases where this standard TRV capability is insufficient and how to remedy the situation.
In some cases, it may be cost-effective to mitigate an excessive prospective TRV instead of installing a circuit breaker with an increased TRV capability. This could be particularly effective if the TRV problem is recognised early in the design stage, so that provision can be made from the start. However, it is not always clear to designers what mitigation options might be available and whether they are cost effective. Therefore, this project also aims to identify practical mitigation options and to provide guidance on when these could be applied.

Method(s)

This project proposes a technical method that will involve engaging researchers to investigate the issue of TRV and produce conclusions that may impact circuit breaker selection and application in a variety of networks. The investigations will address the TRV issue through network modelling, estimating the prospective TRV, identifying potential consequences and risks, and the means to mitigate these.

The planning, training, operation and maintenance requirements of any viable mitigation options will also be established. This information can be used by network companies with similar installations.
The project will be a feasibility study only, with its conclusions intended to further collective understanding of the issue while assessing the viability of mitigation strategies and technologies. Future projects can use this technology to decide if live trials are suitable.

Scope

The scope of this project is to undertake work to quantify the potential range of TRV requirements at different voltage levels (33 kV, 132 kV, 275 kV and 400 kV) by considering the characteristics of the SPT, SPD, SPM, SHET and SHEPD networks. Based on the outcome, standard TRV requirements can then be established. The project will be a feasibility study only, with its conclusions intended to further collective understanding of the issue while assessing the viability of mitigation strategies and technologies. Future projects can use this technology to decide if live trials are suitable.

More precisely the scope covers work which is carried out in the following stages:

· A thorough literature review to identify previous work in this area with regard to TRV standards and mitigation options. Where possible, this should also include notes and reports that have been compiled by working groups that set UK or international standards.

· Using load-flow and fault analysis network data as a starting point, a method to estimate the prospective TRV for various circuit breakers will be devised. This is expected to involve studies of electromagnetic transient behaviour in suitable software. With the exception of overhead lines, parameters for detailed transient modelling of network components are not generally available. Therefore, this part of the project should rely on typical plant characteristics in combination with e.g. sensitivity studies. Innovative approaches to dealing with this analysis will be encouraged during the project.

· For each voltage level, and also considering the IEC62271-100 ratings, the TRV capability that will ensure that most circuit breakers will operate within their rating will be developed.

· An investigation of different fault types (three-phase, line-ground etc.) and advice on the application of the IEC62271-100 ratings for different fault types.

· Guidance will be developed for the interpolation of circuit breaker TRV envelopes and the use of circuit breaker ratings for different fault scenarios i.e. terminal faults, short line fault, long line fault and out-of-phase.

· An investigation will be carried out into the impact of arc models (or the lack of an arc model) on TRV simulations and guidance will be provided for TRV simulations. This will include a discussion on the impact and suitability of generic arc models.

· An investigation into TRV mitigation options will be undertaken and these will be tested and have their efficacy demonstrated by carrying out further transient network studies. A high-level cost for each option will be established and comment on any potential reliability or health and safety issues will be made.

· Practical guidance will be developed for designers to help identify situations where TRV is likely to exceed the standard circuit breaker capability and provide a number of mitigations options. A suitable guidance document will be produced, including an appendix with the reasoning behind the guidance provided.
A progress report will be produced upon the completion of each step outlining the results and findings. The report on the analysis will

make recommendations for standard SPEN and SSEN TRV ratings.

Objective(s)

The overall aim of this project is to quantify the potential range of TRV requirements at different voltage levels (33 kV, 132 kV, 275 kV and 400 kV) by considering the characteristics of the SPT, SPD, SPM, SHET and SHEPD networks. Based on the outcome, standard TRV requirements can then be established. Also, guidance will be formulated on how to identify cases where this standard TRV capability is insufficient and how to remedy the situation. The aims of the project can be broken down as below:

· Establish if the standard IEC 62271-100 TRV capabilities sufficiently cover the prospective TRV that circuit breakers will typically be subjected to in the SPT, SPD, SPM, SHET, SEPD and SHEPD networks (≥ 33 kV).

· Investigate if SPEN and SSEN specifications should require increased TRV capabilities for any voltage level and what the enhanced rating should be.

· Establish and provide guidelines that can be used to identify cases where the standard TRV capability is likely to be insufficient. Investigate and report on cost-effective, practical mitigation options that could be deployed instead of installing a circuit breaker with an enhanced TRV capability.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

n/a

Success Criteria

The success of this project will depend on the completion of the investigation into understanding and quantifying the TRV capabilities of circuit breakers for a variety of networks. Success criteria for the project are:

· Improved understanding of the standard IEC 62271-100 TRV capabilities and their applicability to the SPEN and SSEN networks.

· Gaining an understanding of the appropriate TRV capabilities for use in SPEN and SSEN specifications.

· The dissemination of learning gained through the project.
Stakeholder satisfaction.

Project Partners and External Funding

Scottish Hydro Electric Transmission (SHE Transmission)

Potential for New Learning

The project will provide new learning about:

· The TRV problem and any potential consequences and associated risks.

· The capability of circuit breakers to interrupt the prospective fault current.

· Mitigation options and strategies for this problem and their viability.

· The planning, training, operation and maintenance requirements of any viable mitigation options.
The learning from this project will be disseminated through the online learning portal and also through a workshop.

Scale of Project

This project is a feasibility study into the issues surrounding TRV and possible mitigation solutions. If successful, the learning can be disseminated and future projects can use this information to decide if live trials are suitable. The scale of this project is deemed the minimum necessary to carry out the essential investigations and simulations required to fully investigate and report upon this problem area.

Technology Readiness at Start

TRL2 Invention and Research

Technology Readiness at End

TRL4 Bench Scale Research

Geographical Area

There is no specific geographic area however it will be focussed on the SPEN and SSEN network areas and circuit breaker specifications.

Revenue Allowed for the RIIO Settlement

None

Indicative Total NIA Project Expenditure

£200,000

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:

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)

Please provide an estimate of the saving if the Problem is solved.
Any solutions to the problem learned through this project's investigations will potentially be much more cost-effective than any mitigation options currently employed on the network. There may also be savings through prevented equipment damage.

Please provide a calculation of the expected benefits the Solution

N/A as this is a research project.

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

The project is looking into a problem that affects all network licensees making any learning highly replicable

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

Project will not lead to a rollout (feasibility study only).

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

As networks characteristics change, greater amounts of reactive compensation devices are required across Distribution and Transmission Networks. This project will generate learning that will support this change in network composition and help licensees understand the requirements for TRV rating of circuit breakers and therefore help to optimise investment in circuit breakers.

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

☑ 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.

Checks on ENA Smarter Networks Portal revealed no other projects for this specific problem. A project on shunt reactor switching has been carried out by SPEN covers 33kV switching however this has not investigated the issue at other voltages in depth.

Internet searches reveal that this problem has been researched however there is no research applicable to the SPEN or SSEN network requirements. The aim of this project is to investigate this problem and any mitigation strategies that may exist and verify them with network studies. Consideration will also be given to the planning, training, operation and maintenance requirements of any viable mitigation options providing additional (new) commercial insights for network companies.

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

This project is required as a result of changing network characteristics and identification of ongoing efficiency measures. The issue is only understood on a theoretical basis so far and this project aims to delve deeper into understanding the conditions surrounding the TRV issue and then using the knowledge gained investigate potential cost-effective mitigation strategies which do not currently exist.

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

The investigations performed as part of the project are quite innovative and therefore fall outside the scope of routine business activities. There is also a lack of in-house technical expertise and equipment/software within the affected network licensees to undertake the project under normal business as usual activities.

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

The project involves a collaborative effort between SHE Transmission and Scottish Power Transmission to establish a potential solution to a problem that is becoming more prevalent on their networks. The learning from the project is likely to have impact not only for other network licensees but also for the entire supply chain since there is potential for recommendations from the project to be considered by switchgear OEMs. Ultimately, that would be expected to deliver value to customers. Although the foregoing makes the business case strong, work of this nature still poses financial risk since the outcome may not always be successful. The fundamental aim of NIA funding makes it possible to carry out such investigative research work. In the event of the project outcome being unsuccessful, the sharing of the learning from the project as required under NIA rules means there will be potential for future cost savings from avoidance of investment into similar investigations.

This project has been approved by a senior member of staff

☑ Yes