NIA Project Registration and PEA Document

Date of Submission

Apr 2015

Project Reference Number

NIA_UKPN0002

Project Registration

Project Title

Directional Earth Fault Passage Indicator Trial

Project Reference Number

NIA_UKPN0002

Project Licensee(s)

UK Power Networks

Project Start

January 2014

Project Duration

4 years and 1 month

Nominated Project Contact(s)

Peter Lang

Project Budget

£483,764.00

Summary

The project requires a satisfactory demonstration of the techniques proposed, followed by installation of trial units on the live network to monitor their operation under true fault conditions.

The project will trial 100 units at various secondary substations on closed HV rings.

The sites will be chosen subject to various criteria:

- Number of substations on the closed ring;

- Number of customers on the closed ring;

- Profile of customers on the closed ring;

- Fault history of the feeders;

- Workstream 1 – Modern RMUs with three fault current CTs and VPIS (Lucy VRN2A and Schneider RN2C) and RTU installed;

- Workstream 2 – Legacy RMUs with a core balance CT, a distribution transformer feeding the low voltage network and an RTU installed.

Workstream 1 uses an existing proven fault passage indicator (NX41) that has been widely used on UK distribution networks. The enhancements to the device to enable directional functions was successfully simulated as a desk top demonstration using variable voltage and current inputs at Bengeworth Road on 17 September 2014.

Workstream 2 Ricardo utilized the UK Power Networks' training centre's network at Sundridge which is equipped with standard secondary network transformers and RMUs to successfully demonstrate the directional capabilities. For safety reasons, the training network is very limited in capacity, although it operates at 11kV. For demonstration purposes, the network was energized at a reduced voltage to enable a measurable fault current to be detected. This was carried out on 17 October 2014.

Since the device will be install on a ring switch on an RMU, it will report when a fault is detected in one of three states;

- Fault detected direction INTO the RMU,

- Fault detected direction AWAY FROM the RMU,

- Fault detected but direction UNKNOWN.

Nominated Contact Email Address(es)

innovation@ukpowernetworks.co.uk

Problem Being Solved

Faults occur on HV (11kV and 6.6kV) networks. Faulty sections on radial circuits are conventionally identified using fault passage indicators that operate to show the passage of fault current up to the faulty section, whereas indicators located on the circuit past the fault would not operate.

The LPN network has a number of HV circuits operated as closed rings where the feeders are connected together through switchgear fitted with circuit breakers and relay operated directional protection, commonly known as DOC. Any fault current will pass along both feeders of the closed ring and therefore all fault passage indictors operate making it impossible to determine the faulty section.

The normal switchgear used on HV rings is the Ring Main Unit (RMU), although a wide variety of switchgear manufacturers and types are used in LPN. Communication between the RMU and the control centre is via Remote Terminal Units (RTU). Not all secondary substations in London are fitted with an RTU.

The problem is therefore to be able to identify the faulty section of cable in a closed ring and communicate satisfactory information back to a control centre to enable the faulty section to be isolated for supplies / capacity to be restored. Any additional equipment must be relatively cheap and easy to install.

Method(s)

On radial HV circuits, the fault passage indicator is connected to the RTU, where there is an RTU fitted, and its operation is indicated on the control room diagrams.

This project will develop a fault passage indicator capable of reporting the direction of the fault current and displaying the direction on the control diagram in an easy to understand format.

To enable the direction of the fault to be determined, both the HV voltage and HV current needs to be measured in terms of magnitude and phase at the indicator position to calculate the effective power flow direction of the HV fault current.

The current is measured using current transformers (CT). Modern RMUs have individual CTs on each phase conductor in at least one ring switch or end box. The legacy switchgear has a single core balance CT around the HV cable which can only detect earth faults.

HV voltages are traditionally measured using a dedicated voltage transformer but these are not standard on RMUs so alternative methods of detecting the HV waveform are required. Modern RMUs have a Voltage Presence Indicator Socket (VPIS) which is derived from capacitive bushings around the HV conductor. This gives a low voltage representation of the HV voltage waveform.

Legacy RMUs do not have VPIS but a large number feed the low voltage distribution network via standard transformers ranging from 500kVA to 1000kVA.

Because of the variety in RMUs two workstreams were proposed. The first to develop a device to use on modern RMUs while the second could be used on legacy RMUs:

Workstream 1

A number of manufacturers were contacted and Nortech were selected to add a directional facility to their existing NX41 fault passage indicator. The device would use the VPIS as the voltage source and either the three fault passage CTs to enable phase-phase and earth fault detection, or a core balance CT to enable earth fault detection only depending on what CTs are fitted to the RMUs.

Workstream 2

Ricardo (previously PPA Energy) are currently involved in the UK Power Networks' Distribution Network Visibility (DNV) project, which

is being integrated into Business as Usual. This project utilises HV and LV data, part of which investigated power flow directions.

This project enables Ricardo to build on the experience of DNV and to develop a Directional Earth Fault Passage Indicator (DEFPI). It will derive the earth fault current from a core balance CT. The voltage will be taken from the LV side of a distribution transformer and converted to represent the HV voltage by sequence component transformations and transformer and network data.

Scope

The project requires a satisfactory demonstration of the techniques proposed, followed by installation of trial units on the live network to monitor their operation under true fault conditions.

The project will trial 100 units at various secondary substations on closed HV rings.

The sites will be chosen subject to various criteria:

- Number of substations on the closed ring;
- Number of customers on the closed ring;
- Profile of customers on the closed ring;
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Since the device will be install on a ring switch on an RMU, it will report when a fault is detected in one of three states;

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Objective(s)

The project intends to develop devices that can confidently identify the direction of fault current on closed HV rings and correctly display on the control diagram to enable the correct isolation of faulty sections of HV circuits, thus minimising disruption to customers and minimizing CIs and CMLs.

The devices must be able to be fitted to existing standard RMUs and communicate via standard RTUs as installed on UK Power Networks' LPN network.

The devices must be able to be installed with the minimum resource and network outage requirement.

During the trial, the operation of the device under fault will initially be treated in the same way as a non-direction device until such time as UK Power Networks has confidence in direction being reported correctly.

During initial trials a number of improvements were identified to ensure more consistent and accurate direction indications from the DEFPI units.. A subsequent firmware upgrade has been developed for both types of unit and an additional trial phase planned to collect and assess additional evidence to demonstrate that the units do provide correct direction indications consistently. It is expected that this monitoring phase could last an additional 12 months.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

n/a

Success Criteria

The following will be considered when assessing if the project has been successful:

- Faults experienced on closed rings where a trial DEFPI has been installed give correct directional information by the end of the trial.
- CI and CML values can be saved once the DEFPI indications are used during fault restorations.
- If proven, an understanding of how use of the device could be expanded to radial HV circuits with interconnected LV meshed networks where reverse power flows from the LV network during phase-phase HV faults cause existing fault passage indicators to give misleading information.

Project Partners and External Funding

n/a

Potential for New Learning

n/a

Scale of Project

- The trial will utilise 100 units, 50 from each workstream, these will be installed across the LPN HV network. Once installed, the devices will be monitored for 12 months to gain enough operational experience during faults to enable the units to be accepted for roll out into business-as-usual.
- If accepted, there are potentially over 700 sites that could benefit from a DEFPI if 100% coverage was required on HV closed rings

Technology Readiness at Start

TRL4 Bench Scale Research

Technology Readiness at End

TRL8 Active Commissioning

Geographical Area

This project will trial the new devices on the DOC closed ring circuits in central London.

Revenue Allowed for the RIIO Settlement

None

Indicative Total NIA Project Expenditure

The project plans to install 100 DEFPI (50 of each type). Once a population of indicators is installed (22 installed by 31 March 2015) on the DOC networks, monitoring of HV faults will take place and an assessment on the accuracy of direction will be carried out. The project will complete in December 2016 (assuming sufficient HV faults have been restored).

£483,764 is the total expenditure which we expect will be incurred during the duration of the project

The split of the expenditure is shown below:

IFI: £182,399

NIA: £301,365

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)

Following successful demonstration of the Directional Earth Fault Indicator, there will be savings in terms of reducing CIs and CMLs during HV faults. In 2013, there were 94 HV faults directly affecting DOC rings. These resulted in 1.062 CIs and 0.603 CML. With the introduction of DEFPI devices on DOC rings, we can eliminate most CIs from faults on these rings, which has a value of approximately £500,000 per year. These savings are conditional on the direction being available and actual number of faults in a given period.

Please provide a calculation of the expected benefits the Solution

Base Cost: £4,400

Based on:

- Time to fault-find for 2 engineers
- Number of expected faults per year for the trial area

Method cost: £106,000

Based on:

- 100 units being bought for the trial
- Installation of the units

Benefits: £1,635,812 NPV for the CI/CML savings over the RIIO ED1 period to 2022/23

Financial benefits: £1,534,212 (Base cost - (Method cost - Benefits))

The base cost includes the time operational staff spend testing to prove a healthy circuit before restoring supplies.

The benefits are based on the assumption that 8 events take place a year in the trial area. This is based on 784 Secondary substations that are connected to closed rings (DOC) within LPN.

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

This method is replicable across Network Licensees that operate meshed networks. Current this directly relates to London Power Networks plc and SPEN Manweb plc. As other Network Licensees consider operating meshed networks the method will become part of their installation requirements.

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

Cost of purchasing and installing the devices c. £600 per device.

DEFPI devices can be used on non-meshed networks where a large generator connected to an 11kV circuit, could cause incorrect indications due to fault contribution from the generator. To be effective in such scenarios a number of devices would need to be installed along the circuit making the devices applicable across GB.

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

Network designs are tending towards meshed networks in one form or another; interconnection and embedded generation are examples of this. Power flows will be from multiple sources and fault localisation will require directional elements at a reasonable cost. Satisfactory operation in LPN closed rings could therefore benefit all DNOs.

Or, please describe what specific challenge identified in the Network Licensee's innovation strategy that is being addressed by the project (RIIO-1 only)

Overcoming operational constraints involved in running closed HV rings.

☑ 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.

n/a

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