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

May 2018

Project Reference Number

NIA_NGTO008

Project Registration

Project Title

The FMEA Studies and Risk-based Maintenance for Emerging Power Electronics Assets within GB Power Networks

Project Reference Number

NIA_NGTO008

Project Licensee(s)

National Grid Electricity Transmission

Project Start

August 2018

Project Duration

1 year and 9 months

Nominated Project Contact(s)

Robin Gupta

Project Budget

£340,000.00

Summary

As the GB power system continuously evolves, a set of emerging Power Electronic applications will be implemented within the GBsystem. An increase in power electronics based applications has resulted in more complex AC/DC systems appearing across thetransmission network in the last few years. Improving our understanding of this mixed AC-DC system incorporating power electronicsin terms of possible failure modes and maintenance is necessary.

Nominated Contact Email Address(es)

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Problem Being Solved

Maintenance of traditional primary assets such as power transformers and switchgear in the context of the existing GB transmission system infrastructure is well understood by National Grid. Through a successful risk-based maintenance regime well supported with decades of historic data and experience, National Grid has been able to develop a more appropriate maintenance schedule for these assets.

As the GB power system continuously evolves, a set of emerging Power Electronic applications will be implemented within the GB system. Those applications include the high power LCC-HVDC system for low-carbon energy delivery from Scotland to England (Western Link) and a set of STATCOM-based Dynamic Reactive Compensators in England's South East Coast for regional infrastructure reinforcement.

This increase in power electronics has resulted in more complex AC/DC systems appearing across the transmission network in the last few years. Improving our understanding of this mixed AC-DC system incorporating power electronics in terms of possible failure modes and maintenance is therefore necessary to:

Derisk and adjust future system operation;

Provide successful delivery of infrastructure work;
Further harmonise asset interventions, such as maintenance, repair, renewal-replacement and reinforcement.

Method(s)

The project will focus on the two classes of equipment, which will be of relatively high priority for National Grid's future maintenance work:

· The Thyristor-based Line Current Commutation High Voltage Direct Current (LCC-HVDC);

· The Voltage-Source-Converter-based Static Compensators (STATCOMs).

The project will research and develop Failure Modes and Effects Analysis (FMEA) and will also provide the failure curves for key components of these two types of applications, capturing installation useful-life and wear-out phases.

Existing failure mode data will be collected through literature review and engagement with suppliers. Once the failure modes of power electronics are identified, reliability data gap analysis will be done with the aim to provide inputs to the reliability analysis. The methods used will include, as appropriate, fault-tree analysis, FMEA and FMEA state enumeration.
The reliability models of these components need to be combined with the reliability models of traditional network components to assess the impact of new PE technologies on network operation, if any, reliability of supplies, maintenance and replacement requirements. This requires modelling of different load levels, conventional and wind generations, fault/ outage types, operation policies, etc. and will be resolved with the aid of Monte Carlo simulation procedures. Monte Carlo simulation will also be used to review Risk-based Maintenance (RBM) strategies to assess how they might be used to improve converter lifetimes whilst meeting the system reliability criteria.

Scope

The models developed will be used to review RBM strategies to assess how they might be used to improve lifetimes. Specific outputs (and dates will be):

1. LCC-HVDC:
FMEA and gap analysis – month 6

Monte-Carlo based wear-out simulation – month 11

2. STATCOM:

FMEA and gap analysis – month 15

Monte-Carlo based wear-out simulation – month 20

Objective(s)

To develop FMEA curves to understand how best to manage power electronics assets across their whole life cycle.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

n/a

Success Criteria

This project will be deemed successful if:

1. The failure modes of these two types of converters are understood in more detail.

2. Failure curves or equivalent are produced for all the failure modes associated with each converter station.

3. If a RBM schedule can be developed for each converter type.

4. The outcomes of the work influence the maintenance policy for PE assets

According to Scope of Work, two specified work packages need to be completed on time with key deliverables as follows for it to also be considered successful:

- Project progress report for WP 1A and WP 1B (June, 2019).
- Project progress report for WP 2A and WP 2B (March, 2020).

Project Partners and External Funding

NA

Potential for New Learning

This project will allow all GB network licensees to follow the developed methodology for FMEA studies.

Scale of Project

This project scale was chosen as it covers the two main converter topologies that are of interest to the GB network. Other technologies are available from the market, but are not part of the planned works in the GB network.

Technology Readiness at Start

TRL2 Invention and Research

Technology Readiness at End

TRL3 Proof of Concept

Geographical Area

All the work will take place in desktop studies.

Revenue Allowed for the RIIO Settlement

None

Indicative Total NIA Project Expenditure

£340,000

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)

The project will serve as a first step towards building our understanding about risk based maintenance of power electronic assets and various failure modes and their impact. If the dependence on the supplier can be reduced for maintenance of power electronics based assets, it has a potential of savings of £200k per scheme during a ten-year maintenance period. There are already five existing PE schemes and at least 5 more planned PE schemes in GB transmission networks. Therefore, there is a huge potential for cost savings if dependency on supplier can be reduced by formulating a more independent maintenance strategy for PE assets.

Please provide a calculation of the expected benefits the Solution

N/A for R&D

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

The research outputs will have applicability to the new power electronics projects within the GB transmission networks.

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

This information can be shared with other licensees for the management of their power electronics based electrical assets. This information can be rolled out by adopting the same practices proposed from this work.

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

New or updated Maintenance Strategy, Policy and Specification(s) for PE-based systems;

Project reports, journal/conference publications, workshops.

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

Managing Assets - Managing assets throughout their lifecycle

☑ 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.

External peer review evidence confirmed no unnecessary duplication.

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

The deployment of power electronics assets is continuously increasing. The project will create value by helping the transmission owner to develop a more independent risk based maintenance strategy for power electronics assets. It has not been possible to use a risk based maintenance regime for these assets due to a lack of historic data.

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

Lack of experience with power electronics assets poses a greater risk for the maintenance of these assets. The safest option for the network licensee is to award full annual maintenance contracts to suppliers after the warranty period is over and not to do any R&D which has uncertain outcome. Clearly, it is not the most cost effective approach for the customers. The NIA funding offers the most appropriate route for NGTO to evaluate the possibility of risk based maintenance for power electronics assets.

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

There is a lack of operational data available to transmission owners for power electronics installations. Hence, the project will try to capture existing failure mode data through literature review and engagement with the suppliers. In absence of some of the data, a data extrapolation based on experience will be considered. This poses a technical risk to the successful outcome of this project because the success of FMEA and RBM methodology depends on the validation through actual historic data.

This project has been approved by a senior member of staff

☑ Yes