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

Mar 2024

Project Reference Number

NIA_SPEN_0100

Project Registration

Project Title

LV De Mesh

Project Reference Number

NIA_SPEN_0100

Project Licensee(s)

SP Energy Networks Distribution

Project Start

April 2024

Project Duration

1 year and 4 months

Nominated Project Contact(s)

Andras Nemeth

Project Budget

£400,000.00

Summary

Development, field trial and analysis of LV Network Splitter Systems to prevent LV cable burnout during HV faults on interconnected networks and improve restoration performance without expensive HV unit protection.

Third Party Collaborators

EA Technology

Nominated Contact Email Address(es)

innovate@spenergynetworks.co.uk

Problem Being Solved

Meshing (interconnection) of networks is one of the solutions proposed to increase utilisation of existing assets to support a growth in additional electrical energy use as fossil fuels are retired from heating and transport.

One of the drawbacks of networks meshed at HV and LV is the complexity of the switchgear and protection systems required to prevent back-feeds to faulted network through inverted distribution transformers following HV protection operations and subsequent supply restoration processes. Traditional fully interconnected networks (X-Type Interconnected Networks) employ HV and LV switchgear with unit protection schemes (with pilot wires between adjacent substations and LV Air Circuit Breakers (ACBs) between the LV Board and Transformers) that automatically isolate a faulted HV section. The ACBs are necessary to prevent back-feeds from healthy HV sections into the faulted network section via the LV interconnection.

More recent LV interconnected networks designs (Y-Type Interconnected Networks) allow the use of the simple, standard substation equipment and protection used in low-cost radial network design. Using this design, an upgrade route exists to introduce the benefits of improved load and voltage management facilitated by HV and LV meshing on circuits of radial design with minimal additional cost and customer disruption. Though the benefits in efficient asset utilisation of meshed networks are clear, the simplified design and componentry of Y-Type Interconnected Networks creates a disbenefit in the speed by which customer supplies can be restored following HV faults.

Employing the use of network automation (HV switches that can be remotely operated by control engineers to isolate the faulty part of the network and restore supplies to the remaining customers) for rapid restoration, without being able to ensure that any LV interconnection across these switchable points is broken, risks resupplying the faulted HV section from the remotely restored healthy HV network. Furthermore, experience has shown that, under certain circumstances, network impedances limit the back-feed current flow through the LV interconnected cables to a value that is above the cable rating but below LV substation fuse operating threshold causing LV interconnector cable damage. The subsequent requirement for replacement of entire LV cable sections and reservicing of all the customers on that section of cable is highly disruptive. These risks are currently inhibiting the use of rapid restoration methods

on these types of interconnected networks.

The introduction of power electronics and/or remotely switchable LV nodes in the interconnectors offer solutions to this problem but themselves introduce other technical and commercial issues, not least of which is the requirement for additional space to house additional equipment in existing low-cost substations and urban networks. This project seeks to develop and trial a solution that is deployable within existing substation designs without requirement for modification and which would facilitate the roll-out and execution of rapid restoration methods by managing the risks resulting from back-fed currents on LV interconnectors.

Method(s)

The project will develop, modify, test, and prove a system/process of work which will prevent LV back feeds following a HV fault on a Y-Type interconnected network.

It will include a practical trial with the aim of verifying the efficacy of the system, identifying any practical “Business as Usual” issues associated with wide-spread deployment of the system and to identify associated costs.

The proposed equipment to be used will be a modified combination of the EA Technology ALVIN LV circuit breaker and VisNet Hub LV monitor which will form the basis of the operating system to be deployed.

The output of the project will be a functional specification for a compact LV Mesh Splitter system which can be used by any GB DNO who chooses to utilise the benefits of employing Y-Type interconnected networks. This will be backed up with prototype systems installed in the field considering operating instructions covering the safe installation, operating, maintenance and removal of the LV Mesh Splitter systems

The methods used to provide a solution to the problem will be:

- Research and documentation of the environment in which an LV network splitter device must operate and the equipment standards which apply
- Failure mode analyses to consider the operating conditions and required actions of the device
- Modification of an existing compact circuit breaker device to fulfil the required functions
- Laboratory test of a prototype device to for part of the approval process before devices are deployed on live network trial sites
- Selection of field test sites suitable to determine the ability to deploy the devices on representative networks and to gather data on their operation during real network conditions
- Deployment of a suitable number of systems on selected networks
- Monitoring and analysis of operating conditions on a larger sample of LV Interconnectors on selected Y-Type networks (including those with LV Mesh Splitter Devices fitted)
- Observation of device responses over a suitable monitoring period drawing conclusions for the suitability of the equipment to solve the problem identified
- Consideration of the operational requirements for safe deployment, operation, maintenance, and recovery of field deployed

systems

Scope

The project scope is to design and prove a system that reliably and autonomously disconnects LV backfeeds between Healthy and Faulty HV cable networks during HV fault restoration works but which doesn't otherwise detract from reliable network operation.

The goal is that a solution, if proven to be technically and commercially attractive, is made available at the end of the project to be used alongside other established technology (including remotely controllable HV switching points and directional fault passage indicators) to facilitate the meshing of networks with standard substation equipment and protection by reducing the risks associated with the use of rapid restoration methods following HV faults to an acceptable level.

The project will be split into 4 workstreams.

- Workstream 1: Autonomous De-Mesh Device Design and Functional Specification
- Workstream 2: Device Development and Laboratory Testing
- Workstream 3: Network Monitoring and Live System Trials
- Workstream 4: Project Management, Final Reporting and Dissemination Support

Workstream 1

1. Functional/ Requirements Specification

A document exploring the limitations of existing solutions and identifying the desired functional attributes of the proposed solution. It will include:

i. The required physical and electric characteristics of the system

ii. Logic and requirements for Autonomous, High Integrity Operation

iii. Enhanced protection characteristic that offers discrimination with upstream and downstream devices whilst also offering cable overload protection

iv. An appendix with logical use cases to demonstrate function

2. Functional Requirements Test Sheet

A Test sheet derived from the functional requirements to use later as part of the approvals process before release for live trials

3. Agreed Operating Instructions that cover device installation and commissioning and also any required actions during abnormal network operating conditions

Workstream 2

1. Development of Prototype LV Interconnection Splitter devices

a. Firmware changes to provide the De-Mesh Logic and Timing functions agreed in Workstream 1

b. Introduction of a ‘Cable Safe’ protection curve as defined in Workstream 1

c. Provision of a set of 3 early prototype devices for development and testing

2. Development and Test of a portable Test Box for use during installation and commission.

One test box, suitable for transport between substations and use within a substation will be provided

3. Laboratory Testing of the prototype De-Mesh Devices

a. The prototype devices will be laboratory tested and de-bugged by EA Technology

b. A one-day customer witness test is included for (at EA Technology), using the Workstream 1 Functional specification as a test template. It is expected that this will be required as part of the approvals process before releasing the De-Mesh Devices for the live trials. A test report will be issued following this test as evidence of due process and as part of the project learning record

4. Supply of 5 De-Mesh Systems

a. The Systems will comprise of:

i. 5 sets of 3 individual De-Mesh Devices (15 devices in total). These devices will be clearly marked so that differences between the standard operating ALVINs and these modified units are obvious.

ii. Cabling and connectors for 5 installation sites

iii. 5 VisNet Hub devices with up to 6 sets of Rogowski Coils Load Monitoring, Pre-fault Waveform Capture, suspected Fuse Blow and ALVIN Reclose Communications APPs

b. Data comms and hosting/support services for the 5 VisNet Hub devices will be included for a 6 month period. Standard User Interfaces for the VisNet Hub acquired data will be used and access by the relevant SPEN Engineers is included. No additional development of User Interfaces is planned or included in this project.

Workstream 3

1. Supply of additional Monitoring for interconnector ends without De-Mesh Devices a. 25 VisNet Hub will be provided with up to 6 sets of Rogowski Coils, Load Monitoring, Pre-fault Waveform Capture and suspected Fuse Blow Apps

i. Data comms and hosting/support services (using EA Technology Data SIMs and hosting infrastructure) for the 25 VisNet Hub devices will be included for a 6 month period

ii. Standard User Interfaces for the VisNet Hub acquired data will be used and access by the relevant SPEN Engineers is included. No additional development of User Interfaces is planned or included in this project user

2. Site Selection Support and Decision Recording

3. De-Mesh System Installation and Operation Training Support

a. An allowance for the provision of Training Material in addition to the De-Mesh Device installation instructions included in Workstream 1 has been included.

i. It is envisaged this will be used to supplement any training SPEN will introduce for their operational staff by providing background regarding the system, its operation and application.

ii. Attendance at two training sessions to deliver the material has been included

iii. If it is not required, it will not be charged

4. Assistance during Installation, Commissioning and Decommissioning

a. EA Technology will attend one of the early installation sites to record the installation process and, if necessary, amend the operating instructions from Workstream 1

b. Remote assistance with the commissioning and decommissioning of the De-Mesh Systems and the Monitoring systems referred to in this project proposal is included

5. Trial Analysis and Reporting

a. A series of short reports will be prepared by EA Technology for the purpose of recording any pertinent learning during the trial monitoring period.

i. Information from the De-Mesh system and the Monitoring on networks without De-Mesh Devices fitted will be analysis and the results presented for discussion with SPEN

<u>Workstream 4</u>

1.Final Round Up Report:

a. Suitable for dissemination

b. Final reporting will include a copy of the functional specification updated with relevant project learning

Objective(s)

This project proposes to investigate the application of 'LV Interconnection Splitter Devices' to provide the following envisaged requirements:

1. To prevent LV back-feeds between healthy and faulty sections of HV during restoration so that improved restoration sequences (including automated or remote manual sequences) can be executed with acceptable risk
2. To act autonomously with high integrity (no reliance on communications/ communications optional)
3. To be deployable on existing Y-Type substations and interconnector equipment without requiring planning or civil works.
4. To autonomously restore LV interconnection following HV disruption where conditions allow.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

The Customer Vulnerability tool has shown a net positive impact, with the reduction in number and length of interruptions.

Success Criteria

Development of an LV splitter device to allow autonomous disconnection of LV interconnection during HV faults. Following repair of the HV fault allow autonomous reconnection of the LV interconnection.

Project Partners and External Funding

The Project will be wholly NIA funded by SP Energy Networks. EA technology will be project partners

Potential for New Learning

The success of the project will provide DNO's with a comprehensive method to prevent LV backfeeds on Y-Type interconnected networks along with the additional benefits such a network configuration can provide.

The key learning from the project will be:

- A functional specification for an LV Interconnection Splitter System that can be incorporated into compact LV circuit breakers
- Operational requirements for fitting, operating and recovering an LV Interconnection Splitter system
- New protection characteristics more closely matched to Cable Withstand properties
- Use Cases for the LV Mesh Splitter in different scenarios
- Network performance improvements and any necessary changes to restoration procedure or abnormal system operating conditions relating to the use
- Benefits of network monitoring used in conjunction with the LV Mesh Splitter systems

Dissemination of the learning will be via the sharing of Functional Specifications for the devices deployed and reports detailing the success or otherwise of the devices in the field and other learning pertinent to GB Network operators considering Meshed Networks to release capacity on suitable LV networks at minimal cost.

Scale of Project

To understand the operating conditions prevalent on LV interconnectors and ensure the robustness of the solution, 15 LV interconnectors are to be monitored at each end during the trial.

It is proposed that the developed splitter systems are implemented on 5 of the circuits.

This split of monitoring and deployment of the new technology is designed to manage the risks and costs involved with new equipment deployed on live networks yet allow learning on the installation, maintenance and subsequent removal of the Splitter devices and their behaviour during normal and abnormal operating conditions.

Adding monitoring systems to a further 10 interconnectors increases the chance of experiencing different abnormal operating conditions (including HV faults) and learn about how these are perceived by sensing equipment at the substations at each end of the interconnectors. Data gathered on the monitored circuits can be used in simulation with Splitter devices to gain confidence in their satisfactory operation and inform the various thresholds that are applicable for Splitter action.

A minimum monitoring period of 6 months has been selected to allow enough time, over the number of circuits monitored, to build confidence in the solution and gather supporting evidence to conclude its technical capabilities.

Technology Readiness at Start

TRL4 Bench Scale Research

Technology Readiness at End

TRL8 Active Commissioning

Geographical Area

SP Manweb Licence Area (Merseyside)

Revenue Allowed for the RIIO Settlement

£0

Indicative Total NIA Project Expenditure

£400,000

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:

Delivery of the project will decrease the vulnerability of consumers as the installation of the device will lead to a decrease in customer interruptions and customer minutes lost. Consequently, consumers will have a more reliable and robust power supply.

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)

N/A

Please provide a calculation of the expected benefits the Solution

By facilitating quicker restoration during typical HV faults on Y-type networks, estimations show that CML figures can be reduced by approximately 40%. Given the number of Y-type circuits on the SPM network and average number of faults the total saving could be up to £500k per annum.

The costs associated with LV cable burnouts are also avoided which vary but can be upto £50k per incident, depending on number of customers affected

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

The Device is specifically for Y type networks,but is applicable to all DNOs.

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

An estimate of £10,000 per circuit. For SP Manweb to roll this out across all Y type networks it will cost £2,360,000

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

Most UK networks run radially (not interconnected). SPEN's Y-Type networks are a hybrid design that allows the standard equipment used in radial networks to run interconnected at HV and LV if some interconnection rules are followed.

Interconnection of networks to release capacity is an opportunity that is open to any of GB License Holders. The learning generated on this project is therefore directly applicable to other GB License holders wishing to exploit this opportunity to mesh selected networks at HV and LV.

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

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.

We are not aware of any similar projects having been undertaken.

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

Only SPEN and UKPN operate meshed networks as a design standard. The development of Fault Management Equipment (Reclosers) that are compact enough to replace fuses within a Standard LV Distribution Cabinet is also relatively new and has been recognised in this project to opens up the opportunity for a novel autonomous switching solution that overcomes the overriding disbenefits of previously considered solutions.

As well as the novelty of the application, there are two fundamental technological innovations:

1. The development and use of autonomous logic required to manage the risk of backfeeds through LV interconnection following HV faults.
2. The development and experimental use of new cable-safe protection curves to further reduce the risk of interconnected cable damage over that offered by existing BS88-5 fuses

Other solutions that have been the subject of other innovation projects such as FUN-LV, which assessed remote switching of LV switchpoints had too much reliance on comms. Power Electronics soft open points haven't been deemed suitable for application to manage unwanted backfeeds.

Relevant Foreground IPR

N/A

Data Access Details

The SP Energy Networks Data access policy can be found here.

Please identify why the Network Licensees will not fund the project as apart of it's business and usual activities

This is an unproven technology, which requires significant testing and assessment to minimise the risk of operation on the Network.

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

There are significant technical and operational risks to the solution.

This project has been approved by a senior member of staff

☑ Yes