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

Dec 2013

Project Reference Number

NIA_NGET0073

Project Registration

Project Title

Partial discharge monitoring of DC cable (DCPD)

Project Reference Number

NIA_NGET0073

Project Licensee(s)

National Grid Electricity Transmission

Project Start

November 2012

Project Duration

3 years and 9 months

Nominated Project Contact(s)

Greg Tzemis

Project Budget

£205,000.00

Summary

Recent work at Southampton on PD from AC cable systems indicates that clustering algorithms can be used to distinguish between PD from different sources. It appears feasible to use this technique during DC testing to distinguish between PD from the cable and that from the terminations or external noise sources. The technique relies on analysing the PD signals to measure the energy content in a number of time and frequency windows. The multi-dimensional results are converted to a pseudo 3-dimensional data set for easier visualisation and automatic classification.

In addition to developing a procedure to detect and classify DC PD signals the work will emphasise the need for the technique to be suitable for implementation during DC cable type tests. This requires that PD testing can be done safely in an industrial laboratory without impacting on the smooth running of the type test.

Nominated Contact Email Address(es)

box.NG.ETInnovation@nationalgrid.com

Problem Being Solved

Partial detection (PD) detection in DC systems is significantly more difficult than in AC systems because (i) the discharge repetition rate is far lower and (ii) there is no alternating voltage to which the discharge activity is synchronised. It is therefore difficult to distinguish between PD activity and random background noise.

National Grid's Technical Specifications require mass impregnated cable to be tested to the internationally accepted CIGRE test procedures. As the operating voltages of DC cables increase, cable manufacturers are progressively taking the view that the CIGRE test voltages are too severe and unless the test voltage is reduced (particularly during the cooling phase of heat cycling) there is an unacceptably high risk of the cable failing the type test.

In order to achieve type registration of these cables it will be necessary for National Grid to consider relaxing the test voltage. There is no published basis to justify this reduction and it is difficult to assess the risk of accepting cable systems which cannot meet the CIGRE

requirements.

There is a possible mitigation strategy based on applying condition monitoring techniques during type testing so that the test is not reliant on simple withstand criteria. When a MI HVDC cable fails the heat cycle type test it is likely to be the result of accumulated partial discharge (PD) damage. Hence PD monitoring appears to be the most appropriate option to investigate.

Method(s)

Research

The method that has been proposed for this project includes;

- Literature survey of DCPD testing of cable systems
- Commission MIND DC cable test rig
- Interim report on DCPD tests
- Preliminary report on implementation strategies
- Final Report.

Scope

Recent work at Southampton on PD from AC cable systems indicates that clustering algorithms can be used to distinguish between PD from different sources. It appears feasible to use this technique during DC testing to distinguish between PD from the cable and that from the terminations or external noise sources. The technique relies on analysing the PD signals to measure the energy content in a number of time and frequency windows. The multi-dimensional results are converted to a pseudo 3-dimensional data set for easier visualisation and automatic classification.

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Objective(s)

The objective of this project is to investigate and develop a method for monitoring partial discharge (PD) activity in mass impregnated (MI) HVDC cable. The outputs will enhance National Grid's understanding of high power HVDC cable and facilitate the development of improved Technical Specifications. The test method developed should be sufficiently effective and efficient to allow its deployment within the constraints of a commercial Type Test programme.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

n/a

Success Criteria

This project is successful if knowledge is established on which we can base test procedures on, ahead of HVDC cable installation.

Project Partners and External Funding

The University of Southampton

There is no external funding being brought to this project.

Potential for New Learning

There is significant potential for new learning as this project addresses the asset management and system operation with HVDC cables. This is a new development area, and will provide a valuable insight to the HVDC cable operation. All learning will be disseminated through the ENA Smart Portal, Conferences, Academic papers and also on NationalGrid.com website.

Scale of Project

This project is at a laboratory scale.

Technology Readiness at Start

TRL3 Proof of Concept

Technology Readiness at End

TRL6 Large Scale

Geographical Area

This work is being completed in Southampton, but will provide details applicable to all areas where there are HVDC cables installed, or due to be installed.

Revenue Allowed for the RIIO Settlement

Zero

Indicative Total NIA Project Expenditure

IFI - £80,000

NIA - £125,000

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)

An estimation of the saving if the problem is solved is at least £1m

The new DC developments are in access of £100million, if this project saves 1% then it has saved at least 1 million.

Please provide a calculation of the expected benefits the Solution

Research project - not required.

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

This methodology can be applied to any HVDC cable developments.

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

Unknown at this stage, likely costs will be a new methodology for cable condition monitoring. This is an unknown for us at the moment.

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)

This project addresses reliability of new technology and as such contributes to both asset management and connection to enable increased renewable generation.

☑ 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.

Having reviewed our standard suppliers, including EPRI, univeristies, and the ENA Smart portal, National Grid confirm this work has not been done before.

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