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 2017

Project Reference Number

NIA_SHET_0022

Project Registration

Project Title

Transmission System Fault Level Monitoring

Project Reference Number

NIA_SHET_0022

Project Licensee(s)

Scottish and Southern Electricity Networks Transmission

Project Start

June 2017

Project Duration

1 year and 7 months

Nominated Project Contact(s)

SSEN Future Networks Team

Project Budget

£285,000.00

Summary

The scope of the project will include the following:

- The development of a passive fault level monitoring programme across six transmission substations providing good coverage of the fault levels across the SHE Transmission system in the North of Scotland.
- To compare the current transmission model and fault current calculation method (ER G74) against observed values across a range of system backgrounds from the monitoring programme by using off-line analysis.

Nominated Contact Email Address(es)

transmissioninnovation@sse.com

Problem Being Solved

The calculation of accurate fault levels across the transmission system is a vital task to ensure that primary equipment is adequately rated and protection is correctly set and coordinated across the range of system operating conditions. In addition to the foregoing, a good understanding of fault levels is also important as a measure of system strength which is used in creating system equivalents for a range of analysis tasks (e.g. generator grid code compliance assessment, switching studies and control system tuning). System fault levels are calculated by power system planners using models which are setup to reflect the generation background and network configuration appropriate for the system condition being studied. The minimum system fault level typically occurs during summer months due to lower levels of generation and the presence of system maintenance outages; whereas, the winter months lead to the maximum condition when the highest levels of generation are connected to a largely intact system.

The GB power system is currently undergoing significant changes as major reinforcements are constructed to support a shift in generation away from synchronous machines to renewable technologies using increasing levels of power electronics which provide a much reduced fault current contribution. Recent work by the System Operator as part of the System Operability Framework has highlighted that the accelerating closure of synchronous machine plant will lead to much lower transmission minimum fault levels. With

greater levels of renewables being connected alongside imports via High Voltage Direct Current (HVDC) based interconnectors, the minimum fault levels across the system will drop to an extent which could degrade system power quality. This could make it difficult to calculate satisfactory protection settings and may lead to a requirement to deploy alternative protection schemes from those presently used. There may also be issues with maintaining compliance with voltage step limits and reduced voltage stability margins. This downward trend is of particular interest to SHE Transmission as the system in the North of Scotland already has the lowest fault levels of the three onshore license areas and the resolution of these issues could require significant investment to ensure that the system can continue to operate safely and within planning limits. It is therefore important that the models used by power system planners continue to provide accurate assessments of fault levels – particularly so for minimum fault level conditions.

The contribution from power electronic interfaced generation technologies or Voltage Source Converter HVDC is inherently different to that from synchronous machines and its treatment within existing short-circuit calculation methodologies is the subject of ongoing industry review (e.g. the current review of ER G74 by the ENA). It is timely to commence a study based on fault level monitoring while the levels of these technologies are still modest, as it will allow a degree of benchmarking to be made before major trends in fault level physically emerge in the system.

Method(s)

SHE Transmission proposes a programme of fault level monitoring using a recently developed technique at strategic locations across the North of Scotland with a view to cross-check the calculated results from the detailed system model. SHE Transmission proposes the following programme of activity to address the problem outlined above:

Work package 1: Fault Level Monitoring Method Verification
The fault level monitoring technique chosen is a passive method developed by Outram Research Ltd which involves the derivation of a fault level value from observations of changes in measured voltage and current. To date the method has been laboratory tested and trialled at a number of distribution or industrial substations with promising results. It is recognised that this method is only suitable for assessing fault levels within radial networks supplied from a single grid source and thus it cannot be directly applied within an interconnected transmission system. However, to mitigate this issue it is proposed that the devices are installed on the lower voltage side of Grid Supply Point (GSP) transformers and the calculated grid contribution referred back up onto the transmission system to give an estimate at the supplying transmission bus-bar. SHE Transmission intends to perform a verification check on the passive fault level technique by installing the device at a GSP which is electrically close to, and within one voltage transformation of, a Static Var Compensator (SVC) which makes use of an active fault level estimation technique within its control system for gain optimisation. This fault level estimate is available within the SHE Transmission Supervisory Control And Data Acquisition (SCADA) system and will be used to verify the accuracy of the passive technique. This site is relatively close to several large hydro stations which, due to their operating regimes, will provide known step changes in local fault level which will be beneficial to the testing.

Work package 2: Fault Level Monitoring Campaign
SHE Transmission will identify a further five strategic locations across the North of Scotland which will enable a good assessment to be made of system fault levels at the three transmission voltages (400kV, 275kV and 132kV). Upon the successful completion of work package 1, the fault level monitoring devices will be installed at these locations along with a supporting IT infrastructure and the monitoring programme will commence. This programme will continue for two years with the intention that the hardware and supporting software will remain in service after the completion of the project. The fault level contributions measured by the devices will also be made available to the local DNO SHEPD.

Work package 3: Offline Analysis
With the monitoring programme underway and gathering data, offline analysis will be conducted at regular intervals to cross-check measured values against those calculated from the system model. This will require that the system model is setup with the same generation, demand and network configuration. The offline analysis programme will be defined to investigate not only min/max values over the last monitoring period, but also times of high/low outputs from various generation technologies. From this work it is planned that a good appreciation of variation in fault level will be obtained over the course of system operation. If necessary this analysis will incorporate any recommendations arising from the review of ER G74.

Scope

The scope of the project will include the following:

• The development of a passive fault level monitoring programme across six transmission substations providing good coverage of the fault levels across the SHE Transmission system in the North of Scotland.
• To compare the current transmission model and fault current calculation method (ER G74) against observed values across a range of system backgrounds from the monitoring programme by using off-line analysis.

Objective(s)

1. Carry out an initial validation exercise to confirm the accuracy of the passive fault level estimation technique against a known active method. Should this have a positive outcome, the project will continue, with the following further objectives:
2. Implement a programme of passive fault level monitoring across the SHE Transmission system at several locations, which delivers measured fault level values collected through seasonal and other variations.
3. Carry out regular off-line calculations based on the SHE Transmission GB system model to cross check against the monitored values, delivering an improved understanding of the range of actual fault levels and the behavior of the system model, and improved confidence in decisions made on the basis of the model.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

n/a

Success Criteria

The project will be judged to be a success based on the following criteria:

1. That sufficient evidence is collected to establish the effectiveness of passive fault level monitoring techniques within the transmission system, to enable a decision to be made on long term BAU adoption
2. The comparisons of measured data with off-line analysis supports ongoing industry efforts to validate or improve short-circuit calculation methodologies.
3. A specification is developed which can be used for the competitive procurement of further fault level monitoring equipment

Project Partners and External Funding

N/A

Potential for New Learning

This project will provide the industry with an assessment of the effectiveness of applying passive fault level monitoring techniques within the transmission system which to date have been focused on distribution or industrial networks.

In addition, the project will also provide useful insights into the variation in fault levels during the course of system operation as the generation background changes along with the network topology due to circuit outages.

The project will enable a functional specification to be written for procurement of further fault level monitoring systems, supporting wider adoption of the technique.

Finally, the project will provide an opportunity to benchmark existing fault level calculation methodologies against measured data and support the investigation of improvements.

Scale of Project

The project will grow from an initial trial at one location and will then extend to a further five sites across the SHE Transmission licence area. The sites have been selected to provide a geographical spread across the north of Scotland and include areas with specific technical characteristics (e.g. proximity to industrial demand, influence of different generation types and network topology).

Technology Readiness at Start

TRL6 Large Scale

Technology Readiness at End

TRL9 Operations

Geographical Area

The project will have sites across the region covered by the SHE Transmission licence area ranging from Caithness in the far north, down to the Kintyre peninsular in the south west and across to Aberdeenshire in the north east.

Revenue Allowed for the RIIO Settlement

None

Indicative Total NIA Project Expenditure

Total NIA expenditure = £285,000 of which 90% (£256,500) is allowable NIA Expenditure.

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)

This project would help deliver savings by removing some of the uncertainty surrounding the general trends in system fault levels. Protection mitigations to accommodate reducing fault levels could include replacing existing distance based main protection schemes with a differential alternative and adding more complex overcurrent backup functions. A conservative estimate of the number of 132kV circuits this could apply to in the SHE Transmission area is 20, at an indicative cost per circuit of £82k which includes the protection relays, communications upgrades, engineering and installation. Using these figures gives a potential protection upgrade programme in the region of £1,640k. This project will allow SHE-Transmission to identify with greater precision which circuits will need alternative schemes and when they will need them. This greater clarity on fault level behaviour will avoid unnecessary or premature investment in protection or voltage regulation equipment. Avoiding unnecessary differential protection schemes on as few as five circuits or confirming it is acceptable to defer investment by three years is expected to deliver savings in the range of £402k.

Please provide a calculation of the expected benefits the Solution

On the basis of the above estimates, if savings of £402k can be realized over three years, the net benefit over that period would be £117k.

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

If the application of passive fault level monitoring techniques is found to be accurate, the concept could be rolled out across the three onshore transmission licence areas. The devices could be installed at GSPs in a similar way to that proposed in this trial project. In the SHE Transmission area there are in excess of 70 GSPs and this license area is by far the smallest of the three with the total potential number of sites across GB being easily in the 100s.

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

An estimate of the roll out of this technique across GB is difficult to assess but an indicative value can be calculated from assuming a total of 50 installations at the 132kV voltage level, and approximately £20k per installation. This would give a cost of circa £1m. However it must be recognised that this figure is highly dependent upon the number of transformers within the GSP, available space in relay panels and the availability of communications equipment

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

n/a

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

SHE Transmission has identified issues relating to voltage control as a challenge to be met, and this project, by providing increased confidence in our modelling, will enable us to optimize the timing and nature of interventions, to the benefit of asset health and productivity, and the efficient operation of our network. These are identified as key themes for innovation in SHE Transmission's Transmission Innovation Strategy (2017).

☑ 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.

Based on a review of information in the public domain SHE Transmission is not aware of any trials of passive fault level techniques within transmission systems. This review included a project initiated by Scottish Power to carry out active fault level monitoring at distribution voltage levels, and an active monitoring system used by Western Power Distribution in a project to evaluate fault current limiters.

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