Date of Submission

09 July 2021

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 6 pages in total.

Project Registration

Project Title

LV Predict

Project Reference

ENWL 028

Funding Licensee(s)

Electricity North West Ltd

Project Start Date

1st July 2021

Project Duration

18 months

Nominated Project Contact(s)

InnovationTeam@enwl.co.uk

Project Budget

£555,000

Problem(s)

Distribution Network Operators (DNOs) must undertake planned maintenance work on the Low Voltage (LV) cable network, based on an immediate need to respond to faults, and a longer-term condition-based replacement strategy. It is understood that the degradation of an LV cable will vary depending on many factors including, its construction, the operating environment and loading patterns.

It is widely expected that as the energy system evolves to meet net zero targets, there will be greater electrification of energy (particularly heat and transport), increasing both the mean and volatility of demands across the network, with the greatest impacts expected on the LV system and, in particular, underground cables. This increase in demand on the LV system is expected to increase the degradation rate of cables, eventually leading to higher failure rates. To support electrification and to ensure the robustness of the network, a better understanding of the effect of changes on the LV cable network is required. This relationship, along with relationships related to environmental conditions, could serve as the basis of a more sophisticated risk-based approach to prioritise investment in a more efficient manner while reducing outage risks.

Method(s)

The project will develop a probabilistic framework which predicts the current state of the LV assets across a representative part of the network, most likely as a probability distribution of times to failure, or equivalently the probability of failure in a specific time interval. LV assets are those defined as operating at nominal voltages below 1kV and, for the purposes of this project, we will focus initially on the 400/230V cable network. The model aims to project the estimated degradation trajectory (likely manifesting as increasing failure probabilities) of the LV assets, based on a range of future operating scenarios. This will highlight the high-risk regions of the network that may require future investment to prepare for the increased demand on the network from the transition to Net Zero.

The probabilistic framework will likely be based on Bayesian statistical methods, allowing a precise model to be built using a combination of data and expert opinion, accounting for the varying quality across data sources, to output a probabilistic solution that fully accounts for all identified sources of uncertainty.

The framework will initially be constructed for one cable type and then expanded to cover other cable types and will consist of three internal models: a network demand model, a model of environmental conditions and a degradation model.

- The demand model will include a statistical characterisation of past and present demand patterns, as well as a representation of the way in which these would change if future developments were to follow a particular long-term and large-scale scenario. This will incorporate a wide range of possible data sources including different combinations of smart meters, annual consumption, novel LV monitors, and Maximum Demand Indicators.
- The environmental conditions model/ unit includes a probabilistic representation of the relevant environmental variables and conditions. This could include information on historical defects, ground conditions (e.g., soil chemistry, water table), road conditions and usage, weather, animal populations etc).
- The degradation model will be largely physics based, yet probabilistic in nature, representing the relationship between loading, environmental conditions, and rates of degradation.

The data will be presented visually, showing the effect of historical cable usage, environment and other factors on the LV assets' condition. These outputs will be presented in a Methods and Findings report.

The project shall identify gaps in data and the works required to take the framework to full scale implementation. These findings shall be presented in a business case which shall include cost benefit analysis of all aspects of the framework's functionality.

Scope

The project will be split into three phases:

Phase 1: Literature Review and Approach Finalisation

- Task 1.1: Literature Review: a review of current best practice, relevant innovation projects and methodologies.
- Task 1.2: Approach Finalisation: explore and decide what the user inputs and outputs of the development framework could be including;
    - Cable type
    - Historic demand, including smart meter data where available;
    - LV asset location data, including cases where there are multiple cables in the same track;
    - Novel sensor data
    - Fault data and any available defect data.

Phase 2: Framework Development,

The framework will be designed in an Agile way, iteratively increasing the functionality of the model, whilst proving that each input source is appropriate, and that the prediction accuracy is improved. This approach will reduce risk and maximise cost effectiveness.

First, a clear and complete mathematical specification of the entire problem will be written, allowing a skeleton version of the model to be built relatively quickly, and the complexity and performance of the model will develop over time. This will provide an unambiguous statement of all assumptions, physical constraints, damage functions, data transformations etc.

New functionality is added to the framework and underlying models; for example, adding environment information to the degradation model. Elements of the algorithm will be implemented in code and tested before finalising, this allows for practicalities in the model implementation to feedback to the design of the algorithms.

Phase 3: Business Case Development and Data Visualisation
Task 3.1: Finalisation of Business Case: develop a full business case for further development and/or implementation of the model
Task 3.2: Produce Data Visualisation Outputs: produce the required data visualisation outputs to demonstrate the results

Objective(s)

Each phase will have the following objectives:

Phase 1: Literature Review

- To understand best practice, innovations, and methodologies for modelling the degradation of LV assets. This will include review into generic methods to model the degradation of the polymers used in the manufacture of LV cable insulation, as well as more 'random' events such as rodent damage and roadworks.

Phase 2: Framework Development

- Develop a framework that is useful when testing a range of assumed model structures, and associated algorithms, to determine how accurately they can predict the current and future values of LV asset failure rates.
- To conduct as much validation of the models being trialed as is possible, to judge and communicate exactly what can and cannot be concluded.
- Identify gaps in both data and knowledge that could be populated at a later date.

Phase 3: Business Case Development and Data Visualisation

- Understand the business case for implementation or further development of the framework.
- Investigate data visualisation methods to present and interpret the results of the model.

Success Criteria

This project shall deliver success by developing the following key deliverables:

1) A Literature Review outlining best practice, innovations and methodologies for modelling the degradation of LV assets.
2) Delivery of a prototype analytical framework that enables testing of a range of assumed model structures, and associated algorithms, to provide and compare predictions of current and future values of LV asset failure rates.
3) Drawing from the literature review and the analytical framework development gaps in both data and knowledge will be identified that can be fed back into the models/algorithms as appropriate.
4) Preparation of data visualisation outputs to present and interpret the results of the model.
5) Delivery of the Business Case for implementing further development of the framework.

Technology Readiness Level at Start	**Technology Readiness Level at Completion**
2	4

Project Partners and External Funding

Frazer-Nash Consultancy and TNEI

Potential for New Learning

A variety of new learning shall be generated through development of the probabilistic framework. Learning shall include:

- A detailed understanding of the data sources available within DNOs and external data sources that could contribute to improved understanding of Low Voltage asset condition.
- Gaps in knowledge and data required to make timely and effective network interventions shall be discovered and documented.
- Immediate uses for the framework shall be established and documented.
- Interactions between network demand, environmental and mechanical degradation aspects that contribute to LV asset condition shall be tested to better understand the factors that contribute to LV network degradation mechanisms.
- The business case shall identify the current barriers and solutions, on a cost-benefit basis, for achieving optimum LV network management.

Scale of Project

Development of a prototype framework with effective visualization of findings

Geographical Area

Trial data will be gathered from Electricity North West's license area but will include consultation with other network Licensees

Revenue Allowed for in the RIIO Settlement

None

Indicative Total NIA Project Expenditure

£500,000

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 learning shall have a variety of uses including:

- Utilising calculations and algorithms to help support asset interventions and asset management decision making
- Identify future investment requirements to improve LV asset related data collection
- Utilise environmental data in combination with asset information.

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

This project addresses the objective of increasing lifespan and improve health of existing assets which forsm part of our Optimised assets and practices themes.

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

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

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

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

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

This project could contribute to investment efficiencies in relation to LV cables and other LV asset investments. The business case to be generated as part of the project shall clearly define the potential benefits moving forward.

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).

Research Project only

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.

This project will be replicable to all electricity distribution network licensees and DNOs shall be consulted throughout the project.

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

Immediate opportunities can be in the form of calculations within the probabilistic framework for cable health prediction and shall be documented and shared through project reporting and presentations. These may be adopted by networks at low-cost. However, the business case work stream shall identify gaps in data and longer-term opportunities for improvements, and set out the additional effort required for roll-out.

2c. Does Not Lead to Unnecessary Duplication ☒

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

A review of the smarter networks portal has revealed there are no other projects or initiatives in the UK which are focused on development of a novel framework for LV network assets, combining demand, environmental and mechanical degradation mechanisms.

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

Not Applicable

Additional Governance Requirements
The project is innovative (ie 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.

There has been no previous research in the UK that combines demand information, with environmental and mechanical degradation mechanisms to develop a probabilistic framework that can be used to help inform asset management interventions.

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

The interactions between LV assets (cables in particular), and their environment is largely unknown. Therefore, there is a great deal of uncertainty surrounding these interactions. Utilizing the data categories (environmental, electrical, mechanical etc.) collectively is currently not a business-as-usual methodology so needs significant research ahead of being so.

iii) Please identify why the Project can only be undertaken with the support of the NIA, including reference to the specific risks (eg commercial, technical, operational or regulatory) associated with the Project

There are technical and operational risks associated with the project that need to be further understood including:

- There is a risk that incorrect decisions are made through combining new and novel data sets in novel ways.
- Without validation of the LV Predict methodology, there is a network availability risk related to potential overseen incidents.
- There is a risk that gaps in data and data quality contribute to unforeseen operational consequences.

Has been approved by senior member of staff ☒

Additional Registration Information

Short Name

LV Predict

Introduction

The Low Voltage (LV) distribution network (defined as 1kV and below) represents a significant proportion of network expenditure, yet until recently there has been relatively poor visibility of these assets.

This project will identify and test novel methodologies that could contribute to enhanced asset management for LV network assets by introducing predictive methods based on models that can determine the probability of failure. The quantitative analysis within the project will focus on LV cables, but we anticipate there will be broader learning for other asset types. A business case for implementing further development of the framework shall also be prepared.

Benefits

The output from this work will be the results from a prototype predictive framework that aims to predict the condition of the LV network and forecast the degradation of the network assets through-time based on a range of operating scenarios. Networks will have the opportunity to benefit from increased understanding of how LV assets, in particular, LV cables interact with their environment. In addition, initial results for the prediction of the current condition of the LV network and the forecasted degradation that may lead to short term improvement opportunities. A business case development for further research shall outline future development opportunities, with the eventual target of business as usual implementation.

Technologies (Please Select one of the following)

Active Network Management	☐
Asset Management	☒
Carbon Emission Reduction Technologies	☐
Commercial	☐
Comms & IT	☐
Community Schemes	☐
Condition Monitoring	☐
Conductors	☐
Control Systems	☐
Cyber Security	☐
Demand Response	☐
Demand Side Management	☐
Distributed Generation	☐

Electric Vehicles	☐
Energy Storage	☐
Energy Storage and Demand Response	☐
Environmental	☐
Fault Current	☐
Fault Level	☐
Fault Management	☐
Harmonics	☐
Health & Safety	☐
Heat Pumps	☐
High Voltage Technology	☐
HVDC	☐
Low Carbon Generation	☐
LV & 11kV Networks	☐
Maintenance & Inspection	☐
Measurement	☐
Meshed Networks	☐
Modelling	☐
Network Automation	☐
Network Monitoring	☐
Offshore Transmission	☐

Overhead Lines	☐
Photovoltaics	☐
Pre-Heat	☐
Protection	☐
Resilience	☐
Stakeholder Engagement	☐
Substation Monitoring	☐
Substations	☐
System Security	☐
Transformers	☐
Voltage Control	☐
Gas Distribution Networks	☐
Gas Transmission Networks	☐
Electricity Transmission Networks	☐