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

Mar 2017

Project Reference Number

NIA_UKPN0023

Project Registration

Project Title

Harmonic Effect on Network Assets (HENA)

Project Reference Number

NIA_UKPN0023

Project Licensee(s)

UK Power Networks

Project Start

March 2017

Project Duration

1 year and 4 months

Nominated Project Contact(s)

UK Power Networks - Steve Mould (steve.mould@ukpowernetworks.co.uk) and Maxi Faridi (Maxi.Faridi@ukpowernetworks.co.uk); Northern Powergrid - Roshan Bhattarai (Roshan.Bhattarai@northernpowergrid.com)

Project Budget

£441,000.00

Summary

The project will include the following tasks:

- A literature study into the deleterious effects of harmonics on various network assets (e.g. transformers) and their contributions to losses.
- Estimation of cost benefit of harmonic management/reinforcement versus harmonic levels.
- Testing at the Power Networks Demonstration Centre (PNDC) a selection of network assets, such as distribution transformers, to observe performance issues identified in the literature review at various levels of harmonics, which will be injected in the LV and 11kV network of the PNDC.
- Reconciling the observed results against the above modelling
- A guidance document on harmonic effects on various assets / equipment will be published.
- Utilisation of asset design documentation to model/estimate heating, life-cycle effects of power quality and power loss.

Nominated Contact Email Address(es)

innovation@ukpowernetworks.co.uk

Problem Being Solved

DNOs' current understanding of harmonics is limited to the procedures specified in engineering recommendations such as ER G5/4-1. That document, and those supporting it such as Engineering Technical Report 122 and G97, identify how network assessment should

be undertaken and the limits that should be applied. What these documents do not explain are the risks and costs for both the DNO and their customers associated with exceeding the harmonic limits.

Reinforcing the network to tackle power quality (PQ) issues carries significant costs and in some instances may be the only solution available to minimise harmonic distortion. Adding harmonic filters where required can introduce additional issues such as change in the harmonic resonance of the circuit to which they are applied; effectively solving one problem whilst creating others. Understanding the impact of harmonics on network equipment and losses will help DNOs make informed decisions on how they wish to operate their networks and manage harmonic issues. It will also highlight the areas on the network they should prioritise for circuits most effected by harmonics and inform how reinforcement budgets may be most effectively utilised.

A revision to G5/4-1 is currently underway which will reassess the planning limits stated within the document and also places a requirement on DNO to measure to the 100th harmonic. The ability to measure the 100th harmonic is subject to debate, as most voltage transformers (VTs) will not respond above 20th harmonic order. Given the costs associated with meeting this requirement it is envisaged that the work undertaken as part of this project will help to support whether measurement to 100th harmonic is necessary. The learning is also likely to be of interest to the G5/4-1 working group as it will validate (or otherwise) the planning limits that are published within the revised document.

Method(s)

This project will establish the effects of varying levels of power quality on a selection of important network assets/equipment in-terms of power-losses/heating, malfunction and operational-life. The effect on customer's equipment such as transformers will also be considered, to understand the extent to which the gap between planning levels and compatibility levels can be narrowed without degradation to lifetime or functionality of this equipment. Further, where applicable, the project will examine the potential effect of customer equipment on harmonic attenuation/amplification

Scope

The project will include the following tasks:

- A literature study into the deleterious effects of harmonics on various network assets (e.g. transformers) and their contributions to losses.
- Estimation of cost benefit of harmonic management/reinforcement versus harmonic levels.
- Testing at the Power Networks Demonstration Centre (PNDC) a selection of network assets, such as distribution transformers, to observe performance issues identified in the literature review at various levels of harmonics, which will be injected in the LV and 11kV network of the PNDC.
- Reconciling the observed results against the above modelling
- A guidance document on harmonic effects on various assets / equipment will be published.
- Utilisation of asset design documentation to model/estimate heating, life-cycle effects of power quality and power loss.

Objective(s)

The aims of the project are to:

- Understand the impact of harmonics on network assets;
- Estimate the cost benefit of harmonic management/reinforcement versus harmonic levels; and
- Validate the above using testing where possible.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

n/a

Success Criteria

The project will be deemed successful if:

- The impact of harmonics on network assets (limited to those assets assessed in the project) is quantified;
- It provides evidence to review the applicability of existing harmonic planning levels and determine the risk associated with exceeding them; and
- A guidance document on the effect of harmonics on various assets/equipment, including losses, has been published.

Project Partners and External Funding

n/a

Potential for New Learning

n/a

Scale of Project

The project is being carried out initially as a literature review followed by experimental work at the PNDC. Some online network assessments are likely to be carried out at a limited number of sites which is not confirmed at this stage.

Technology Readiness at Start

TRL1 Basic Principles

Technology Readiness at End

TRL3 Proof of Concept

Geographical Area

Testing the impact of harmonics on network assets will primarily be at the PNDC. Locations for online network assessments are to be determined during the project.

Revenue Allowed for the RIIO Settlement

There is no expenditure in the RIIO-ED1 settlements associated with this work.

Indicative Total NIA Project Expenditure

UK Power Networks: £225k
Northern Powergrid: £216k

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)

Studies have estimated that the cost of poor PQ to the overall EU economy as high as €150Bn pa. (R. Targosz & J.Manson,"Pan European LPQI PQ Survey",CIRED 2007. Available online at: leonardo-energy.org/webfm_send/165)

Increasing penetration of distributed generation (DG) and power electronic-driven loads are causing a proliferation of harmonics. This research project provides foundations to better understand this problem.

Please provide a calculation of the expected benefits the Solution

This is a research project and as stated in the NIA governance document section 3.19, there is no detailed cost benefit analysis required due to low TRL and insufficient information at this stage to carry out cost benefit analysis.

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

The methods being considered are not bespoke to UK Power Networks' or Northern Powergrid's assets and will be transferrable across other distribution licence areas.

The project will provide insight to whether the planning and compatibility limits are still valid. The outputs of this project will feed directly in to the G5/5 working group to provide evidence as to whether the limits should be subject to change. Increasing the harmonic levels at which DNOs operate their networks could provide reinforcement cost savings where power quality is the reinforcement driver.

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

G5/5 suggests increasing the harmonic orders that are considered up to the 100th order. There is currently uncertainty whether this frequency range can be measured accurately. This project will help to understand the possibilities and limitations associated with this measurement. It will also provide insight into whether it's necessary to measure to this harmonic order. Most DNOs' existing equipment is not capable of measuring these frequencies and replacement of existing equipment would carry significant costs.

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

All DNOs are impacted by power quality issues and follow the same industry guidance. Any learning generated by this project will be applicable to all DNOs. With the transition to a Distribution System Operator (DSO), and the increased usage of Low Carbon Technologies (LCTs) such as distributed generation, electric vehicles and heat pumps that can present potential power quality issues, the knowledge gained is likely to be very relevant.

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.

n/a

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