WESTERN POWER DISTRIBUTION
Serving the Midlands, South West and Wales

Date of Submission

August 2019

NIA Project Registration and PEA Document

Notes on Completion: Please refer to the **NIA Governance Document** to assist in the completion of this form. Please use the default font (Calibri font size 10) in your submission. Please ensure all content is contained within the boundaries of the text areas. The full-completed submission should not exceed 7 pages in total.

Project Registration

Project Title

Automatic Location of Arc-faults through Remote Monitoring (ALARM)

Project Reference

NIA_WPD_041

Funding Licensee(s)

Western Power Distribution

Project Start Date

September 2019

Project Duration

Years	Months
2	8

Nominated Project Contact(s)

Chris Harrap

Project Budget

£493,000

Contact Email Address

wpdinnovation@westernpower.co.uk

Lead Sector

Electricity Distribution	☒	**Gas Transmission**	☐
Electricity Transmission	☐	**Gas Distribution**	☐

Other Sectors

Electricity Distribution	☐	**Gas Transmission**	☐
Electricity Transmission	☐	**Gas Distribution**	☐

Research Area

Network improvements and system operability	☐
Transition to low carbon future	☐
New technologies and commercial evolution	☒
Customer and stakeholder focus	☐
Safety, health and environment	☐

Problem(s)

It is widely understood that underground LV networks regularly experience pecking faults – short duration arc faults typically caused by water ingress at partially damaged cable sections or connection/transition points in the network. Such events progressively damage the cable system, and can lead to the development of fuse-operating transitory faults (with customers off for the time required to change fuses). This can then develop to permanent faults with longer customer outages occurring for reactive fault location and repair to be completed.

Fault data from the last four regulatory years shows there have been 331 LV feeders with four or more transient fuse incidents in the East Midlands region of WPD. In total, 526 fuse incidents occurred after there had already been four incidents.

Method(s)

The project proposes to test the feasibility of a technical alternative and lower cost fault locating device. This will be achieved by WPD providing a real-world testing opportunity, and by the manufacturer using this opportunity to demonstrate (and tune at their cost) the fault locating device's operation.

The project proposes to install substation monitors capable of identifying and locating distance to cable arc-faults. Each monitor consists of Rogowski Coil based phase-current sensors (for up to five LV feeders) together with voltage taps, connected to a Metrology and Communications Unit (MCU) which processes the sensor data and generates and logs substation loading and condition parameters.

Each monitor will capture and retain voltage and current waveforms from the monitored LV feeders when pre-set triggers are activated (e.g. rate of change of voltage or phase current). The captured waveforms will be forwarded via a GPRS/mobile data connection to a processing data centre where inductance and resistance values for the faulting network will be estimated. The estimated value of inductance will then be used to establish a distance to fault estimate.

Scope

The project will follow a two phase approach.

In Phase One, monitors with the supplier's existing fault location capability will be installed, and data will be analysed by the supplier. This Phase One data will primarily be used to confirm operating parameters for improved data capture hardware that the supplier has also already designed. This improved fault location hardware and capability will then be deployed and tested in Phase Two of the project.

Phase Two will then seek to demonstrate optimised fault location data for monitored feeders to the distribution business.

Objective(s)

1. Test the feasibility of a technical alternative and lower cost fault locating device.
2. Derive insight into the potential to more widely and cost-effectively deploy such monitoring equipment to feeders showing early indications damage (e.g. transient fuse operations).

Success Criteria

Overall success will be:

- Identification of pecking faults within monitoring data, reliably distinguishing them from other network transients and disturbances
- Capture of sufficient pecking fault data to estimate confidence in DtF indications for transient arc-faults;
- Quality of captured auxiliary data (e.g. upstream and downstream network impedance indications) is sufficient to support reliable distance to fault calculations
- Quantitative understanding of the frequency and magnitude of transient arc-faults on monitored feeders
- Automatic generation and notification of distance to fault indications; and

DtF indications are successfully used by local teams to guide repairs ahead of permanent faults developing.

Technology Readiness Level at Start	Technology Readiness Level at Completion
TRL 5	TRL 8

Project Partners and External Funding

This project will be supported by Lucy Electric GridKey.

Potential for New Learning

It is expected that the parties involved will learn to what degree the utilised relatively low cost hardware and associated software algorithms can accurately predict:

- the distance to fault for fuse operating faults; and
- the distance to damage for transient non-fuse-operating pecking events that frequently are the precursors to transitory faults/fuse operations and permanent faults

Given the technically alternative impedance measurement basis of the system, the project will also be testing this approach.

Scale of Project

The project proposes the installation of 26 monitors across the East Midlands region of WPD. This test deployment represents around 17% of the number of monitors that might potentially be required for the East Midlands, one of the four licence areas operated by WPD. The field work will last a period of up to 21 months.

Key to the project's success is fitting monitors to feeders that are suffering from pecking arc-faults, and that these arc-faults reoccur in a reasonable period of time. The judgement of scale is that 26 monitors will be sufficient to collect data on active arc-faults on a range of different feeder lengths/degree of branching and demonstrate the effectiveness of the fault locating capability. The risk of fitting fewer is that the project collects insufficient data to reasonably demonstrate capability and draw conclusions.

Each monitor would be capable of monitoring the LV feeder on which fuse operations have occurred, plus up to four further LV feeders at that substation location.

Geographical Area

The project will take place in the East Midlands region of WPD. Specific LV feeders will be selected as an initial task in the project. Feeders will be selected based on incident history (with likely criteria being at least four fuse replacement incidents, of which one has occurred in the last 12 months), and discussion with local teams.

Revenue Allowed for in the RIIO Settlement

£0

Indicative Total NIA Project Expenditure

The project budget is £493,000, of which £443,700(90%) is NIA expenditure.

Project Eligibility Assessment

Specific Requirements 1

1a. A 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 systems and 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	☐

Specific Requirements 2

2a. Has the Potential to Develop Learning That Can be Applied by all Relevant Network Licensees ☒

Please answer one of the following:

i) Please explain how the learning that will be generated could be used by relevant Network Licenses.

The distance to fault algorithm that will be validated by this project will be applicable to the majority of underground LV networks in the UK. The equipment and software required will be commercially available to all the network licensees following successful completion of this project, and some existing customers with GridKey hardware may be able to upgrade their equipment in the field to add the functionality in a cost-effective manner.

ii) Please describe what specific challenge identified in the Network Licensee's innovation strategy that is being addressed by the Project.

WPD's Innovation Strategy seeks to identify and test ideas that show the potential to improve the efficiency and effectiveness in the way we deliver our services to customers. These innovation ideas are developed as part of a balanced programme of projects grouped by WPD around three main categories (Assets, Customers and Operations), and across five innovation themes that are common to the ENA's Innovation Strategy.

The proposed project (assessment of a technically alternative and lower cost approach to locating transient fuse-operating faults) fits within the Operations category of the programme, and aligns with the "Network Improvements and System Operability" theme.

Specifically, this theme has the goal of further developing asset management strategies and capabilities to minimise the cost of managing aging assets. This should be seen in the context of the expectation that future utilisation of, and reliance on these assets will increase through the anticipated uptake in low carbon technologies such as vehicle charging and also the longer term potential provision of energy for heating.

Is the default IPR position being applied?

Yes	☒
No	☐

If no, please answer i, ii, iii before continuing:

i) Demonstrate how the learning from the Project can be successfully disseminated to Network Licensees and other interested parties

N/A

ii) Describe how any potential constraints or costs caused, or resulting from, the imposed IPR arrangements

N/A

iii) Justify why the proposed IPR arrangements provide value for money for customers

N/A

2b. Has the Potential to Deliver Net Financial Benefits to Customers ☒

Please provide an estimate of the saving if the Problem is solved.

Solving the Problem (cost effectively identifying the location of and acting on arc-faults on cable networks that lead to transient fuse operations and permanent faults) would lead to improved CI and CML performance of electricity networks. This is particularly important given the anticipated future increase in public reliance on electricity networks to underpin transport and heating. In addition, having a reliable fault location offers the potential for reduced operating costs with avoided restoration activity and less excavation work.

Please provide a calculation of the expected financial benefits of a Development or Demonstration Project (not required for Research Projects). (Base Cost – Method Cost, Against Agreed Baseline).

Modelling suggests that with around 150 LV feeder monitors installed at one point in time in a DNO region:

- annual avoided CI/CML (IIS) value via the Interruptions Incentive Scheme could be around £106k per annum;
- the saved cost of not attending avoided incidents is £75k per annum; and
- the annualised hardware cost of monitoring with 150 systems would be around £43k.

Considering base costs and method costs over five years, based on the modelling:

- Base Cost is £3,834,000 (current levels of incidents on feeders considered)
- Method Cost is £3,148,000 (reduced levels of incidents on considered feeders, through acting on monitoring data, plus monitoring costs)
- Base minus Method Cost is £686,000 (£3,834,000 minus £3,148,000)

Please provide an estimate of how replicable the Method is across GB in terms of the number of sites, the sort of site the Method could be applied to, or the percentage of the Network Licensees system where it could be rolled-out.

The Method is expected to be widely replicable on radial LV cable networks across GB.

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

The initial equipment and installation costs of rolling out such a proven Method would be in the region of £380,000 per DNO region, based on consideration of the trial region. The cost of roll out across GB would be a multiple of this based on individual DNO region levels of LV faults, and number of units that could cost beneficially be deployed.

2c. Does Not Lead to Unnecessary Duplication ☒

Please demonstrate below that no unnecessary duplication will occur as a result of the Project.

Whilst LV fault location has been the subject of previous innovation funding, review of NIA and precursor documentation suggests that this technical method and monitor cost, focused on the capability to locating early development arc-faults has not previously been supported.

If applicable, justify why you are undertaking a Project similar to those being carried out by any other Network Licensees.

N/A

Additional Governance Requirements

Please identify that the project is innovative (i.e. not business as usual) and has an unproven business case where the risk warrants a limited Research, Development or Demonstration Project to demonstrate its effectiveness ☒

i) Please identify why the project is innovative and has not been tried before

The project brings together a technically alternative approach to identifying fault locations, building on established substation monitoring equipment, providing a lower cost point device/system than is currently available. If this proves technically viable, then the lower cost point offers the potential for wider cost-beneficial deployment of systems to monitor networks and locate damage locations before they become subject to repeated incidents, a common feature of network fault development. Wider deployment could lead to improved reliability of electricity network, the reliance on which is likely to grow significantly in the future.

ii) Please identify why the Network Licensee will not fund such a Project as part of its business as usual activities

Given the current Technical Readiness Level of the product is 5, it is not yet appropriate to roll out such a product as part of business as usual activities.

iii) 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

Whilst the equipment provider has undertaken modelling and limited field testing of the product they have developed to date, the technical performance of the units cannot be fully tuned and demonstrated without systematic trialing on real world networks and the faults that occur on them. NIA support can provide this systematic testing.

Additional Registration Questions

These are required for summary section of registration; some areas can be copied from sections above.

Technologies (select all that apply)

☐ Active Network Management	☐ Environmental	☒ Network Monitoring
☒ Asset Management	☐ Fault Current	☐ Overhead Lines
☐ Carbon emission Reduction Technologies	☐ Fault Level	☐ Photovoltaics
☐ Commercial	☒ Fault Management	☐ Protection
☒ Condition Monitoring	☐ Harmonics	☐ Resilience
☐ Community Schemes	☐ Health & Safety	☐ Stakeholder Engagement
☐ Comms & IT	☐ Heat Pumps	☒ Substation Monitoring
☐ Conductors	☐ High Voltage Technology	☐ Substations
☐ Control Systems	☐ HVDC	☐ System security
☐ Cyber Security	☐ Low Carbon Generation	☐ Transformers
☐ Demand Response	☒ LV & 11Kv Networks	☐ Voltage Control
☐ Demand Side Management	☐ Maintenance & Inspection	☐ Gas Distribution
☐ Distributed Generation	☒ Measurement	☐ Gas Transmission
☐ Electric Vehicles	☐ Meshed Networks	☒ Electricity Distribution
☐ Energy Storage	☐ Networks Automation	☐ Electricity Transmission

Project Short Name

ALARM (Automatic Location of Arc-faults through Remote Monitoring)

Project Introduction

The project will demonstrate an alternative approach to identifying the location of transient LV (pecking) faults while the cable is in normal service, before they have developed to a permanent fault requiring immediate location and repair. The project will achieve this by installing 26 newly developed monitoring devices at selected sites in the East Midlands region, and assessing the effectiveness of the associated distance to fault calculation results on real networks in normal service.

Project Benefits

The project aims to provide non-financial benefits to customers through a reduction in the number of supply interruptions due to transient fuse-operating faults, reducing customer inconvenience. These same avoided interruptions also have a potential financial benefit for WPD through a reduction in the number (and associated cost) of fuse operation incidents, and also through the regulatory Interruption Incentive Scheme (IIS). These potential financial benefits are balanced against the cost of purchasing and installing such monitoring systems. For a five year period, considering the East Midlands region, the potential savings of a successful lower cost monitoring system are modelled as £686,000.

This project has been approved by a senior member of staff.