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 2018

Project Reference Number

NIA_UKPN0037

Project Registration

Project Title

SYNAPS Fault Detection, Classification & Location Solution

Project Reference Number

NIA_UKPN0037

Project Licensee(s)

UK Power Networks

Project Start

June 2018

Project Duration

1 year and 7 months

Nominated Project Contact(s)

Rona Mitchell

Project Budget

£679,854.00

Summary

Many faults on the low voltage (LV) network are caused by gradual degradation of underground feeder cables. As the cables age/insulation layers gradually break down allowing the ingress of moisture, which starts to cause momentary short circuits between the conductors. This causes an arc which often vaporises the water and clears the fault. These faults are known as ‘transient faults’, and they are invisible to the DNOs and customers. As the cables degrade further the arc current may be sufficient to cause a fuse to blow, causing a power cut. If the fuse is replaced, the fault will appear to have cleared. However, the underlying fault will remain, meaning that the fuse will blow again, giving rise to an ‘intermittent fault’. Eventually fuse replacement will not clear the fault and the fault becomes permanent.

Current DNO practice is mostly reactive, with faults only becoming visible when they are reported by customers. Standard practice is then to replace the fuse, if the fault is not cleared then technologies such as Time Domain Reflectometry (TDR) are employed to locate the fault. These faults account for a significant proportion of LV network costs and Customer Minutes Lost (CML). To technically and economically improve the performance of the LV network, there is a requirement to move from reactive to proactive management of LV faults.

Nominated Contact Email Address(es)

innovation@ukpowernetworks.co.uk

Problem Being Solved

Many faults on the low voltage (LV) network are caused by gradual degradation of underground feeder cables. As the cables age/insulation layers gradually break down allowing the ingress of moisture, which starts to cause momentary short circuits between the conductors. This causes an arc which often vaporises the water and clears the fault. These faults are known as ‘transient faults’, and they are invisible to the DNOs and customers. As the cables degrade further the arc current may be sufficient to cause a fuse to blow, causing a power cut. If the fuse is replaced, the fault will appear to have cleared. However, the underlying fault will remain, meaning that the fuse will blow again, giving rise to an ‘intermittent fault’. Eventually fuse replacement will not clear the fault and the fault becomes permanent.

Current DNO practice is mostly reactive, with faults only becoming visible when they are reported by customers. Standard practice is then to replace the fuse, if the fault is not cleared then technologies such as Time Domain Reflectometry (TDR) are employed to locate

the fault. These faults account for a significant proportion of LV network costs and Customer Minutes Lost (CML). To technically and economically improve the performance of the LV network, there is a requirement to move from reactive to proactive management of LV faults.

Method(s)

The SYNAPS (synchronous analysis and protection system) solution will be deployed in substations and feeder link-boxes or feeder pillars. It applies innovative algorithms to power waveforms in order to detect and classify fault events.

SYNAPS uses state-of-the-art advanced statistical signal processing and machine learning algorithms to identify unique features of LV feeder cable faults (including early transient so called 'pecking' faults). A high sample rate detector is then employed to identify faults, when a manifesting fault is detected the sensor records the fault waveform and transmits to the server software for further processing. The server software classifies fault type and location (target accuracy 3m) utilising Powerline Technologies (PLT) proprietary algorithms.

Existing solutions use voltage/current analysis that give an approximate location of the fault, which is then pinpointed with gas sniffers and thermal cameras. These techniques are mainly used for permanent faults and the equipment; when used en masse is expensive.

SYNAPS could enable DNOs to make significant reductions in the cost of LV network operation, replacing expensive and manpower intensive operations with automated procedures. The detection and location of faults at an early stage, before they become permanent, will facilitate proactive planned maintenance, rather than expensive reactive emergency action. Faults can be detected, classified and located before a fuse failure, giving the DNO the opportunity to repair the fault before or immediately after the first fuse failure.

Scope

The project will seek to validate and trial the SYNAPS LV fault detection, classification and location solution. The project will cover technology validation and demonstration on an operational network taking the solution from TRL4 to TRL6.

Stage 1: Technology validation (TRL5 Technology Demonstration)

Stage 2: Prototype design for testing on the LV network. SYNAPS demonstration in a working environment (TRL6 Technology Demonstration)

Objective(s)

Stage 1 Objectives – SYNAPS Technology Validation at Power Networks Demonstration Centre (PNDC) (TRL5)

- Demonstrate a two-unit SYNAPS system
- Test SYNAPS technology at PNDC
- Validate technology and prove it can detect, classify and locate faults to required level of performance
- Collect and analyse data to facilitate improvements in algorithms
- Collect and analyse data to facilitate future improvement of LV network simulation model
- Preparation for Stage 2

Stage 2 Objectives – Demonstration of SYNAPS operation in a working environment on UKPN network (TRL6)

- Enhance SYNAPS algorithms and demonstration system based on PNDC report
- Understand network interface/connection requirements
- Two pairs of sensors will be delivered to the participating DNOs (one set for UK Power Networks & one set for SSEN) for operation on actual LV network
- Design concept and specification for link box/substation sensor (including transducer)
- Document the cable calibration procedure
- Enhancement of LV network simulation model to include cable calibration
- Demonstration of prototype SYNAPS sensors on feeder(s) chosen jointly with UK Power Networks and SSEN (detection, classification and location of faults on feeders with known issues) installation for duration of demonstration only and supported by personnel from the manufacturer and the DNOs.
  -Incudes detailed site surveys to establish optimal locations for prototype SYNAPS system
  -Deployment of prototype SYNAPS system on problematic feeders with known faults
  -SYNAPS will be used in conjunction with traditional fault location instruments, such as TDR and cable sniffers, in order to validate location results when faults become permanent

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

n/a

Success Criteria

Demonstrate the following:
1. Determine whether the SYNAPS system can reliably detect transient faults on LV networks
2. Determine whether the SYNAPS system can accurately classify faults on an LV network

3.Determine if the SYNAPS system can locate faults on an LV network with a precision similar to or better than existing technologies.
4.Demonstrate installation on an operational LV network
5.Document network installation requirements, including learnings from the initial live network usage.

Project Partners and External Funding

Scottish and Southern Electricity Networks, Powerline Technologies Ltd. and the Energy Innovation Centre.

Potential for New Learning

The main learning, from stage 1 & 2, that will be shared with other DNOs is expected to include:

- How the SYNAPS system can be used for early detection, classification and location of pre-faults (transient, 'pecking' faults) on a live network
- The reliability with which the equipment can detect early transient and permanent faults using the system
- The reliability of characterisation of faults
- The accuracy of fault location using the SYNAPS system.
- Standards and specifications related to the SYNAPS system that are required for network installation.

This will demonstrate the capability of the pre-emptive fault detection solution.

Scale of Project

At this stage of product development, the decision to trial the device at the PNDC is helping to de-risk the project. If Stages 1 and 2 of this project are successful, then wider scale trials may take place.

Technology Readiness at Start

TRL4 Bench Scale Research

Technology Readiness at End

TRL6 Large Scale

Geographical Area

Trials will take place on the PNDC network and on selected UK Power Networks and SSEN networks.

Revenue Allowed for the RIIO Settlement

There was no revenue allowed in the RIIO settlement for investigating innovative ways of detecting, classifying and locating intermittent faults.

Indicative Total NIA Project Expenditure

£679,854

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)

As stated before in the problem a significant proportion of LV costs and customer minutes lost (CML) are attributed to permanent LV faults.
If the SYNAPS system is successful and is rolled out to business-as-usual, the following benefits are estimated:
- 50% of LV faults could be prevented
- 25% of LV faults could be precisely located

Please provide a calculation of the expected benefits the Solution

Base Cost: £0
Method cost per DNO: £339,927
Benefits/Savings as a result of CI/CML benefits, quicker repair due to fault location improvements and avoided costs of LV repairs due to prevented faults: £394,498
NPV: Base Cost - (Method Cost - Benefits): £54,571

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

The solution is applicable to all GB network operators and could be applied to all underground LV networks.

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

To roll the method out across GB, there will be cost associated with the equipment and with training of staff to use the SYNAPS system. After the trial, the unit cost of equipment is expected to be in the region of £10,000.

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

The learning from this project will be about a new method to enable proactive LV fault management. This will be of value to all Network Licensees, as LV fault management is an issue affecting each one. If the SYNAPS system is able to accurately detect, characterise and locate faults, it will feed into a potential wider scale trial that will seek to deliver customer and network benefits.

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.

This project is being carried out collaboratively between UK Power Networks and SSEN with assistance from the Energy Innovation Centre.
The project technology providers, PowerLine Technologies are familiar with the work carried out under previous projects such as the TP22, Kelvatek Bidoyng and also Northern Powergrid project, FORESIGHT – LV pre-fault recognition and management.
There is no replication or duplication in this project as it is utilising a completely different type of technology than has been used in other LV fault projects which has the potential to deliver improved results.

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

Traditionally LV fault location has used well known techniques such as impulse reflection and volt drop. SYNAPS provides innovative and sophisticated real-time fault monitoring, diagnosis and location capability using unique state-of-the art machine learning algorithms to detect, classify and accurately locate fault conditions by examining voltage and current waveforms from multiple locations in real-time. This has not been used previously, because machine learning technology was not advantageous in technology or cost.

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

The project is still at a low TRL level and there are a number of issues and risks to overcome before the technology is mature enough for it is used as part of business as usual activity.

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

The project can only be undertaken as an innovation pilot given the operational risks associated with the deployment of an unproven solution in network operations. The technology has been tested in a laboratory environment, but requires a true network test to prove its viability. The proposed approach to LV fault finding also has an unproven business case, and the range of potential benefits should be tested before the tool can be deployed. As noted in the NIA guidance, certain projects are speculative in nature and yield uncertain commercial returns. This is the case for with this project. There is a commercial risk that the solution trialled in the project is not adopted by the stakeholders involved following the trial period. This could be due to the fact that the solution has not reach the level of maturity required for business-as-usual application. If the project is successful, it will have proven a technical solution which will improve network performance. The specific details regarding the benefits are captured under section 2b of this document.

This project has been approved by a senior member of staff

☑ Yes