NIA Project Registration and PEA Document

Date of Submission

Feb 2019

Project Reference Number

NIA_UKPN0047

Project Registration

Project Title

HV Feeder monitoring to pre-empt faults

Project Reference Number

NIA_UKPN0047

Project Licensee(s)

UK Power Networks

Project Start

February 2019

Project Duration

4 years and 2 months

Nominated Project Contact(s)

Chino Atako, Kevin Dennis

Project Budget

£2,107,303.78

Summary

Distribution Network Operators (DNOs) experience faults on their electricity distribution networks, which result in Customer Interruptions (CIs) and Customer Minutes Lost (CMLs). Most CIs and CMLs are incurred on the high voltage (HV) network. DNOs implement a number of measures to reduce the amount of CIs and CMLs incurred, for example through switching via automation and or remote control, use of protection relays to identify faults and minimise impact. However, these measures mostly only address scenarios where the fault has already materialised. Further improvements in network performance and reduction in operating costs could be achieved if DNOs are able to monitor key network characteristics, e.g. voltage and current in real-time, and carry out interventions (e.g. asset or component repairs) before a fault materialises. Monitoring network characteristics in real-time presents some practical challenges and considerations. For example:

•	What are the typical network characteristics that are identifiable before different types of faults?
•	How would the location of the emerging fault be identified?
•	What are the operational processes and steps that would need to be followed to successfully pre-empt an emerging fault?

This project aims to test a solution, "Distribution Fault Anticipation" (DFA), to monitor feeders to pre-empt faults. The DFA solution consists of a disturbance recorder (which can be installed on HV or 33kV feeders to monitor network characteristics) and a "Master station" (a cloud-based service which provides the secure conduit and main data repository between the DFA and the DNO). This will be trialed alongside a network analysis tool (ASPEN Distriview) and Fault Passage Indicators (FPIs) to monitor a selection of HV and 33kV feeders and expectantly identify the location of network issues before they manifest into faults.

Nominated Contact Email Address(es)

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Problem Being Solved

Distribution Network Operators (DNOs) experience faults on their electricity distribution networks, which result in Customer

Interruptions (CIs) and Customer Minutes Lost (CMLs). Most CIs and CMLs are incurred on the high voltage (HV) network. DNOs implement a number of measures to reduce the amount of CIs and CMLs incurred, for example through switching via automation and or remote control, use of protection relays to identify faults and minimize impact. However, these measures mostly only address scenarios where the fault has already materialized. Further improvements in network performance and reduction in operating costs could be achieved if DNOs are able to monitor key network characteristics, e.g. voltage and current in real-time, and carry out interventions (e.g. asset or component repairs) before a fault materializes. Monitoring network characteristics in real-time presents some practical challenges and considerations. For example: "what are the typical network characteristics that are identifiable before different types of faults?", "how would the location of the emerging fault be identified?", "what are the operational processes and steps that would need to be followed to successfully pre-empt an emerging fault?"

This project aims to test a solution, "Distribution Fault Anticipation" (DFA), to monitor feeders to pre-empt faults. The DFA solution consists of a disturbance recorder (which can be installed on HV or 33kV feeders to monitor network characteristics) and a "Master station" (a cloud-based service which provides the secure conduit and main data repository between the DFA and the DNO). This will be trialed alongside a network analysis tool (ASPEN Distriview) and Fault Passage Indicators (FPIs) to monitor a selection of HV and 33kV feeders and expectantly identify the location of network issues before they materialize into faults.

Method(s)

January 2022 Update:

This change request is for approval of a six-month extension to the project and to increase the overall budget of the project by £100,790, to cover additional project costs in Scottish and Southern Electricity Networks (SSEN).

Approval of the project extension will allow UK Power Networks (UKPN) and SSEN to achieve key project outcomes.
• Complete all outstanding installations on the project (6 DFA devices in SSEN, and 5 ground-mounted FPIs in UKPN); delays to installations were due to limited resource availability and COVID-19.
• Collate additional evidence to validate the use of the Distribution Fault Anticipation (DFA) solution as an effective means of pre-empting faults on the distribution network.
• Collate, review, and finalise requirements for a potential transition of the solution to business-as-usual (BAU) activities.

Approval of the additional funds will support additional costs to SSEN, during the six-month extension, and for a further six-month transition period, and will include:
• Licensing and support costs for the DFA solution
• Nortech project support costs
• Internal labour costs for installations
Similar costs in UKPN will be funded within the existing project budget and contingency.

The scope of the project, including the aims and objectives, remain unchanged.

This project involves the trial of the Distribution Fault Anticipation device, DFA-Plus, to pre-empt faults on the electricity distribution network. The DFA-plus is an on-line monitoring device typically installed at a substation and used to monitor outgoing feeders from the substation. The DFA applies sophisticated high-precision waveform analysis to the data (real-time current and voltage) that it captures. It compares the detected activity to an internal library of known activity characteristics including high impedance faults. The device then determines whether the data is normal or abnormal and if abnormal, matches the activity with the most likely fault type via proprietary analysis. It then reports findings via a web-based interface, emails or SMS.

The aim of the project is to test the functionality of the DFA device alongside other network monitoring equipment such as fault passage indicators, to determine if it is an effective means of identifying and locating network anomalies on HV and 33kV feeders before they materialise into faults. Key activities that will be carried out during the project include:

• Select 32 typical feeders across two DNO Groups (16 in UK Power Networks, and 16 in Scottish and Southern Electricity Networks) ensuring that we have a mix of predominantly underground feeders, overhead feeders and feeders with both underground and overhead sections. (Note: the original project plan was to select 47 feeders across three DNO groups – UKPN, SSEN and SPEN. However, SPEN withdrew from the project after stage one)

• Install disturbance recorders (DFAs) at the source Primary or Grid substations for each of the selected feeders

• Install fault passage indicators at strategic points on the feeders (for both underground and overhead sections and tee'd sections)

• Monitor "events" (disturbances or significant changes to network characteristics) on each feeder and individual sections via the

disturbance recorders and FPIs installed on the network

- Compare "events" to a library of known activity characteristics for various types of faults (including high impedance faults).

- Investigate "events" (field investigations) to identify issues (emerging faults) on the network

- Carry out proactive repairs to resolve pre-fault disturbances

- Update library of known pre-fault disturbances

August 2022 Update:

This change request is for approval of a seven-month extension to the project (taking the project end date to 31 March 2023) and to increase the overall budget of the project by £192,202.78 to cover additional project costs in Scottish and Southern Electricity Networks (SSEN) and UK Power Networks (UKPN). The outstanding installations in SSEN and UKPN were as a result of technical challenges in some of the selected sites.

The proposed scope for the time extension to 31st March 2023 is summarised below:

• Installation of outstanding DFA-Plus units; 1 in UKPN and 5 in SSEN.
• Redeployment of one or more units in SSEN, to feeders in Scotland.
• Continuous monitoring of DFAs and FPIs via the DFA portal and the iHost platform respectively.
• Field investigations of DFA and FPI notifications.
• Comparison of DFA and FPI notifications to other network data to validate outcomes.
• Completion of a final report outlining findings and post-project proposals.

This project involves the trial of the Distribution Fault Anticipation device, DFA-Plus, to pre-empt faults on the electricity distribution network. The DFA-plus is a single-ended on-line monitoring device typically installed at a substation and used to monitor outgoing feeders from the substation (illustrated in Figure 1). The DFA applies sophisticated high-precision waveform analysis to the data (real-time current and voltage) that it captures. It compares the detected activity to an internal library of known activity characteristics including high impedance faults. The device then determines whether the data is normal or abnormal and if abnormal, matches the activity with the most likely fault type via proprietary analysis. It then reports findings via a web-based interface, emails or sms.

Scope

The project will be carried out in three stages, over a two-year period, each stage dependent on the success of the previous stage. Details of the stages are given below:

1. Stage one: Tests at the Power Networks Demonstration Centre (PNDC) managed by the University of Strathclyde. To include:

o Trial of 2 DFA devices, 3 ground-mounted FPIs, 3 pole-mounted FPIs and ASPEN Distriview

o Test process integration of the DFA devices with 3G/4G/other communications, FPIs etc.

o Test four typical pre-fault scenarios which will be simulated on the test electricity distribution network

o Duration – Two weeks

2. Stage two: Network trials in UK Power Networks and Scottish and Southern Electricity Networks. To include:

o UK Power Networks and Scottish and Southern Electricity Networks each with 11 DFAs, 10 ground-mounted FPIs and 10 pole-mounted FPIs. Note: the 2 DFA devices from stage one will be reused in the network trials alongside 20 new DFA devices

o Develop and test operational process and practicalities of the solution, develop operational experience, review performance.

o Duration - Initially for 6 months and then through until the end of the project, if the project proceeds to stage three.

3. Stage three: Extended network trial in UK Power Networks and Scottish and Southern Electricity Networks. To include:

o   Scottish and Southern Electricity Networks with 5 DFA devices, 10 ground-mounted FPIs and 10 pole-mounted FPIs;

o   UK Power Networks with 5 new DFA devices (in addition to the devices used in stage 2);

o   Refine operational process, increase operational experience; review performance; and

o   Duration - 18 months (this was the original plan; the project is now being extended to end on 31 March 2023).

The proposed approach would enable us to demonstrate process-level integration with UK systems and gain operational experience in trying to pre-empt faults.

Objective(s)

The objectives of the project are to:

•   Validate the process of sampling network characteristics (such as voltage and current), using DFA devices, in real-time to identify pre-fault disturbances;

•   Validate the process of analysing system performance, and sending notifications of pre-fault disturbances, in real-time;

•   Prove the analytical capability of the DFA devices to identify different types of pre-fault conditions in real-world environments;

•   Develop and validate a process to use outputs of multiple tools (DFA devices, FPIs, protection, modelling tools etc.) to identify the source and location of pre-fault disturbances;

•   Develop and validate an operational process for responding to DFA outputs and carrying out repairs to pre-empt faults.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

n/a

Success Criteria

The criteria will be used to determine whether the project has been successful:

•   Consistent delivery of notifications or identification of disturbances (pre-fault conditions), via the DFA online portal, detected on the electricity distribution network.

•   Field confirmation of emerging faults, following investigations of notifications.

•   Proof of savings (including finance, CO_2 emissions, QoS performance) as a result of DFA devices on feeders during the trial period.

Project Partners and External Funding

The project partners for this project will be Lord Consulting (Australia and New Zealand), Nortech Management Ltd (UK) and Power Networks Demonstration Centre. The Energy Innovation Centre will also provide administrative support on the project.

Potential for New Learning

This project has a high potential to deliver new learning with regards to:

•   The method's viability to consistently identify disturbances on the electricity network, in real-time;

•   Provide accurate location of the disturbances;

•   Effective process to utilise disturbance recorder outputs to identify and repair network disturbances before they materialize into faults.

The learning form the project will be shared via the ENA smarter networks portal and other industry portals, via reports and

presentation.

Scale of Project

The project will be completed as a collaborative project between UK Power Networks and Scottish and Southern Electricity Networks. This will involve field trials of 32 DFA devices, on HV and 33kV feeders, spread across the five DNOs operated by UK Power Networks and Scottish and Southern Electricity Networks.

Technology Readiness at Start

TRL6 Large Scale

Technology Readiness at End

TRL8 Active Commissioning

Geographical Area

The geographical areas served by the five DNOs managed by UK Power Networks and Scottish and Southern Electricity Networks:

UK Power Networks (London Power Networks plc, South Eastern Power Networks plc, Eastern Power Networks plc); Scottish and Southern Energy (Scottish Hydro Electric Power Distribution plc, Southern Electric Power Distribution plc)

Revenue Allowed for the RIIO Settlement

No revenue has been allowed for this project in the RIIO-ED1 settlement.

Indicative Total NIA Project Expenditure

The total allowable expenditure on the project in RIIO-ED1 is £1,896,573.40 with the following amounts for the three DNO Groups: UKPN: £841,695.10 SSEN: £829,878.30 SPEN: £225,000.00 No revenue has been allowed for this project in the next price control review period RIIO-2; the project will be completed before RIIO-2.

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)

Gross Annual savings following deployment of 60 DFA devices across UKPN and SSEN (i.e. 30 per DNO) is £853,500.
This assumes that we are able to pre-empt 8 faults per year (by carrying out proactive repairs) with the proposed solution. It also assumes that proactive repairs are at least 40% cheaper than reactive fault repairs. The savings also exclude the cost of rolling out the devices (capital cost of the devices) ,
includes £1,344,000 of operational savings (based on an assumed 40% reduction in fault repair costs) and includes £490,500 of recurring costs for the solution.

Please provide a calculation of the expected benefits the Solution

A CBA has been used to confirm expected return from this project if successful. There will be a net benefit of £1,231,443.68 during RIIO-ED2. This is at project scale (32 DFA devices across UKPN and SSEN) and includes: testing of the solution, operational trials to develop processes and recurring costs for maintaining the solution until the end of RIIO-ED2. A breakdown of the costs and savings is given below:

• Base Cost: £5,768,341.20
• Method cost: £5,962,914.98
• Benefits/Savings: £1,426,017.46
• NPV: Base Cost - (Method Cost - Benefits): £1,231,443.68

The following assumptions were used to calculate the benefits:

• The solution will pre-empt 8 faults, 0.0226 CI/100cc and 0.0171 CML on each feeder per year, by enabling the DNOs to carry out proactive repairs.
• Proactive repairs are at least 40% cheaper than reactive fault repairs (note operational savings for the DNOs).
• The three DNOs are able to claim QoS benefits from outperformance of OFGEM CI and CML targets.

OFGEM CI and CML targets.

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

The approach, using DFA to pre-empt faults, will be applicable to other DNOs due to the similarity in their distribution network design and typical network configurations. The solution will be best suited to worst performing feeders, and will deliver operational benefits where there are four or more faults per year.

DNOs will need to install the DFA devices and implement the solution based on the learning from the project. The DFA devices are relatively easy to install and can utilise existing VTs and protection CTs at Primary substations.

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

The cost of rolling out the Method across GB would depend on the commercial rates agreed with the DFA supplier. However at the project rates (£15,000 per DFA device), the method will cost ~£1.5m plus recurring costs for communications, inspections and maintenance, field investigations to verify network disturbances , assuming it is rolled out across 100 feeders across the UK.

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 DFA solution has been used successfully to pre-empt faults in the USA, Australia and New Zealand. However, the technology is unproven in the UK. The operational voltages, typical network running arrangements and operational challenges in the UK are different to the USA, Australia and New Zealand. This project aims to determine whether the DFA solution is a viable solution for pre-empting faults on UK distribution networks.

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

This project addresses a number of areas identified in some UK DNO's innovation strategies including:

1. Increase efficiencies: By validating and applying this approach to pre-empt faults, UK DNOs will reduce the number of HV and 33kV faults that occur and the overall fault repair costs.

2. Improve quality of supply: By identifying pre-fault conditions and carrying out repairs before they materialize, DNOs will be able to reduce Customer Interruptions (CIs) and Customer Minutes Lost (CMLs) incurred each year.

3. Continuous improvement: This project will trial a novel application of existing technologies and will provide a platform for continuous improvement in distribution network management.

☑ 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.

As part of the process to develop the project scope, UK Power Networks placed a call for solutions for FHV feeder monitoring via the Energy Innovation Centre. No identical solutions were found via this process. A review of previous IFI, NIA and NIC projects also did not reveal any similar solutions.

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

The project is innovative because it is using existing technologies in a novel way to identify emerging problems on the distribution network. The key innovative aspects of the project include: • Using sampling of network data at high frequencies and waveform analysis to identify disturbances; • Comparing these disturbances to a library of typical disturbance patterns for different types of faults; • Augmenting the process with Fault Passage Indicators which have been tuned to identify disturbances; and • Using a modeling tool and outputs from the DFA devices to identify the source of disturbances on a HV feeder. This approach has not been tried before because there was no known library of disturbances for different types of HV faults in the UK. The library that will be used on the project has been developed from other trials in the USA, Australia and New Zealand.

Relevant Foreground IPR

n/a

Data Access Details

Waveform data will be captured for each network disturbance recorded by the Distribution Fault Anticipation devices. Examples of waveforms that are characteristic of different types of network disturbances and faults will be included in the final report.

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

The Network Licensee is not funding the project's business as usual activities due to the significant initial cost to validate the solution via network trials. There are no allowances in the RIIO-ED1 plans to fund this work. There is also some risk that the proposed trial may highlight operational challenges that have not yet been highlighted from a desktop review of the solution.

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 is also some risk that the proposed trial may highlight other operational challenges that have not yet been highlighted from a desktop review of the solution.

This project has been approved by a senior member of staff

☑ Yes