WESTERN POWER DISTRIBUTION
Serving the Midlands, South West and Wales

Date of Submission

September 2015

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	Project Reference
Voltage Reduction Analysis	NIA_WPD_010

Project Licensee(s)	Project Start Date	Project Duration
Western Power Distribution East Midlands, Western Power Distribution South Wales, Western Power Distribution South West, Western Power Distribution West Midlands	Sep 2015	9 Months

Nominated Project Contact(s)	Project Budget
Matthew Watson - WPD Innovation & Low Carbon Engineer	£167,300

Problem(s)

LV voltages must be kept between the statutory limits of 230V + 10% or - 6% (253.3V-216.2V). With minimal active voltage control beyond the 33/11kV transformers and designs based on demand dominated networks, the voltages are generally set as high as possible to account for voltage drop along the network and ensure that voltages never drop below the limits.

However reducing network voltage can have significant benefits, particularly where there is a large concentration of resistive loads. For these types of loads reducing the voltage will reduce the maximum demand requirements and, depending on the control mechanism, can also reduce the consumption.

The magnitude of the reaction to the reduction depends on the specific make-up of the network load. As this is generally unknown there are various wide ranging estimates, going from consumption dropping by the square of the reduction to no drop at all.

With such uncertainty it is important to quantify the reactions of consumption, maximum demand and voltage profiles to voltage drop to allow network licensees to implement voltage reductions and pass on the benefits to customers.

Method(s)

Initial analysis of voltage profiles in South Wales was conducted as part of the Low Voltage Network Templates (LVNT) tier 2 LCNF project. This showed that voltages at both substations and feeder ends sat at the higher end of allowable range, with very few (only 0.015%) measurements below the statutory limits. As such a program of voltage reduction was carried out in the area covered, altering the Automatic Voltage Control (AVC) settings at the 33/11kV transformers. These were shifted from a target of 11.4kV (±200V) to 11.3kV (±165V), approximately 0.88%
Following this reduction the South Wales Voltage Reduction IFI project was run to assess the effect of this change. Using the data captured by the LVNT monitoring equipment a statistically significant change was detected on the corresponding dates and it was seen that the reduction in voltage had caused a 1.5% reduction in consumption.

Whilst this shows that small voltage reductions can have a large effect on consumption, the analysis was limited by the data available at the time and leads to many additional questions.
The analysis only covered approximately 1 month following the reduction, January 2015, and so questions about the effects of time and seasonality couldn't be answered. Furthermore the effect of substation make up was not addressed nor the effect of the change

on Maximum demand.

As such this project seeks to follow up this promising IFI project with a much fuller analysis on a more complete data set. This should help us to quantify the effects of reducing network voltages in a more detailed manner.

Scope

This project has no operational element as the monitoring equipment is already in place. The University of Bath shall analyse the large database of voltage current and power measurements for the area. This will include whole year of data following the voltage change.

The detailed areas to be assessed are:

- The effect of seasonality on consumption reduction
- The effect of customer make up on consumption reduction
- The effect of seasonality on demand reduction
- The effect of customer make up on demand reduction
- The effect of the 11kV voltage reduction on LV voltage profiles
- The effect of temporary voltage reduction on demand and consumption (investigate the effects of National Grid's operation Juniper on our monitored network).

Objective(s)

The objective of this project is to refine our estimates on the effects of voltage reduction on consumption, demand and voltage profiles.
By understanding the effects of key parameters current predictions can be improved and the benefits better understood. The assessment of existing profiles should also indicate the available scope for further reduction.

Success Criteria

There are multiple success criteria:

- Quantify the effect of seasonality, time and substation type on consumption reduction
- Quantify the effect of seasonality, time and substation type on Maximum demand reduction
- Quantify the effect of 11kV voltage reduction on LV substation and feeder end voltage distributions
- Refined estimate of the benefits of voltage reduction as well as the scope for further reduction

Technology Readiness Level at Start	Technology Readiness Level at Completion
6	8

Project Partners and External Funding

University of Bath: the UoB have extensive experience in this area having worked with WPD on both the LVNT project and the South Wales Voltage reduction IFI report. They currently hold the data base required for the analysis and have extensive experience manipulating it.

Potential for New Learning

This project will help to qualify and quantify the findings of the previous projects. By better understanding the effects of voltage reduction on different substations at different times of year, further reductions could be implemented and more benefits delivered to customers.

Scale of Project

The project will use existing monitoring equipment installed as part of the LVNT project. This consists of approximately 800 substations and 3600 feeder end monitors. The existing database contains over half a billion data points, with over 3 years of data. We aim to analyse a full year's data following the voltage reductions to better understand effects such as seasonality.

Geographical Area

The geographical area is identical to that covered by LVNT. This covers a large part of South Wales, extending as far west as Llanelli and as for north as the Brecon Beacons national park.

Revenue Allowed for in the RIIO Settlement

Nil

Indicative Total NIA Project Expenditure

£150,570

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 GB the Network Licensee must justify repeating it as part of a Project) equipment (including control and communications systems and 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	☐

Specific Requirements 2

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

Please answer one of the following:

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

This project aims to quantify the reduction in demand and consumption that can be expected from a long term reduction in 33/11kV AVC settings.
All quantification will be made against data that is readily available to all network licensees.
This would allow DNO's to reassess their 11kV voltage settings to maximise these benefits whilst incorporating their individual network topologies.

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

2b. Is the default IPR position being applied?

Yes	☒
No	☐

If no, please answer i, ii, iii before continuing:

i) Demonstrate how the learning from the Project can be successfully disseminated to Network Licensees and other interested parties

ii) Describe any potential constraints or costs caused or resulting from, the imposed IPR arrangements

iii) Justify why the proposed IPR arrangements provide value for money for customers

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

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

Each network may choose to enact different levels of reduction depending on their specific network topology.

However if the 0.88% reduction were implemented across Great Britain and the 1.5% reduction in consumption was valid across the year then the total GB consumption (289,976GWh, DUKES 2015) would reduce by 4349.64GWh.

By using the Domestic and Industrial/Commercial split for GB from DUKES (108,420 GWh Domestic, 181,556 GWh Industrial/commercial) and standard unit costs from DECC's Quarterly Energy Prices July 2015 (15.53/kWh for Domestic and 9.55 p/kWh for industrial and commercial) the value of this reduction from customer bills is approximately £511 million per year.

ii) 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).

For the demonstration project the voltage was reduced by 0.88% over South Wales. Using a similar methodology to above the base cost of current energy bills in South Wales is: £1.067 billion. The method cost involved a reduction by 1.5% and hence has a value of £1.051 billion. The Financial benefit is therefore approximately £18.7 million.
Base cost – Method cost = financial benefit,
£1.067 billion- 1.051 billion = £18.7 million

iii) 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.

Reducing voltage settings would be possible across all UK sites however the scale of the reduction would depend on network topology. On long heavily loaded feeders the voltage drop across the LV may allow for very little reduction. Inversely lightly loaded feeders may be able to accommodate significant long term drops. The additional analysis we will conduct on the effects on voltage profiles will help to clarify this.

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

Reducing voltage via changes in AVC setting is a very simple task. All it requires is the visit of trained personnel to site to adjust the relay. This should take no more than 1 man-day per site. With approximately 4800 primary substations across the UK this should take approx. 4800 man days.

2d. Does Not Lead to Unnecessary Duplication 

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

This project will deepen the learning gained from previous projects and enhance our understanding of the effects of voltage reduction. The aim is to follow on from existing project s and use the existing infrastructure to gain further learning at minimal costs.

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

As mentioned above this project follows on from the LVNT tier 2 LCNF project and the South Wales voltage reduction analysis IFI report. These have established valuable base knowledge that we are looking to deepen. The effects of voltage reduction on maximum demand has also been investigated by ENW's CLASS however this was in response to a short term reduction rather than a long term setting change. Both projects look at voltage reduction but with a view to different implementation.