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 2016

### Project Reference Number

NIA_SPT_1610

## Project Registration

### Project Title

Innovative Approach for Transmission Harmonics Issues

### Project Reference Number

NIA_SPT_1610

### Project Licensee(s)

SP Energy Networks Transmission

### Project Start

January 2017

### Project Duration

2 years and 1 month

### Nominated Project Contact(s)

Eric Brunger, Elena Chalmers

### Project Budget

£195,000.00

### Summary

Five main work packages will be implemented in this project.

**WP1: Develop Grid Model**

The existing grid models will be extended to add the wind farms to evaluate various operational events. This will allow the harmonic emissions for each windfarm to be estimated and reported upon.

**WP2: Harmonic Impedance Scans**

The main busbars will be monitored using impedance frequency scans, and the findings will inform simulations run on grid assets to identify both short- and long-term issues and concerns. This will allow a number of filters to be developed and their efficacy evaluated.

**WP3: Developing Harmonic Limits**

Frequency scans will be carried out at the coupling for each wind farm, and the results compiled into a technical report.

**WP4: Detailed Harmonic Filter Designs**

The outcomes of WP2 and WP3 will be used to inform the final technical specifications for the harmonic filters for each location. The results of this design will be compiled into a report.

**WP5: Performance Review**

Over an extended period, the performance of the harmonic filters will be monitored and compared to the simulation results. Any discrepancies will be noted and investigated to identify the issues that may be causing it. If any major discrepancies are found, the filters' paramaters may be redesigned.

## Third Party Collaborators

Electric Power Research Institute

WSP UK Limited

## Nominated Contact Email Address(es)

innovate@spenergynetworks.co.uk

## Problem Being Solved

This is the second stage of a project looking at harmonic filters on the transmission network. This follows on from a feasibility study (NIA_SPT_1506) which looked at the optimisation of the location and size of harmonic filters across a section of the network in a co-ordinated manner.Harmonic Filtering has been previously looked after by individual developers, and this project will make good contribution so that customers can made reduced investment to safeguard the quality and standards of electricity supply.

SPEN is currently developing an extensive network in South West Scotland for the connection of a number of windfarms.The harmonic performance of this network has to be evaluated with the aim of:

a) Developing a coordinated, efficient and cost-effective harmonic filtering solution.
b) Setting harmonic emission limits for each windfarm.
c) Substantially reducing the risk of harmonic non-compliance for both SPEN and windfarm developers.
The extensive use of cables in the transmission and windfarm networks indicates a risk of lower-order harmonic resonances in the network. It is expected that the high resulting voltage gain factors will dictate the installation of a number of harmonic filters, even if the background harmonics in the existing network are within acceptable limits and the harmonic emissions from the windfarms are low. An optimised harmonic filtering solution may require installation of filters on the transmission network and/or the windfarm connection points.

It must be pointed out that some uncertainties around the final configuration of the network exist: Some generators may not go ahead with their connections or change the total power output of their windfarms. Further, the extent of the windfarm cabling on the various windfarms is unknown.

## Method(s)

SPEN will undertake a Harmonic study, which will lead to the development of a Harmonic filtering solution. This solution will be revewed and refined, if necessary. Each windfarm to be connected will be assessed and have a harmonic specification prepared, and the existing background harmonic measurements will be assessed. Finally, a technical specification for the harmonic filters will be prepared. While this project is carried out in the trial area (South-west Scotland), the outcome and specification will have direct impact on transmission reinforcement and planning.

## Scope

Five main work packages will be implemented in this project.

**WP1: Develop Grid Model**

The existing grid models will be extended to add the wind farms to evaluate various operational events. This will allow the harmonic emissions for each windfarm to be estimated and reported upon.

**WP2: Harmonic Impedance Scans**

The main busbars will be monitored using impedance frequency scans, and the findings will inform simulations run on grid assets to identify both short- and long-term issues and concerns. This will allow a number of filters to be developed and their efficacy evaluated.

**WP3: Developing Harmonic Limits**

Frequency scans will be carried out at the coupling for each wind farm, and the results compiled into a technical report.

**WP4: Detailed Harmonic Filter Designs**

The outcomes of WP2 and WP3 will be used to inform the final technical specifications for the harmonic filters for each location. The results of this design will be compiled into a report.

**WP5: Performance Review**

Over an extended period, the performance of the harmonic filters will be monitored and compared to the simulation results. Any discrepancies will be noted and investigated to identify the issues that may be causing it. If any major discrepancies are found, the filters' paramaters may be redesigned.

## Objective(s)

**WP1: Develop Grid Model**

A model of the Grid, incorporting  aggregated wind farm models, and a report detailing the assumptions of this model.

**WP2: Harmonic Impedance Scans**

Technical report to be generated detailing Frequency scan results, and filter solutions.

**WP3: Developing Harmonic Limits**

Technical report detailing the results of frequency scans per wind farm.

**WP4: Detailed Harmonic Filter Designs**

Technical report detailing the specification for each harmonic filter.

**WP5: Performance Review**

Final report collecting all progress to date, critical assessment of simulation accuracy with regard to measurements, and final conclusions on the project.

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

n/a

## Success Criteria

The delivery of the above objectives, within budget and within agreed timelines, as is reasonable depending on the knowledge at this stage of the development phase.

The project will be managed within SPEN applying due diligence and best practices where appropiate.

The staged outcomes will include reports and specifications available for other licencees.

## Project Partners and External Funding

n/a

## Potential for New Learning

n/a

## Scale of Project

This project covers the infrastructure investment requirements in the area to reinforce the existing network between 3 transmission substations in an area which is subject to high levels of generation connection requests. The combination of these factors aligns to it scaleability and typifies the issues caused by harmonics.

## Technology Readiness at Start

TRL3 Proof of Concept

## Technology Readiness at End

TRL6 Large Scale

## Geographical Area

This covers the South West of Scotland Network, in particular the double- circuit between Coylton 275kV and New Cumnock 275kV and extend to Tongland 132kV.

## Revenue Allowed for the RIIO Settlement

None

## Indicative Total NIA Project Expenditure

£95,000 (Including internal 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)

One of the issues caused by harmonics is voltage rise on the transmission network through increased reactive power. This can cause many problems on the transmission network that need to be mitigated either through reconductoring and reinforcement, or the use of other generation or power devices which will absorb the reactive power. Reducing the harmonics present on the network from wind farms will mitigate the need for this reinforcement or use of power devices. One conventional measure is to address this issue by individual wind farm developers. Such an approach may lead to duplication of investment.

The successful delivery of this project will represent a reduction in costs to the TO and, as such, represents improved value for the consumer.

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

N/A- research-based project.

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

All TO's face these issues on their transmission networks, particularly in areas where there are large numbers of wind farm connections or contacted wind farm connections.

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

The cost for rolling this out across GB is difficult to estimate at this stage. The technical specifications which will come from this project will help to reduce both the cost and time that developing a new filter system will take as both it and the monitoring carried out in the project will provide a framework for future designs.

## 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 Transmission Networks operators have these Harmonic issues and the learning from the preformance of the filter as per the final report will inform other TO's in Harmonic Filter design for Wind Farms.

While this project will be trialled in the South-west Scotland area, the result will be applicable for other licencees.

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

The transmission harmonics issues will be addressed.

☑ 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