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

Aug 2019

Project Reference Number

NIA_WPD_043

Project Registration

Project Title

Harmonic Mitigation

Project Reference Number

NIA_WPD_043

Project Licensee(s)

National Grid Electricity Distribution

Project Start

September 2019

Project Duration

2 years and 6 months

Nominated Project Contact(s)

Yiango Mavrocostanti

Project Budget

£425,375.00

Summary

The Harmonic Mitigation project will simulate a new solution for managing the harmonics in the network. This solution will consist of an algorithm which will be controlling existing inverters in order to improve harmonics.

Third Party Collaborators

Swansea University

Power Systems Consultants UK Limited

Problem Being Solved

It is expected that due to the increasing number of non-linear devices being connected to the distribution network, the harmonics in the network can become a challenge for Distribution Network Operators (DNOs). Existing solutions for managing harmonics are not suitable for dynamic networks with varying operating conditions or can be very expensive. Therefore, it is important to find alternative solutions in order to be able to manage harmonic levels in the network in a cost effective way.

Method(s)

The aim of this project is to develop an algorithm that can improve the network's harmonic levels by controlling existing Distributed Generation inverters and will be delivered by Swansea University. As part of this, a number of power system studies will be performed in order to develop, implement the algorithm and test its operation. The algorithm will also be tested in a simulated environment at a university laboratory. This project will provide recommendations as to whether a further project is recommended for the trial of the algorithm in the network. The technical work produced will be reviewed by Power Systems Consultants (PSC).

Scope

The project has been split into the following Work Packages:

- Work Package 1 – Literature Review, Model Creation and Base Studies: As part of this Work Package, a detailed literature review will be done on the already developed approaches to managing harmonics in the network and any algorithms that relate to the proposed approach in the Harmonic Mitigation project. Additionally, the MATLAB model of the network that will be analysed will be

created and validated. The base case harmonic studies will also be run in this Work Package, providing the reference that will be used to assess the algorithms impact on harmonic levels in the following Work Packages.

- Work Package 2 – Algorithm Design, Development and Implementation for single inverter control: This Work Package will involve the design and implementation of the algorithm that will be able to control each inverter individually.
- Work Package 3 - Algorithm Design, Development and Implementation for multiple inverter control: As part of this Work Package, the algorithm will be further developed so that it can control multiple inverters.
- Work Package 4 – Hardware In the Loop (HIL) Testing: In this Work Package, the developed solution will be used in order to demonstrate the operation of the algorithm on an actual inverter at a university laboratory. As part of this test, the model of the network used in Work Package 2 will be used to simulate the test network and an actual inverter will be connected to this simulated network. The operation of the algorithm and control of the inverter will then be tested.

Objective(s)

The main objectives of the project are:

- Completion of literature review on existing solutions for managing network harmonics.
- Creation of an algorithm that by controlling each inverter individually is managing the network's harmonics.
- Creation of an algorithm that by controlling all inverters in the network is managing the network's harmonics.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

n/a

Success Criteria

The project will be considered successful if:

- The developed algorithm can improve the harmonic levels when controlling one converter.
- The developed algorithm can improve the harmonic levels when controlling multiple inverters.
- The Hardware In the Loop testing confirms the correct operation of the algorithm and successful response from the inverter.
- Knowledge is gained on whether the harmonic levels in the network can be improved by controlling existing inverters.
- Conclusions are made on whether a demonstration project is recommended.

Project Partners and External Funding

Swansea University will complete all the Work Packages and Power Systems Consultants (PSC) will provide technical support by reviewing all deliverables and power system studies.

Potential for New Learning

The learning that will be generated in this project will be applicable by all UK DNOs since it will show through power system studies whether it is possible to manage the harmonics in the network using existing DG inverters. The design of the algorithm that will be developed and the final full code will be documented in the relevant reports and shared with all UK DNOs so that it can be studied on any other network.

Scale of Project

The project will involve a number of power system studies on one 33kV network in order to develop the algorithm and simulate its operation.

Technology Readiness at Start

TRL2 Invention and Research

Technology Readiness at End

TRL4 Bench Scale Research

Geographical Area

The 33kV network fed by Tiverton BSP will be used in the power system studies that will be done in this project.

Revenue Allowed for the RIIO Settlement

N/A

Indicative Total NIA Project Expenditure

£382,837.50.

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 is a research project and will provide an evaluation of the financial benefits of having alternative ways of managing network harmonics compared to existing solutions.

Please provide a calculation of the expected benefits the Solution

n/a

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

This project aims to show through power system studies whether the network's harmonics can be improved using existing network inverters and recommend whether a demonstration project of a replicable solution should be completed next.

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

n/a

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

The learning that will be generated in this project will be applicable by all UK DNOs since it will show through power system studies whether it is possible to manage the harmonics in the network using existing DG inverters. The design of the algorithm that will be developed and the final full code will be documented in the relevant reports and shared with all UK DNOs so that it can be studied on any other network.

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.

A Harmonic Mitigation algorithm has not been studied previously, therefore no duplication will occur as a result of this project.

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 project aims to develop an algorithm that can control existing Distributed Generation (DG) inverters in the network in order to improve the harmonic levels. If successful, it could provide an innovative solution for harmonic management that does not require expensive and bulky harmonic filters.

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

The TRL of the technology is low since a Harmonic Mitigation Algorithm has not been studied or implemented previously. Therefore,

further work is required before implementing this technology as part of business as usual activities.

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

This NIA project is necessary in order to provide the knowledge needed to decide whether an implementation trial of this technology is recommended. The algorithm needs to be developed and simulated in order to prove the concept before trialing.

This project has been approved by a senior member of staff

☑ Yes