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NIA Project Registration and PEA Document

Date of Submission

Mar 2018

Project Reference Number

NIA_NPG_021

Project Registration

Project Title

Holistic Fault Prediction

Project Reference Number

NIA_NPG_021

Project Licensee(s)

Northern Powergrid

Project Start

March 2018

Project Duration

4 years and 1 month

Nominated Project Contact(s)

Neil Dunn-Birch

Project Budget

£400,000.00

Summary

Historically fault location techniques have predominantly been applied to any incidents on the network that generates fault current, both intermittently occurring faults or when the fault is permanent. This applies equally to the low voltage network and the high voltage network. The primary driver has been to protect the network's infrastructure from serious damage that can result in hazardous and unsafe conditions as a result of the continued flow of fault current. This is achieved by protection systems that interrupt fault current in as short a time as possible to limit any damage and to minimise the duration of interruptions to customers' supplies. This is an inherently reactive approach.

In the interests of improving customer service it is beneficial to try to avoid such unplanned interruptions by anticipating when a circuit's performance is rapidly degrading.

Ideally we can then anticipate when a fault will occur and arrange for a live line work or a planned interruption to repair a circuit before it becomes either intermittent or permanent. This will provide both an improvement to customer service and, as a result of replacing reactive with proactive interventions should also improve operational planning and efficiency.

Nominated Contact Email Address(es)

yourpowergrid@northernpowergrid.com

Problem Being Solved

Historically fault location techniques have predominantly been applied to any incidents on the network that generates fault current, both intermittently occurring faults or when the fault is permanent. This applies equally to the low voltage network and the high voltage network. The primary driver has been to protect the network's infrastructure from serious damage that can result in hazardous and unsafe conditions as a result of the continued flow of fault current. This is achieved by protection systems that interrupt fault current in as short a time as possible to limit any damage and to minimise the duration of interruptions to customers' supplies. This is an

inherently reactive approach.

In the interests of improving customer service it is beneficial to try to avoid such unplanned interruptions by anticipating when a circuit's performance is rapidly degrading. Ideally we can then anticipate when a fault will occur and arrange for a live line work or a planned interruption to repair a circuit before it becomes either intermittent or permanent. This will provide both an improvement to customer service and, as a result of replacing reactive with proactive interventions should also improve operational planning and efficiency.

Method(s)

To address these issues large amounts of network data are currently available at all voltages and associated with many different types of assets. Traditionally we have looked at such data as single variables and normally when associated with the identification and diagnosis of a particular, specific and usually active fault type. Much broader analysis of network data-flows are possible. Particular types of network activity may be characteristic of developing, but not yet active, faults. Broad holistic and interactive assessment across single and multiple data-sets may give additional insight where, for instance, disturbances on the LV network when correctly interpreted with HV network information give indications of impending faults that would not be detected by looking at any single dataset.

This is a programme of work which will uncover, evaluate and prototype a range of deep data analysis algorithms and techniques which could be used to provide fault anticipation functionality within a Distribution Network Operator's system. The programme will include prototype software and end user case studies, and from this an appropriate commercial development and deployment strategy will be developed for the future. Practical deployment and commissioning issues will be identified to support the move to "Business as Usual".

The work is speculative and the underlying basis is not currently well characterised. The project will be delivered via high-end university resource through the establishment of one or more PhD projects through the Future Power Networks & Smart Grids Centre for Doctoral Training

Scope

The most promising opportunities for this approach have not yet been identified and as such all datasets relevant to assets at any voltage level are deemed within scope.

Objective(s)

The project will:

- Identify suitable existing data sets and data analysis algorithms and techniques which could be used to provide fault anticipation functionality using operational and other datasets available within Northern Powergrid and/or other DNOs or external sources. This may include those related to previous LCNF and current NIA projects, e.g. Customer Led Network Revolution and Smart Data).
- Audit the data and monitoring systems deployed and under development at Northern Powergrid in order to support the requirements analysis and specification activities for fault anticipation. This will also provide knowledge and understanding of practical ways to access data in real-time for fault anticipation.
- Make recommendations for specifications for and approaches to the capture of suitable data for fault anticipation and interpretation for any network.
- Research and develop holistic, multivariable data analysis algorithms that can interpret signals and their interaction and identify complex degradation modes in advance of failures, in order to predict faults and enable network intervention before outages can impact customers.
- Prototype a fault anticipation decision support system for operational engineers based on the algorithms and techniques identified above.
- Report on the findings and learning from the project to other DNOs and interested parties..

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

n/a

Success Criteria

Assessment of whether the primary objectives can in fact be achieved by technologies available or developed through the project are the primary determinants of success. The approach proposed is new to electricity networks and the utility of such approaches needs to be determined as part of the project.

Dissemination of project outcomes, whatever they are, is a core success criterion.

Project Partners and External Funding

EPSRC Centre for Doctoral Training in Future Power Networks & Smart Grids (University of Strathclyde and Imperial College). £200k. The CDT includes several key industry stakeholders including other DNOs, and equipment manufacturers.

Potential for New Learning

The project brings an increase level of sophistication to the analysis and anticipation of network faults. As far as can be determined no

such system, based on complex variable interaction, across large parts of a network in order to determine local network health has been attempted. As such the learning generated will be new and unique. The project outcomes will be specifically useful for all DNO networks but will also be generally useful in that a new approach applicable to many types of issue will have been demonstrated as applicable to electricity (and other utility) networks.

Scale of Project

The project is primarily desktop/laboratory scale. During the initial stages of the project the scale of the project as the fault anticipation methods are researched and algorithms developed the project's scale will be small, primarily academic study. Later, as suitable data gathering methods are identified, there may be monitoring of a limited number of network assets (e.g. pole mounted auto reclosing devices).

Technology Readiness at Start

TRL3 Proof of Concept

Technology Readiness at End

TRL7 Inactive Commissioning

Geographical Area

The project is applicable to both Northern Powergrid's Northeast and Yorkshire licence areas.

Revenue Allowed for the RIIO Settlement

None

Indicative Total NIA Project Expenditure

£200,000

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:

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)

The potential financial benefits to the customers result from the absence of costs associated with an interrupted power supply. The precise financial benefit to customer due to a reduction in unplanned outages is difficult to determine precisely although it is likely that there are severe financial costs associated with unanticipated outages.

Please provide a calculation of the expected benefits the Solution

Low TRL. Not applicable.

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

The methodology is applicable to all aspects of the GB network, gas as well as electricity.

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

The main costs associated with rolling out this method on the network are likely to be associated with ensuring that suitable transducers and communications links are available to collect the required data streams at a suitable frequency for fault anticipation. Such instrumentation is rapidly becoming standard across networks. Additionally the techniques are anticipated to be relevant to whatever data is available and therefore for many applications additional costs would be minimal. Other costs are related to the software algorithms to detect various types of pre-fault activity. These are likely to be relatively low although integration in control systems might be required.

An initial estimate is that significant implementation of project outputs could be undertaken for less than £250k.

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 gained from developing fault anticipation algorithms (using suitable data streams from network transducers and other sources) would be advantageous to any Distribution Network operator to reduce the number of faults.

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

Holistic fault detection and anticipation is a specific project detailed in the Northern Powergrid's Innovation Strategy. The project supports the key innovation objective of improving the reliability and availability of the network, identified by stakeholders as their most important objective. Additionally the project will potential support another specific innovation objective of reducing the overall cost of operating the network.

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.

Although previously completed work has been carried out on fault anticipation this project aims to further develop the techniques via interactive and holistic approaches. No evidence that this has previously been undertaken on the GB network could be found.

Approaches currently seem to be immature and mainly directed towards black-box machine learning approaches.

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 problem is a statistical, and interactive approach to data analysis from a broad range of sources. Whilst common for considerable time in other industries, such a manufacturing, it is not clear why this has not been trialled previously within the electricity industry. The very large data flows and the the relatively recent ability to examine these in ner to real time may have been a reason for not exploring

this area earlier..

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 outcome has a relatively high risk of technical and/or economic failure. Other projects with more favourable risk profiles have been prioritised ahead of this..

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

NIA funding has been used to match/part match EPSRC funding providing a high degree of leverage for the funds allocated. Delivery through the Strathclyde/Imperial CDT also provides additional high quality academic input to the proejct that would not be available through alternative providers.

This project has been approved by a senior member of staff

Yes