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

Jun 2016

Project Reference

NIA_SSEPD_0029

Project Registration

Project Title

11kV power electronics providing reactive compensation for voltage control

Project Reference

NIA_SSEPD_0029

Project Licensee(s)

Scottish & Southern Electricity Networks

Project Start

June 2016

Project Duration

4 years and 4 months

Nominated Project Contact(s)

SSEN Future Networks Team

Project Budget

£732,000.00

Summary

To show that the new power electronic reactive compensation unit can be deployed across a range of locations and to deal with a range of potential voltage problems.To show over a period of between 18 months and 2 years of on site operation that the new units reliably improve the voltage profile seen by our customers both in terms of absolute voltage, and the magnitude of apparent voltage changes.The device will be tested at the Power Networks Demonstration Centre (PNDC) in Cumbernauld. This will ensure that it can operate over the full voltage, and frequency envelope it is designed for. This testing is important as these extreme events are unlikely to occur very often, if at all, on our normal network. However the capability of the electronic reactive compensation unit to operate under these unusual conditions to maintain voltage is very important. The equipment supplier has developed the device and will own all the associated Intellectual Property. Scottish and Southern Energy plc will develop installation methods and the communications required to allow the device to be integrated into our overall voltage control system. All development carried out by SSEPD will be shared with other DNOs
Power quality monitoring will be carried out at each site before and after installation, to ensure that harmonic emissions are within acceptable limits. We will also check that the device does not result in noticeable flicker due to rapid voltage changes.

We will deploy three units on different network types to tackle different problems.

1. A network with a large wind turbine and several smaller wind turbines where there are problems with the voltage rising too high at times of low load and high wind output.2. A network where the existing voltage control methods, result in a large range of voltages presented to customers. For the particular circuit where a trial unit is to be installed, these are automatic tap changers on 132/33kV transformers, fixed tap 33/11kV transformer, and an 11kV voltage regulator several miles away from the fixed tap transformer. The overall source impedance of the network is so high that step changes in load result in large changes in voltage. The high speed operation of the device should result in smaller apparent voltage changes to customers.3. A network with a large PV farm and several

smaller PV installations where there are potential problems with the voltage rising too high at times of low load and high PV output.

Nominated Contact Email Address(es)

fnp.pmo@sse.com>

Problem Being Solved

Rural areas of GB are supplied by networks which often experience large voltage changes. These are a consequence of changing customer loads or generation output in the network. When these changes take place in a network with a high source impedance they result in noticeable changes in voltage. The voltage can in some cases go outside of the statutory limits. At low voltage these are 230v plus 10% to minus 6% or from 253 volts down to 216.2 volts.

There are several ways to tackle this problem as follows.

1. Reduce the source impedance by installing larger transformers, cables and overhead lines.
2. Install voltage regulators to increase or decrease the voltage.
3. Install reactive power compensation equipment to increase or decrease the reactive power flowing in a network. Reactive power can have a significant effect on the voltage. Typically generating reactive power at the remote end of a circuit will boost voltage and absorbing reactive power will reduce voltage. If there is only one requirement then capacitors can be used to boost voltage. Shunt reactors can be used to reduce voltage.

A range of manufacturers have produced power electronic reactive power compensation units, these can be used to both create reactive power like a capacitor, or to absorb reactive power like a shunt reactor. The power electronics in these devices typically operate at 400 to 480 volts and at the smallest end of the range are directly connected to LV networks. Where connection is required to high voltage networks this is carried out using suitable interposing transformers. Typically the power electronics require cooling, which is usually carried out by blowing air through the unit with a fan. For larger units the air may be cooled using an air conditioning system.

Power electronic reactive power compensation units have several advantages over fixed capacitors and shunt reactors.

• Firstly they can be fitted with very fast acting control systems which can correct voltages so quickly that customers do not notice that they have operated.
• Secondly they can be controlled to provide small steps in output to closely match the required reactive power to that required to keep a constant voltage on the network.
• Thirdly they can continue to provide reactive voltage support during both voltage and frequency deviations from normal.

The currently available power electronic reactive power compensation units have the following disadvantages

• Firstly, they need an interposing transformer to allow connection an HV network
• Secondly, the cooling system is noisy, and can be unreliable
• Thirdly, overall cost of ownership tends to be high.

Method(s)

A technical method is proposed. This involves the deployment of a newly developed power electronic reactive power compensation unit, of a novel design which operates with a direct connection at 11kV. This may eliminate most of the issues noted above with current products

• The device uses power electronics connected directly at 11kV hence eliminating the expense of an interposing transformer between low voltage power electronics and the high voltage network. By removing the transformer the overall weight is reduced considerably. A device with a rating of +-1MVAr can be mounted in three tanks. These along with a control box, and external HV switches can be mounted on a wood pole structure comprising two poles. This type of arrangement is often used for 100kVA and 200kVA transformers.
• In addition, cooling is done passively using an oil based cooling liquid. This eliminates the need for fans, air filters etc which both reduces noise and eliminates lots of components which are prone to failure. The cooling liquid is based on a vegetable oil. In the unlikely event of a leak the liquid is biodegradable. The liquid also has a relatively high flash point reducing the risk of fire should the tank be ruptured.

The device will be tested at the Power Networks Demonstration Centre (PNDC) in Cumbernauld. This will ensure that it can operate over the full voltage, and frequency envelope it is designed for. This testing is important as these extreme events are unlikely to occur very often, if at all, on our normal network. However the capability of the electronic reactive compensation unit to operate under these unusual conditions to maintain voltage is very important. The equipment supplier has developed the device and will own all the associated Intellectual Property. Scottish and Southern Energy plc will develop installation methods and the communications required to allow the device to be integrated into our overall voltage control system. All development carried out by SSEPD will be shared with other DNOs

Scope

To show that the new power electronic reactive compensation unit can be deployed across a range of locations and to deal with a range of potential voltage problems.
To show over a period of between 18 months and 2 years of on site operation that the new units reliably improve the voltage profile seen by our customers both in terms of absolute voltage, and the magnitude of apparent voltage changes.
The device will be tested at the Power Networks Demonstration Centre (PNDC) in Cumbernauld. This will ensure that it can operate over the full voltage, and frequency envelope it is designed for. This testing is important as these extreme events are unlikely to occur very often, if at all, on our normal network. However the capability of the electronic reactive compensation unit to operate under these unusual conditions to maintain voltage is very important. The equipment supplier has developed the device and will own all the associated Intellectual Property. Scottish and Southern Energy plc will develop installation methods and the communications required to allow the device to be integrated into our overall voltage control system. All development carried out by SSEPD will be shared with other DNOs

Power quality monitoring will be carried out at each site before and after installation, to ensure that harmonic emissions are within acceptable limits. We will also check that the device does not result in noticeable flicker due to rapid voltage changes.

We will deploy three units on different network types to tackle different problems.

1. A network with a large wind turbine and several smaller wind turbines where there are problems with the voltage rising too high at times of low load and high wind output.
2. A network where the existing voltage control methods, result in a large range of voltages presented to customers. For the particular circuit where a trial unit is to be installed, these are automatic tap changers on 132/33kV transformers, fixed tap 33/11kV transformer, and an 11kV voltage regulator several miles away from the fixed tap transformer. The overall source impedance of the network is so high that step changes in load result in large changes in voltage. The high speed operation of the device should result in smaller apparent voltage changes to customers.
3. A network with a large PV farm and several smaller PV installations where there are potential problems with the voltage rising too high at times of low load and high PV output.

Objective(s)

1. Determine the operational requirements of the device and the standards that it should be constructed to.
2. Confirm that the device meets the construction standards.
3. Establish a safe connection methodology for both overhead line, and ground mounted variants of the device.
4. Determine, by testing, that the device meets the operational specifications.
5. Install two pole mounted and one ground mounted device on the distribution network.
6. Monitor the effects on the network by comparing voltage profiles from before and after the installation of the devices.
7. Confirm that the device is reliable in service, and across a range of weather conditions, and determine the cost of maintenance.
8. Determine the suitability of the method for business as usual deployment

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

n/a

Success Criteria

This project will be successful if we are able to determine the ability of the devices to maintain the voltage within statutory limits and to reduce apparent step changes in voltage.

Project Partners and External Funding

None

Potential for New Learning

This project has the potential to provide learning about
- The application of power electronic reactive compensation units of about +-1MVAr to manage the voltage on long 11kV networks

- Reduction in costs and weight by the application of electronics directly connected at the 11kV voltage level
- Learning from the project will be disseminated by presenting at the LCNI conference and at a directly arranged dissemination event arranged for other DNOs and other interested parties.

Scale of Project

The scale of this project is required to ensure that a range of networks experiencing different issues are dealt with.
• Voltage variations from PV generation,
• From Wind generation
• From changes in load have different characteristics.
In addition the scope of the project will allow us to evaluate different connection methodologies for overhead line and under ground cable networks.
All this learning would not be possible with a smaller scale project.

Technology Readiness at Start

TRL6 Large Scale

Technology Readiness at End

TRL9 Operations

Geographical Area

Highland Region within SHEPDs licenced network area, two sites.
North West Region within SEPDs licenced network area, one site.

Revenue Allowed for the RIIO Settlement

None

Indicative Total NIA Project Expenditure

£732,000 90% (£658,800) of which is allowable NIA 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)

For the SHEPD and SEPD areas over the period from 2018/19 to the end of RIIO ED1 we expect that 10 cable overlays and 5 overhead line rebuilds of 11kV circuits can be avoided by installing 15 of these units.
The Base cost of these projects is £5,365,000 - Method cost of £3,072,500 giving a saving of £2,292,500 in RIIO ED1

Please provide a calculation of the expected benefits the Solution

Two cost benefit analyses have been carried out. The first is based on replacing a 16mm 11kV overhead line with 70mm overhead line, for a distance of 10km to reduce the source impedance. This results in a cost savings of £342,500 for an expenditure of £157,500 for the pole mounted unit. The second cost benefit analysis has been based out installing 5km of 240 mm underground cable to provide a low impedance circuit, in addition to an existing circuit and produces cost savings of £58,000 based on an expenditure of £228,500 for the ground mounted unit.

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

The method proposed in this project can be rolled out to any distribution network with a high source impedance where there are issues with overall voltage range or with voltage step changes.

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

The specification will be provided to other DNOs as part of the sharing of knowledge gained and they will be able to use this at minimum cost to determine which circuits would provide them with cost savings compared to the base cost.

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

n/a

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.

Based on a review of the projects registered under IFI, NIA and NIC as well as information from the supplier of the proposed method, there is no other project using directly connected high voltage electronics to provide reactive power compensation for voltage control in GB hence there is no duplication.

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