Energy Networks Innovation Process

Project Closedown Report Document

Date of Submission: 16/06/2021

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Project Title (*This cannot be changed once registered*)	Project Reference
11kV Power Electronics providing reactive compensation for voltage control	NIA_SSEPD_0029
Funding Licensee(s)	**Project Start Date**
Scottish Hydro Electric Power Distribution, Southern Electric Power Distribution	June 2016
Project Duration	**Year**
51 months	2021

Nominated Project Contact(s)

SSEN NIA Programme Delivery Manager – Colin Mathieson

1. 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 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.

2. 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

3. 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.

4. Performance compared to the original project aims, objectives and success criteria

Details of how the Project is investigating/solving the issue described in the NIA Project Registration Pro-forma.
Details of how the Project is performing/performed relative to its aims, objectives and success criteria.

Rural areas of GB are supplied by electrical networks which often experience large voltage changes, which potentially impact upon the domestic customers in a range of ways from the dimming of lights and on the rare occasion short duration power cuts. The voltage changes are a consequence of the changing commercial customer loads or generation output in the network, especially from renewable power sources.

This project was designed to investigate a newly developed power electronic reactive power compensation unit, of a novel design which is directly connected into the 11kV network, to determine if it could reduce the voltage swings and benefit the LV network.

Objective 1: Determine the operational requirements of the device and standards it should be constructed to

Rigorous testing of the new power electronic reactive compensation unit was successfully undertaken at the Power Networks Demonstration Centre (PNDC) in Cumbernauld which enabled equipment to be built to meet the operational requirements of the first field trial. Commissioning of the first network installation on the Isle of Lewis has taken place, to replace a failed static compensator (STATCOM) which provided voltage regulation for a small community-owned wind farm. The rated Volt-Ampere Reactive (VAR) capacity and dynamic response time of the device are sufficient to meet the operational requirements for this application.

Following the successful commissioning of a unit on the Isle of Lewis in May of 2019 various studies were conducted by planning engineers to determine and identify a further two suitable locations for the other units. A potential site was identified in Oban district however due to COVID-19 and critical activities being prioritised in the region and restrictions on travel the planned installation was postponed. These unforeseen circumstances associated with COVID-19 have unfortunately resulted in the project being closed before further installations could take place.

Objective 2: Confirm that the device meets the construction standards

Following the trial period, the device conforms to relevant standards for insulation, electrical performance, control integration and weather resistance. These characteristics have been tested at the PNDC and subsequently in the field at the first installation site on the Isle of Lewis.

Objective 3: Establish a safe connection methodology for overhead line and ground mounted variants

The pole structure selected for the pole mounted overhead line variant has been used before for other voltage regulator devices of similar size and weight. An electrical protection scheme has been designed and validated at the PNDC through a series of connection and interruption tests. The first installation was completed based on the findings of the offline trial. The practical issues around maintaining electrical safety clearances associated with installing the units in a ground mounted environment are proving difficult to overcome.

Objective 4: Determine, by testing, that the device meets the operational specifications

The device installed at PNDC has undergone electrical performance and SCADA integration testing. The practical elements of the installation and the testing undertaken were designed to ensure that compliance of the device to operational specifications could be validated. The design considered the pole structure, earthing and protection configurations which would be introduced in a typical

operational environment. The performance of the device at different voltage setpoints was thoroughly tested to ensure that its operational envelope would be appropriate and that its response time was quick enough to provide fine control of voltage excursions.

Subsequently, a device was installed at the first location on the Isle of Lewis. The device was successfully commissioned and continues to be monitored as part of ongoing learning into the device's performance under a range of different operational conditions. This objective has largely been met.

Objective 5: Install two pole-mounted and one ground mounted device on the distribution network

This objective has been partly achieved with the first pole-mounted installation on the Isle of Lewis. The travel restrictions as a result of COVID-19 have prevent the two further installations. Given the challenges around electrical system safety of the ground mounted design, the pole-mounted configuration will be adopted for future installation of the units.
Objective 6: Monitor the effects on the network by comparing voltage profiles from before and after the installation of the devices

It has been possible to remove the network operational constraints associated with the community wind farm on the Isle of Lewis following the successful installation and commissioning of the first device. The voltage had been limited due to the failure of the STATCOM, however with the new device installed the network can be operated normally, which highlights the success of the new equipment.

Objective 7: Confirm that the device is reliable in service, and across a range of weather conditions, and determine the cost of maintenance

This objective has in the main been met with the device on the Isle of Lewis operating throughout an entire year and being subjected to seasonal changes.

The equipment's maintenance costs are comparable with other common types of substation electrical equipment over its first year of operation. Unfortunately, the device on the Isle of Lewis was hit by lightning which has resulted in the necessary replacement of all three current surge arrestors and control panel at a cost of £20,000.

Objective 8: Determine the suitability of the method for business as usual deployment

The device on the Isle of Lewis has performed as intended and has specifically addressed voltage constraint problems faced at the wind farm, thus partially demonstrating its suitability for consideration in business as usual deployment.

Given the technology's satisfactory performance to date in supporting renewable generation, the Flexible Solutions Team within SSEN are exploring further opportunities in which the devices could be used to assist with new remote renewable connections where there are system network challenges which reduce the volume of energy the wind farm could export onto the system. The successful trial of this equipment has also led to further engagement with Equipment Policy Team and the potential to consider a formal technical approval process.

This device also has the potential to increase the output of a renewable generator, which is at the edge of the electrical network. The learning from the project has been shared with Parties that have the ability to exploit the technology in this way. Please note that in this case the device would be owned, operated and maintained by the renewable generator.

5. Required modifications to the planned approach during the course of the project

The Network Licensee should state any changes to its planned methodology and describe why the planned approach proved to be inappropriate. Please confirm if no changes were required

A re-assessment of the purchased device's ability to be installed in a ground mounted arrangement was considered unviable given the challenges around maintaining electrical safety from the system.

There have been two duration extensions requested during the project;

- It took longer than anticipated to conclude the necessary agreements and meet the requisite governance for importing the three devices into the UK, as they were manufactured abroad; and
- due to delays in finding suitable network locations for the installations of the remaining two devices which in the end were not installed due to the further site access restrictions associated with COVID-19.

6. Lessons learnt for future projects

Describe how the project (methodology, stakeholder engagement etc.) changed, or provided opportunities, from your expectation at the start of the project and therefore could be useful for a future project. In addition, please discuss the effectiveness of the research development or demonstration undertaken.

In projects where the method involves products developed abroad, the procurement process can be long drawn out due to the need for harmonisation of different rules and approaches. There is no simple way to predict how much time it can take to complete the necessary formalities; a significant slack period should be included to cover procurement. In hindsight, a full year for procurement should have been considered at the start.

Also, if supplier experts are essential for some of the site acceptance activities, additional time contingency ought to be considered to allow for the proper coordination of the availability timings of all stakeholders.

Identifying suitable ground mounted arrangements for the installations of the current devices has proven very difficult given the challenges around maintaining electrical clearances and safety from the system.

This device solves a very specific electrical system power quality issue, the trial positively highlighted the device's ability to satisfactorily mitigate and address the localised power quality challenge. There has been a significant interest in the dissemination events and received very positive feedback. However, there are limited opportunities on the distribution network presently to deploy the device. One of the qualities of the device is its ability to increase the power flow onto the network from a renewable generator in a remote location. There would be a significant number of existing and future renewable generators which could benefit from acquiring, owning and operating this device.

7. The outcomes of the project

When available, comprehensive details of the Project's outcomes are to be reported. Where quantitative data is available to describe these outcomes it should be included in the report. Wherever possible, the performance improvement attributable to the Project should be described. If the TRL of the Method has changed as a result of the Project this should be reported. The Network Licensee should highlight any opportunities for future Projects to develop learning further.

A summary report has been produced detailing real time field performance of the 11kV DVAR VVO device. The dissemination event shared the learning outcomes for the Isle of Lewis trial, more details can be found on the SSEN Innovation Website. As a result of the trail the Technical Readiness Level (TRL) of the device increased from TRL6 to TRL8 and with the correct processes and procedures in place it would be suitable for business as usual operation, without the requirement of further investigative work.

The summary report highlights improved levels of voltage and reactive power compensation on the network. The business will look to explore other opportunities thought the Active Network Team and their interaction with new renewable generation connections to use the devices specifically targeted at either wind or PV farm installations.

8. Data Access & Quality Details

A description of how any network or consumption data (anonymised where necessary) gathered in the course of the Project can be requested by interested parties. Please include a link to the publicly available data policy.

Data sharing requests can be made in accordance with SSEN Network Innovation Competition (NIC) and Network Innovation Allowance (NIA) Data Sharing Procedure, further details may be obtained via emailing - future.networks@sse.com

9. Foreground IPR

A description of any foreground IPR that have been developed by the project and how this will be owned.

This project will only provide knowledge about how to apply an already developed technology whose background IPR is owned by the supplier.

SSEN has developed installation methods and the communications required to allow the device to be integrated into our overall voltage control system. The knowledge developed by SSEN in the trials will be applicable to all GB networks and has been shared with all interested parties through dissemination events and a summary report.

10. Planned implementation, recommendations or next steps

Please describe the next steps to implement this innovation project. What policies and standards need to be updated or created as part of this implementation.

Following the successful installation and trial of the pole-mounted device, developments are in progress for the consideration of the devices being adopted as BaU through a formal technical approval process with Engineering Policy. Subject to its adoption, appropriate guidance for planning options and installation will be rolled out throughout the business in due course.

11. Other comments

N/A

12. Standards Documents

Identify any industry standards that may require updating due to the outcomes or understanding developed from this innovation project. If no standards will need to be updated, please state - not applicable

N/A