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## NIA Project Registration and PEA Document

### Date of Submission

Jan 2015

### Project Reference Number

NIA\_SHET\_0014

## Project Registration

### Project Title

Partial Discharge Monitoring to Reduce Safety Criticality

### Project Reference Number

NIA\_SHET\_0014

### Project Licensee(s)

Scottish and Southern Electricity Networks Transmission

### Project Start

January 2015

### Project Duration

5 years and 10 months

### Nominated Project Contact(s)

Fiona Irwin

### Project Budget

£1,300,000.00

## Summary

To install online trial PD monitoring systems incorporating alternative technologies and suppliers at selected sites and integrate with SHE Transmission's SCADA system in order to collect, store and analyse output PD event data to establish if this can be used to improve the management of safety critical plant. Learning from this project will also be used for further work to incorporate PD failure precursors into control and protection schemes.

### Nominated Contact Email Address(es)

transmissioninnovation@sse.com

## Problem Being Solved

Transmission Owners in GB have a common methodology for prioritising asset replacement. The methodology requires a risk based approach from the combination of an assessment of asset health and assessment of asset criticality. Criticality is defined as having three elements, safety criticality, environmental criticality and system criticality. Overall criticality is taken as the highest of the three elements. Plant such as circuit breakers which are in a substation located in a public place end up with a high safety criticality score i.e. a disruptive failure is likely to send shards of porcelain into the street / playing field / etc which could result in serious harm or even fatality. The current criteria which define safety criticality are only the location and impact of failure of an asset, neither of which can be changed without relocation.

The result is that plant in such locations always appears high up on the list of asset replacement priorities, regardless of the condition of the plant. We are therefore seeking ways to reduce the criticality score of assets. Various options exist including :

- Construction of solid barriers; which have planning consent issues and block views into substations with increased likelihood of theft and vandalism.
- Replacement of plant and equipment with different failure mechanisms such as dry type transformers or composite bushings. This is

an expensive option, especially where equipment is in otherwise good condition.

- Reduction of the likelihood of disruptive failure by continuous monitoring and proactive intervention.

This project will evaluate the last option as a means of improving asset criticality indices by assessing the ease with which continuous partial discharge (PD) monitoring can be integrated with internal Supervisory Control and Data Acquisition (SCADA) systems. According to one of UK's experts in PD, around 85% of all high voltage disruptive equipment failures are due to PD activity. If PD can be detected timeously through continuous monitoring then there can be early intervention to avert unexpected, often catastrophic, failure in service.

PD detection principles in PD monitoring systems are largely understood. There have already been some trials in SHE Transmission as well as other networks which were aimed at understanding the range of PD detection technologies available and their effectiveness. These trials have demonstrated that PD detection techniques are now largely mature. However, use of permanent online PD systems in business as usual (BAU) in network asset monitoring is still not standard practice since interpreting and obtaining actionable information from any such detection is quite difficult and requires specialist knowledge.

Currently, most PD monitoring is done as part of routine equipment inspection using handheld or mobile systems. Numerous variables including factors such as ambient conditions, background noise effects and frequency of inspections can impact the integrity of the inspection results thereby causing either hesitation or disproportionate response to PD detected this way, a situation which creates a conundrum for decision makers. As a result, conclusive presence of PD is usually only confirmed on the basis of consistent trends observed over a period of time. One of the ways to obtain such trends and also improve data resolution is to install temporary online PD monitoring systems on affected plant for specified periods depending on the perceived gravity of the problem. Typically, these temporary installations report their data to servers belonging to suppliers of the technology in use who have the expertise to interpret it and raise alerts. The biggest downside to this method is that should events evolve fast, there is high likelihood of equipment failing during the intervening period, a situation that is unacceptable when monitoring safety critical equipment.

This project aims to start addressing the limitations of routine interspersed PD inspections of equipment and also the inherent delays due to reliance on third party alerts for responding to PD issues arising from temporary online PD installations. If successful, the method can then be adopted in monitoring assets with high safety criticality to enable earlier intervention. Although this intervention may not be necessary in every case, it is a precaution that is justified for safety reasons and still more cost-effective than alternatives.

## Method(s)

This is a technical method to continuously monitor critical assets for PD and integrate the installed measurement sensors with SHE Transmission's SCADA in order for PD event data to be collected, stored, analysed and to enable PD interpretation to become part of routine internal control room activities.

At least two PD monitoring technologies based on different detection principles and from independent suppliers will be installed at each of at least two sites identified as either having high safety criticality or having the requisite conditions to enable adequate learning about the integration of PD detection with SCADA systems\*. This is necessary to ensure that the most viable PD monitoring solution or combinations thereof are established at the end of the project for potential rollout. An effective way of integrating PD data from the installed trial systems with existing SCADA infrastructure will be established. This will involve providing tools for making PD data and the user interface on which it is presented more intuitive to enable operational staff to interpret it more accurately without the need for intensive expertise. This knowledge will enable formulation of standard procedures that can be used by asset management staff to make appropriate decisions.

After installation and commissioning, a period of close monitoring will follow for a period of at least 18 months. All data from installed PD systems will be collected and stored for retrieval and regular analysis. During that period, experts independent from the PD monitoring systems suppliers will provide evaluation and validation of the systems.

The results from the trial will be used to inform an assessment of the viability of this method to reduce the cost of managing safety critical assets. At the end of the project, the trial installations will be assessed for ongoing use as business as usual.

\*29/09/2015: The main focus of this project is to demonstrate effective integration of PD detection with SCADA. The sites nominated for the trial have no known history of PD but have been chosen on the basis of safety criticality to ensure that if real PD should commence in the future there will already be a system in place to mitigate the potential impact. To complete the evaluation and validation of the trial systems, simulated PD signals will have to be used.

As part of routine mobile inspections, a site has been identified where there is some evidence of PD activity. This presents a potential learning opportunity to test the integration of this real PD data with SCADA as part of this trial. A change in methodology is proposed to include monitoring the relevant part of this site. Under current practice, this monitoring would be temporary and the data produced

would go to the monitoring equipment suppliers who would provide alarms should things appear to escalate. Under this project, this data will be retained internally and will form part of the analyses proposed in the rest of this project.

## Scope

To install online trial PD monitoring systems incorporating alternative technologies and suppliers at selected sites and integrate with SHE Transmission's SCADA system in order to collect, store and analyse output PD event data to establish if this can be used to improve the management of safety critical plant. Learning from this project will also be used for further work to incorporate PD failure precursors into control and protection schemes.

## Objective(s)

The overall objective of the project is to identify an economic solution to reducing asset criticality. This will be achieved through the following activities:

- Deployment of a continuous PD monitoring system at selected substations and monitoring the systems for at least 18 months to identify and understand excursions from expected levels of PD through all ambient and operational conditions
- Delivery of tools for simplifying output PD data interpretation and compilation of suitable procedures for actions in event of alarms
- Review of technical confidence and effectiveness of the trial systems with other approaches to reduce asset criticality.

## Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

n/a

## Success Criteria

The project will be considered a success if it can determine the viability of continuous PD monitoring as a tool for management of safety critical assets on the network.

## Project Partners and External Funding

Not applicable

## Potential for New Learning

Partial discharge detection systems are not new. They are used extensively at present but they do not interface directly with "business as usual" substation control systems. Invariably, partial discharge monitoring systems rely on external analysis of complex readings, with alarms being raised via e-mail or SMS text alerts.

This project seeks to move the use of partial discharge monitoring to a new level which in the future may lead to full integration of the monitoring system with the other protection functions within the substation. It will not be suitable in all applications, with the major concern being false alarms; potentially resulting in costly interventions for no benefit. By integrating with internal SCADA systems, storing all data internally and simplifying interpretation, the problem of false alarms may eventually be overcome resulting in improved accuracy of subsequent decisions. If this concern can be mitigated, the systems could be widely deployed to improve system safety.

Learning from this project will be shared through the online portal, the annual conference and workshops.

## Scale of Project

SHE Transmission has a number of assets with high safety criticality as a result of location and their impact upon failure. This trial involves installation at two such sites to demonstrate the technology. The outcome of this project is likely to have a significant impact on future asset management policies and it is vital that the quality of results is high. The scale of the project therefore reflects the aforesaid impact. Any lesser project scale would not be able to provide adequate data to enable evaluation.

## Technology Readiness at Start

TRL5 Pilot Scale

## Technology Readiness at End

TRL7 Inactive Commissioning

## Geographical Area

This project will be undertaken within the SHE Transmission area, at suitable substations located in Scotland.

## **Revenue Allowed for the RIIO Settlement**

£5.5M has been included for replacement of circuit breakers at three high safety criticality sites within the RIIO-T1 settlement

## **Indicative Total NIA Project Expenditure**

This project will be fully funded from SHE Transmission's NIA allowance.

The total expenditure is expected to be £1.3M, 90% of which 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 focuses on understanding the interpretation of online PD and development of a criterion for predicting when disconnecting equipment becomes essential. The most significant benefit is safety. If equipment can be isolated successfully ahead of disruptive failure, the risk to safety will be reduced. The financial benefits of avoided safety incidents cannot be quantified but it is assumed that any significant incident will be in the factor of millions. At the same time, planned maintenance is not as disruptive to users of the system as an unexpected event.

Assets which score high on safety criticality can be prioritised for replacement even when they still have significant remaining useful life. Under RIIO-T1, three sites with such assets have been identified in SHE Transmission and the cost of replacing them is estimated at £5.5M. This project may result in deferral of such replacements, leading to totex savings which would ultimately benefit consumers. Savings for other network owners will depend on the volume of assets classified as having a high safety criticality but may be significantly higher.

#### Please provide a calculation of the expected benefits the Solution

Base Cost – Method Cost = Financial Benefit

£4,500,000 - £1,300,000 = £3,200,000

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

The techniques employed in this method, if successful, could be rolled out to any transmission substation where asset replacement is prioritized due to safety criticality scoring. This method would offset the criticality scoring by proving the equipment is still in acceptable condition and can therefore be kept in service for longer.

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

The cost of rollout of this method will be dependent on the number of sites which will be identified by all Transmission licensees as having high safety criticality scores. This information is not publicly available. Under RIIO-T1, three such sites have been identified on SHE Transmission's network. Deploying this method to each site under business as usual is estimated to cost approximately £300k. The total rollout costs will therefore be this estimated unit cost multiplied by the total number of sites identified as having high safety criticality scores across GB. This estimated figure is however likely to go down as the technology used in the method becomes more

familiar and its uptake increases.

### 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

Any current PD monitoring is limited both in scope and time. Most monitoring is instigated after problems have surfaced. This project aims to incorporate PD monitoring as part of standard architecture for critical assets. A study of the data collected is expected to provide information which can form the basis of response to PD, something that is currently not possible. The experiences from this project may form the basis of asset management standards which can be applied by other network licensees.

Where assets are being prioritized for replacement due to a criticality scoring, this system may allow that replacement to be offset by a number of years, achieving financial benefits for both customers & the network owners. This strategy could be applied by other network owners where their own sites are considered to have high criticality.

#### 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.**

There has not been any project of this nature. Suppliers of the technology and other network licensees have all indicated that this is something that they have not yet tried. A review of all current NIA projects on the ENA Smarter Networks Portal and past IFI projects has also shown that this has not been done before in GB.

**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