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NIA Project Registration and PEA Document

Date of Submission

May 2023

Project Reference Number

NIA2_NGET0038

Project Registration

Project Title

Network Intelligence through Probabilistic Risk Assessment Methodology (NIPRAM) to improve electricity system restoration

Project Reference Number

NIA2_NGET0038

Project Licensee(s)

National Grid Electricity Transmission

Project Start

July 2023

Project Duration

0 years and 9 months

Nominated Project Contact(s)

Tinashe E Chikohora

Project Budget

£437,968.00

Summary

Local Joint Restoration Plans (LJRP) detail the agreed method and procedures used to restore the total system following a total or partial shutdown. For Transmission Licensee's, an LJRP defines the critical assets and substations selected for initial re-energisation of the transmission network.

NGET forecasts a growth in LJRPs across the transmission system. In many cases this is where the network by design offers less redundancy or is depleted whilst network reinforcements are carried out. In these instances, optimising LJRP energisation strategies is critical.

This project seeks to demonstrate a rigorous quantitative risk analysis methodology for the pre-planning and selection of assets and substations included within LJRP's. The project will enable a greater level of intelligence relating to network performance and decision optimisation following a shutdown.

Third Party Collaborators

Aerospace Technical Services

Nominated Contact Email Address(es)

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Problem Being Solved

At present, Local Joint Restoration Plans (LJRP) restoration routes are driven primarily by electrical characteristics and pre-defined asset capabilities. The following shortfalls have been identified in current restoration strategies:

- There are limited methods to compute probabilistic measures that indicate re-energisation risk factors, probability of successful re-

energisation or time to complete energisation.

- Determination of restoration routes is largely qualitative in nature, with little consideration for asset criticality. This provides insufficient situational awareness during outage planning and control phases.
- Asset health data is not adequately incorporated into the calculation of the optimal re-energisation routes.

Method(s)

NGET recognises that the first step to address the challenges highlighted above is to select an LJRP as a use case to analyse and optimise using probabilistic risk assessment (PRA) methods.

NGET will provide system architectural data (one line diagrams), asset health data (mean time between failure, asset health indices, effective ages, etc.) and SME input. This will enable the supplier to perform a normative analysis, utilising quantitative methods to establish the risk factors and resilience of assets both individually and collectively as an LJRP route option.

The analysis methods will include:

- PRA analysis of the selected LJRP. This includes preliminary data gathering and analysis, the PRA effort, sensitivity analysis around key model parameters, and what-if analyses.
- Aggregating asset level data to construct a Bayesian network that describes the functional characteristics of the LJRP. This quantitative framework will be used to make probabilistic inferences on the system as a whole and enables the analyst to identify:
 - The top-level system probability of failure
 - A complete set of potential root causes of failure and their probabilities of occurrence
 - Ranking of assets by risk importance
- Production of a technical report in the form of a standard operating procedure, which outlines optimised routing patterns given various asset failure configurations.
- Production of decision analysis guidance for implementation of the LJRP and expected implementation timings. This will include asset criticality, risk factors and probability of successful re-energisation within a defined timescale.
- The result of this analysis will provide operators operational insight regarding asset management decisions that will maximally ensure successful re-energisation of the LJRP.

Scope

The scope of this project is limited to the assessment of a single LJRP consisting of 3 restoration route options. This use case has been selected to provide diversity of substation design, asset class and restoration routes. In total there are 11 transmission substations and 17 transmission circuits which will be subjected to detailed PRA analysis.

Each option within the LJRP will be assessed to provide:

- Quantitative measure of re-energisation risk factors.
- Probability of successful LJRP implementation.
- Establishment of optimum routing options based on network topology and time to completion.
- Asset criticality scoring.
- Targeted / enhanced asset maintenance and end of life recommendations.

Objective(s)

The objective of this project is to demonstrate the use of probabilistic risk assessments (PRA) & analysis for the purpose of system restoration. The project will provide a data driven assessment of risk factors associated with the selected LJRP. This will facilitate more advanced, intelligent decision-making during implementation of the LJRP and improve the situational awareness of current resilience levels. This effort will utilise innovative analytical methodologies to do the following:

- Demonstrate the implementation of PRA methods and techniques applicable to system restoration strategies.
- Demonstrate the establishment of a data-driven, quantitative restoration plan which considers key factors such as asset criticality.
- Compute probabilistic measures that indicate re-energisation risk factors and the probability of successful re-energisation.
- Incorporate asset conditions data into the calculation of optimal re-energisation patterns in LJRP implementation.
- Delivery of a technical report in the form of a standard operating procedure, which outlines optimised routing patterns given various asset failure configurations.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

An assessment of distributional impacts (technical, financial and wellbeing related) for this project has been carried out using a

bespoke assessment tool, which assesses the project as having a positive, negative or neutral effect on consumers in vulnerable situations. To help inform the assessment, this tool considers the categories of consumers identified in the Priority Services Register.

This project has been assessed as having an overall positive impact on consumers in vulnerable situations. The assessment has identified that this project will look to enhance network resilience, least cost decision making, transmission capability and operability that will ultimately reduce exposure costs for households.

Success Criteria

This project is deemed as successful if the 5 objectives are achieved. A proof of concept of PRA tools and techniques which can be applied across the electricity system restoration framework would define a project success.

Project Partners and External Funding

N/A

Potential for New Learning

The potential new learnings from this project are:

- Identification of PRA tools and techniques which can be used to implement new quantitative methods across the electricity system restoration framework.
- Application of normative analysis methods which can be transferred to other network assets and processes to further reduce risk cost and exposure.
- Creation of a standard operating procedure to provide data driven intelligence for LJRP implementation and creation.

The learning will be disseminated through the publication of project progress and closedown reports on the ENA portal. Various workshops and dissemination events would also be planned.

Scale of Project

The scale of the project includes the following.

- Current methodology discovery
 - Architectural data discovery
 - Asset data discovery
 - Current methodology assessment
- Data analysis
 - Asset probability of failure data
 - Consequence data analysis
- Probability Risk Analysis
 - Option 1 analysis
 - Functional block diagram and fault tree analysis
 - Probabilistic analysis & consequence analysis
- Option 2 analysis
 - Functional block diagram and fault tree analysis
 - Probabilistic analysis & consequence analysis
- Option 3 analysis
 - Functional block diagram and fault tree analysis
 - Probabilistic analysis & consequence analysis
- Results aggregation
- Final documentation and reporting

Technology Readiness at Start

TRL5 Pilot Scale

Technology Readiness at End

TRL7 Inactive Commissioning

Geographical Area

The project will largely involve data sharing and subsequent analysis by experts at Aerospace Technical Services (ATS) premises and

NGET premises.

Revenue Allowed for the RIIO Settlement

N/A

Indicative Total NIA Project Expenditure

Total NIA expenditure: £397,967.42

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:

A successful path to net zero necessitates changes our existing Electricity System Restoration (ESR) preparation arrangements. Traditionally system restoration has been dependant on conventional synchronous generators, which the transmission system was strategically reinforced around.

The ESR standards recognise a need to shift from a centralised restoration strategy to a diverse portfolio of providers to ensure effective system response. This along with a BEIS directive to restore 60% of national demand within 24 hours correlates to a greater proportion of the transmission network being utilised in system restoration.

Inverter based and grid forming technologies are also playing an increasingly important function in system restoration. The use of this technology necessitates a reliable transmission network in areas which often do not have the same level of network redundancy as large conventional power stations.

It should also be noted that the energy transition is driving a growth in network reinforcements which require system access and network outages. It is inherent that these outages deplete the resilience of the network and the impact of these on LJRP strategies is critical.

How the Project has potential to benefit consumer in vulnerable situations:

The importance of a secure electricity supply is ever increasing. The electrification of transport and heat is placing greater reliance on a secure electricity supply. The project analysis will identify the highest risk components of the system within the LJRP, which will enable decision makers to make optimal decisions on inspection, replacement, and reinforcement of those critical components, leading to improved network management decisions. These optimised network management decisions will enable more efficient use of not only operations & maintenance but capital resources resulting in cost reductions and/or reallocation of resources to reduce risk and improve the continuity of service to vulnerable customers.

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)

N/A

Please provide a calculation of the expected benefits the Solution

The benefits of this project premise on an exposure cost, which is calculated from the probability of a total or partial shutdown taken from the National Risk Register and the value of lost load within the LJRP network. A conservative estimate that the effort will reduce the LJRP implementation time by approximately 12.5% through a migration from a limited subjective/qualitative analysis to wholistic quantitative analysis. This reduces the overall exposure cost over the next 6 years by £3.41m.

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

The initial use case is based on an LJRP which will be strategically selected to provide a variety of asset classes, substation design and network complexity. In total there are 11 transmission substations and 17 transmission circuits which will be subjected to detailed PRA analysis. Already, at PST stage, SP Energy Networks (SPEN) and National Grid Electricity Distribution (NGED) have expressed interest to be kept abreast of project developments. The methods will be distributable to the wider electricity system restoration framework.

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

The costs of running the initial use case project will capacitate NGET personnel to then be able to fully deploy the same methods and analyses to other network LJRPs attributed to NGET. Whether there will be need to procure any further supervisory expertise will be tracked after project delivery. NGET personnel training costs are expected.

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

This project will use probabilistic risk analysis methods on network assets and system restoration strategies. As such, the optimisations that arise are easily adoptable in any power network system run by other relevant network and/or transmission licensees. The project outputs will enable NGET and any other transmission or distribution network operator to quantify its current state of readiness to implement an LJRP, identifying critical paths and asset criticality.

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

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.

At present, LJRP's are dictated primarily by the electrical network characteristics and defined asset capability with no quantitative consideration to network resilience or risk profiles of selected routes. Digital-Twin Enabled Innovation for Energy Network Restoration (DELIVER), NIA2_NGET0033, provides decision based on the electrical performance of the system whilst this project optimises a completely separate set of decisions based on asset condition and criticality i.e. by way of probabilistic risk assessments. The projects complement each other and are critical to implementing an LJRP successfully.

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

Currently, NGET are using a qualitative risk approach in LJRP planning. The project brings an innovative solution case by way of a wholistic quantitative risk assessment approach to improve the current and future LJRPs and decision-making. The application of these advanced quantitative methods is a first-of-its kind capability within LJRPs.

Relevant Foreground IPR

All IPR is governed by the "National Grid Standard RII0-2 Contracting Position – JOINT IP OWNERSHIP" that sets out National Grid's standard approach to Network Innovation Allowance (NIA) funded projects under the RII0-2 framework. The foreground IPR will mainly be the arising probabilistic risk assessments methods and reports, for the different options considered, and including the assets data manipulations. The background IPR for the effort will be contributed by the solution supplier.

Data Access Details

Data for this project and all other projects funded under the Network Innovation Allowance (NIA), Network Innovation Competition (NIC) or the new Strategic Innovation Fund (SIF) can be found or requested in a number of ways:

A request for information via the Smarter Networks Portal at <https://smarter.energynetworks.org>, to contact select a project and click 'Contact Lead Network'. National Grid already publishes much of the data arising from our innovation projects here so you may wish to check this website before making an application.

Via our Innovation website at <https://www.nationalgrid.com/uk/electricity-transmission/innovation>

Via our managed mailbox box.NG.ETInnovation@nationalgrid.com

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

The proposed solution is innovative in nature, with a component level of risk that is unsuitable to Business as Usual (BaU) implementation straightaway and thus BaU is not the appropriate funding mechanism for this project.

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

A total or partial shutdown of the National Electricity Transmission System is a high-risk, low probability event as captured on the UK Governments National Risk Register. The result of an ineffective system restoration to consumers is intolerable. The project settles in to get support of NIA, in a fully controlled environment where there is no risk of causing network disruptions/outages while optimisation analysis and effective mitigation methods could also be safely developed. Therefore, NIA, rather than BaU, is the appropriate funding mechanism for this project.

This project has been approved by a senior member of staff

Yes