Date of Submission

Feb 2018

# NIA Project Registration and PEA Document

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.

## Project Registration

**Project Title**

Primary Networks Power Quality Analysis

**Project Reference**

NIA_WPD_028

**Project Licensee(s)**

Western Power Distribution East Midlands, Western Power Distribution South Wales, Western Power Distribution South West and Western Power Distribution West Midlands

**Project Start Date**

March 2018

**Project Duration**

3 years and 0 months

**Nominated Project Contact(s)**

Jonathan Berry

**Project Budget**

£1,358,400

**Problem(s)**

The harmonic content of waveforms and power quality (such as flicker, voltage sags and swells, voltage unbalance) within the primary network is not routinely monitored at present. However, WPD is now required to publish harmonic data in order to facilitate LCT connections.

In addition, there is uncertainty that power quality (PQ) monitors are giving an accurate reflection of power quality and harmonics in different levels of the distribution network. This uncertainty arises from the transducers providing inputs to the monitors, rather than the monitors themselves.

The impact of power electronic devices on the harmonics and power quality of primary networks is currently uncertain. As more and more low carbon technologies (LCTs) are connected with power electronic inverters, the effects on the network, moving forwards, are increasingly unclear. In some situations, the interaction of devices may be constructive and reduce harmonic / power quality issues. In other situations, the devices may interact in a more destructive way. There is also uncertainty surrounding the localisation of harmonic / power quality issues and whether these issues will become more widespread.

Existing business practices use snapshots of PQ data for analysis (for example, a week of data is used to represent the entire year of network operation). The major drawback with this approach is that the data captured during the short monitoring period may not be truly representative of the worst-case network operating conditions, seen during other times of the year. In addition, current business practices are labour-intensive in terms of retrieving data from site and analysing the data. Moreover, current techniques do not give WPD full visibility of power quality / harmonics away from the LCT points of connection.

**Method(s)**

This project will build on existing best practice, overcoming the limitations outlined above, and evaluate how harmonics and power quality can be monitored and analysed in a cost-effective way across wide areas of the network. The core method for this project shall achieve this by: 1) installing communicating power quality monitors throughout two areas of primary network, and 2) through developing a system that automates power quality data retrieval and analysis tasks. The two areas of primary network will be selected so that comparisons can be made: one area will be chosen with a high penetration of LCTs, whereas the other area will be chosen with a low penetration of LCTs.

The core method is supported by several other activities:

Investigation of transducer characteristics for harmonics detection;

Selection of two contrasting areas for trial power quality monitor installations;

Creation and use of detailed models of the two areas for power quality and harmonics analysis;

Quantification of the harmonic contributions of different types of power electronic devices.

**Scope**

The project's scope consists of the following work packages:

Investigating transducers (VTs etc.) to confirm that harmonics are being passed through to power quality monitors without introducing further harmonics or eliminating them;

Selecting two areas of WPD's network (BSPs through to the LV side of Primary substations) for comparative assessments of harmonics and power quality. One area will be selected as a 'control' case with a low penetration of LCTs, whereas the other area will have a high penetration of LCTs;

Creating detailed models of the two areas for power quality and harmonics analysis;

Installing communicating power quality monitors within the two areas to generate data for comparison with the models. Also, comparing co-located power quality monitors with each other for consistency of results;

Generating power quality heat maps and decision support tools, including the modelling of future impacts of LCTs (with a 2030 horizon) based on sources such as WPD and DECC future energy scenarios;

Quantifying the harmonic content contribution of different types of power electronic devices and creating a series of templates for use in future analysis; and

Automating data retrieval and analysis tasks, which are currently manual and time-intensive, to allow valuable engineer resource to be used more effectively.

**Objectives(s)**

The objectives of this project are to:

Understand the power quality / harmonics impact of LCTs throughout primary networks in a systematic way;

Understand the behaviour of PQ monitoring transducers in a systematic way;

Automate power quality / harmonics data retrieval and analysis processes;

Develop a decision support tool for modelling and forecasting harmonic / PQ effects

**Success Criteria**

Impact of LCTs on power quality and harmonics within primary networks better understood;

Power quality monitors installed at trial locations and remote retrieval of data successfully demonstrated;

Tools for automating power quality data retrieval and analysis demonstrated;

Policies created to implement project outputs in WPD's business.

**Technology Readiness Level at Start**

TRL 5

**Technology Readiness Level at Completion**

TRL 8

**Project Partners and External Funding**

Nortech Management Limited – Project Delivery Support and provider of power quality monitor interface devices, monitoring platform, and software development.

**Potential for New Learning**

Understanding of how LCTs impact on waveform harmonics, not just at the point of connection but across the network;

Understand the extent to which systems can be put in place to automate power quality / harmonics data retrieval and analysis;

Understand transducer characteristics with respect to detection of harmonics.

**Scale of Project**

The project will encompass two BSPs and downstream infrastructure, covering, per BSP:

The 33 kV side of the BSP.

All the Primaries downstream of the BSP.

- At one or two Primaries, two PQ monitors of different types will be installed to allow comparison of their results.

- At one or two Primaries, PQ monitors will be installed at both 33 kV and 11 kV, where it is technically feasible to do so. This will give full visibility of harmonic currents passing through the Primary transformers and enhance the validation of the harmonic network models.

One or two distribution substations.

One or two customer connection points embedded within the network, such as generation sites with inverter-connected generation. Monitoring will be installed on WPD's side of the point of connection.

One BSP (and downstream network) will be used as the 'control' case i.e. it will be selected based on limited LCT integration to date, to give a good indication of the current state of harmonic pollution and power quality.

The other BSP (and downstream network) will be selected based on higher levels of LCT integration, so that the impact of LCTs on harmonic pollution and power quality can be measured.

**Geographical Area**

The project will take place in WPD's West Midlands licence area.

**Revenue Allowed for in the RIIO Settlement**

None

**Indicative Total NIA Project Expenditure**

£1,222,560

## Project Eligibility Assessment

**Specific Requirements 1**

**1a. A 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 the GB the Network Licensee must justify repeating it as part of a Project) equipment (including control and communications systems and software) [X]

A specific novel arrangement or application of existing licensee equipment (including control and/or communications systems and/or software) [X]

A specific novel operational practice directly related to the operation of the Network Licensee's System [ ]

A specific novel commercial arrangement [ ]

**Specific Requirements 2**

**2a. Has the Potential to Develop Learning That Can be Applied by all Relevant Network Licensees**

**Please explain how the learning that will be generated could be used by relevant Network Licenses.**

N/A

**Please describe what specific challenge identified in the Network Licensee's innovation strategy that is being addressed by the Project.**

The project will address the specific challenge of Primary Network Power Quality Analysis, as identified in Section 6.9.16 of WPD's Innovation Strategy.

**2b. Is the default IPR position being applied?**

| | |
|---|---|
| Yes | X |

**2c. Has the Potential to Deliver Net Financial Benefits to Customers?**

| | |
|---|---|
| Yes | X |

**Please provide an estimate of the saving if the Problem is solved.**

If successful, the project should result in savings of £3k - £27.2k per monitored site, which, if rolled out across GB would lead to savings of £2.5m - £22.8m.

**Please provide a calculation of the expected financial benefits of a Development or Demonstration Project (not required for Research Projects). (Base Cost - Method Cost, Against Agreed Baseline).**

This project will implement a monitoring and analysis system for assessing the Power Quality and harmonic content of waveforms in Primary Networks, reducing uncertainties and facilitating increased integration levels of LCTs.

**Base case cost: £8.5k - £32.7k per monitored site**

Typically, it takes an engineer 1 day, on average, to travel to site, install power quality monitoring equipment and confirm that the equipment has been configured correctly. In order to gain the same level of visibility as the proposed Method, the engineer would need to make 52 – 104 further visits to site to collect the data (based on one visit per week or per fortnight over a two-year period). When the equipment is re-deployed, it takes the engineer a further ½ day to return to site and decommission the equipment. Moreover, due to the amount of data involved, it can take days of effort for the engineer to manipulate the data and extract value from it.

The total number of man-days per site is 28.5 – 54.5. With engineering time costing £300/day (internal resources) or £600/day (contracted, due to resource limitations) the cost per site of achieving full PQ visibility is £8,500 - £32,700.

The base case approach does not scale well, particularly if resources are limited. For the 28 sites within scope of this project, the base case approach would cost £238,00 to £915,600.

**Method cost: £5.5k per monitored site**

The novel Method is to install communicating PQ monitors and develop software to automate the labour-intensive elements of the data analysis process. With remote communications, the PQ monitor installation can be validated remotely and re-configured (if required) remotely. This reduces commissioning time from 1 day per site to ½ day per site.

The major benefit of the Method is designing out the need for site visits to retrieve the data and using software to automate labour-intensive processes. On this basis, need for any further site visits can be completely eliminated, as can the need for expending time to manipulate the data (because this is done automatically by the software).

This approach is scalable and gives WPD much more flexibility when gather data for PQ assessments. The Method cost is £154,000 (i.e. £5.5k per site, based on 28 sites monitored over 2 years).

**Financial benefit: £3k - £27.2k per site**

The financial benefit ranges from £3k per site (fortnightly site visits and low cost of resources in base case) to £27.2k per site (weekly site visits and high cost of resources in base case), based on a two-year monitored period.

**Please provide an estimate of how replicable the Method is across GB in terms of the number of sites, the sort of site the method could be applied to, or the percentage of the Network Licensees system where it could be rolled-out.**

Using a conservative estimate that the Method is adopted at 60 primaries per DNO licence area (representing those with the highest penetrations of inverter-connected LCTs), based on the 14 DNOs within GB, the Method could be replicated across 840 sites.

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

Based on rolling out the Method at the 840 sites described above, the replication cost would be approximately £4.6m. This would lead to savings of £2.5m - £22.8m across GB.

**2d. Does not Lead to Unnecessary Duplication**

Yes X

**Please demonstrate below that no unnecessary duplication will occur as a result of the Project.**

No other GB DNO project is investigating the same problem and method proposed in this project. Other projects exist that have some elements of power quality / harmonic monitoring and analysis, but none of these focus on increasing visibility of power quality in primary networks and in particular the impact of increasing LCT penetrations.

**If applicable, justify why you are undertaking a Project similar to those being carried out by any other Network Licensees.**

N/A

## Additional Governance Requirements

**Please identify**

that the project is innovative (ie not business as usual) and has an unproven business case where the risk warrants a limited Research and Development or Demonstration Project to demonstrate its effectiveness X

**i) Please identify why the project is innovative and has not been tried before**

The key innovative aspects of this project are the development and use of communicating power quality monitors, the wide-area deployment of these within primary electricity networks to provide comprehensive visibility of power quality in those networks, and developing processes to automate the analysis of the power quality data that is gathered. Other innovative elements include evaluating the accuracy of transducers used for capturing power quality data and the comparison of different monitoring units. Power quality is more of an issue now than it was in the past due to the changing nature of the devices that are now connected in to the network, as many LCTs use power electronics to interface with the electricity network. So now there is a need to better understand power quality issues in the network and this project aims to provide some of that understanding.

**ii) Please identify why the Network Licensee will not fund such a Project as part of its business as usual activities**

If the project is successful the benefits from exploiting the method could be significant; however, the method and the benefits are as-yet unproven, so therefore would not be considered for funding through business as usual.

**iii) Please identify why the Project can only be undertaken with the support of the NIA, including reference to the specific risks (eg commercial, technical, operational or regulatory) associated with the Project**

As noted above, the method and benefits of this project are so far unproven so therefore an R&D project funded through the NIA is the appropriate route for testing. Although individual elements of the method are proven – for example, non-communicating power quality monitors, and the data collection and monitoring platform – they have not been brought together and this presents several risks: • The technical risk of interfacing together equipment from several different suppliers that have different communications protocols. • The technical risk of installing and integrating new equipment in to existing substations. • The technical risk of developing automated power quality analysis tools. • The commercial risk of funding an as-yet unproven method with as-yet unproven benefits

**Approved by senior member of staff**