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## NIA Project Registration and PEA Document

### Date of Submission

May 2026

### Project Reference Number

NGED\_NIA\_089

## Project Registration

### Project Title

LUCID-LV: Learning Unknown Cable Impedance from Demand – Low Voltage

### Project Reference Number

NGED\_NIA\_089

### Project Licensee(s)

National Grid Electricity Distribution

### Project Start

June 2026

### Project Duration

1 year and 7 months

### Nominated Project Contact(s)

David Penfold

### Project Budget

£432,195.00

## Summary

LUCID-LV is an innovation project to improve understanding of low voltage (LV) network behaviour where existing cable data is incomplete or uncertain. The project uses smart meter voltage and demand data, combined with network topology, to infer key characteristics such as cable impedance without the need for intrusive or costly field surveys.

A key focus is extending analysis from feeder level to customer-level connections, including service cable and loop impedance, supporting more consistent assessment at the point of connection.

The project aligns with development of the Connection Readiness Indicator (CRI) and aims to enable faster, more transparent connection decisions. It is delivered by NGED in collaboration with Loughborough University (CREST), combining operational knowledge with advanced modelling expertise.

## Preceding Projects

NIA\_WPD\_066 - Smart Meter Innovations and Test Network (SMITN)

## Third Party Collaborators

Loughborough University

## Problem Being Solved

Low voltage (LV) network planning and connection assessment currently rely on incomplete and uncertain cable data, particularly for underground and service cables. A significant proportion of the network lacks accurate impedance information, meaning that modelling is often based on assumed values rather than measured or inferred characteristics.

This creates uncertainty in voltage and thermal assessments, increasing the risk of inconsistent connection decisions, inefficient use of network capacity, and potentially unnecessary or mistimed reinforcement.

The issue is becoming more critical as demand from low carbon technologies (such as electric vehicles, heat pumps, and distributed generation) increases, driving more dynamic and less predictable network behaviour.

At the same time, there is a growing requirement to assess connection capability at customer level, particularly through the development of the Connection Readiness Indicator (CRI). This requires a more granular and consistent understanding of network conditions at the point of connection, which is not currently achievable with existing data and modelling approaches.

## Method(s)

The LUCID-LV project will develop and validate methods to estimate unknown LV cable impedance and related network characteristics using existing network and smart meter datasets.

The project combines smart meter voltage and demand data with LV network topology and engineering modelling techniques to infer network behaviour under real operating conditions. The objective is to improve understanding of underground mains and service cable characteristics where asset records are incomplete, uncertain or unavailable.

The approach builds on existing LV modelling and phase identification methods, including work previously developed under SMITN, but applies these techniques specifically to impedance estimation and cable characteristic inference. The project moves away from fixed assumption-based modelling towards a more data-led approach using observed network behaviour and measured network responses.

Recent increases in smart meter penetration and improvements in network data availability now provide sufficient granularity to investigate whether impedance and related cable characteristics can be estimated without intrusive surveys or widespread physical inspection.

The project is structured into the following work packages:

- **WP1 – Feeder Selection and Data Preparation**

Selection of representative LV feeders and preparation of aligned datasets combining smart meter and network topology data. This includes initial data assessment, cleansing and validation activities.

- **WP2 – Data Processing and Architecture**

Development of data handling processes and structures to support modelling and analysis, including scalable and repeatable data preparation methods.

- **WP3 – Network Modelling and Impedance Estimation**

Application of engineering-based power flow modelling to simulate feeder behaviour and identify impedance values that align with observed smart meter data.

- **WP4 – Asset and Cable Type Inference**

Investigation of analytical and machine learning techniques to infer cable types and related characteristics from observed electrical behaviour.

- **WP5 – Validation and Accuracy Assessment**

Comparison of estimated outputs against known network records and reference datasets where available, including assessment of accuracy, uncertainty and confidence levels.

- **WP6 – Customer-Level Modelling and CRI Application**

Extension of the methods to customer-level modelling, including service cable and loop impedance estimation, to support connection assessment and development of the Connection Readiness Indicator (CRI).

- **WP7 – Outputs and Pathway to Scale**

Consolidation of findings, assessment of operational applicability and definition of a potential pathway towards larger-scale deployment.

Outputs from each stage will be iteratively refined, with learning fed back into model development. The final outputs will demonstrate how the methodology can support improved planning and connection decision-making across the LV network.

## Measurement Quality Statement and Data Quality Statement

The project will primarily utilise existing smart meter voltage and demand data, LV network topology records, and associated asset datasets provided by participating network operators. No new field measurement equipment is currently proposed within the core

project scope.

The methodology uses smart meter data as an input to infer characteristics of the LV network and associated cable impedance behaviour. The project is intended to derive network-level insights and is not designed to infer characteristics or behaviours relating to individual customers.

Data quality assessment and validation activities will be undertaken throughout the project to ensure that datasets used within modelling and impedance estimation activities are suitable, representative and traceable. This will include assessment of data completeness, temporal alignment, consistency checks, outlier identification and suitability for modelling purposes.

The project will apply engineering-based validation techniques to compare estimated impedance values and inferred cable characteristics against known network records and reference datasets where available. Assumptions, limitations, uncertainty levels and validation outcomes identified during the work will be documented within project outputs and final reports.

All data processing, cleansing, transformation and analytical methodologies will be documented within project deliverables and managed under the relevant partner quality assurance procedures. Project findings, methodologies and validation processes will be recorded in sufficient detail to support reproducibility and dissemination of learning across GB network licensees.

A Data Protection Impact Assessment (DPIA) has been completed to assess and manage privacy risks associated with the use of smart meter and network datasets within the project. The project will operate in accordance with applicable data protection legislation, internal governance procedures and agreed contractual data handling arrangements between project partners.

Where project partners or suppliers are provided access to NGED datasets or systems, appropriate security and information governance controls will apply, including controlled access arrangements, data handling procedures and relevant supplier security obligations. Data will be managed using appropriate technical and organisational controls proportionate to the sensitivity of the information being processed.

The project does not intend to publicly disclose customer-level data. Any dissemination outputs, reports or shared datasets will be aggregated and anonymised where required to ensure that no personal or commercially sensitive information is disclosed.

## Scope

The LUCID-LV project will develop and validate a methodology to improve understanding of low voltage (LV) network behaviour by estimating unknown cable impedance and related characteristics using existing data sources.

The scope covers the full process from data preparation through to application in planning and connection assessment. This includes the integration of smart meter voltage and demand data with network topology, development of modelling and inference techniques, and validation of outputs against known data.

The project will focus on both LV mains and customer-level connections, including service cable and loop impedance, reflecting the increasing need for assessment at the point of connection. Outputs will support the development of a Connection Readiness Indicator (CRI) capability, enabling more consistent and transparent connection decisions.

The project is structured as a feasibility phase and will:

- Demonstrate the technical capability to infer impedance using existing data
- Quantify accuracy, uncertainty, and applicability across different network conditions
- Assess the extent to which improved data can support planning and connection decisions
- Define a pathway for scaling and operational deployment in a follow-on project

The scope does not include full operational deployment or system integration into business-as-usual processes, which would be addressed in a subsequent phase.

The project is expected to deliver the following benefits:

For consumers

- Faster and more consistent connection assessments, reducing delays and uncertainty
- Improved transparency in connection decisions at customer level
- More efficient utilisation of existing network capacity, reducing the need for costly reinforcement

For the electricity distribution system

- Improved planning accuracy through better understanding of LV network behaviour

- Enabling automated network analysis which would otherwise fail when key network parameters are missing
- Potential to defer or avoid reinforcement by unlocking latent network capacity
- Reduced need for intrusive and costly field validation or surveys

#### Financial Benefit Context

The project represents a relatively low-cost feasibility investment (~£498k) compared to alternative approaches for improving LV network visibility.

Traditional methods, such as large-scale field validation or data collection, could require investment in the range of £6m–£50m. In contrast, this project leverages existing data to provide a scalable and cost-effective alternative.

Typical LV reinforcement schemes range from approximately £250k to over £1m per project. By improving planning accuracy and enabling better utilisation of existing assets, the project has the potential to reduce unnecessary reinforcement and deliver significant cost savings to the electricity system over time.

#### Strategic Position

The project supports wider network modernisation by enabling a transition toward data-driven planning and connection assessment. It aligns with increasing demand for customer-level visibility and supports future implementation of CRI.

As a feasibility project, the primary outcome is to demonstrate value and define a clear pathway to scale, rather than deliver immediate operational deployment.

### Objective(s)

The objective of the LUCID-LV project is to develop and validate a scalable, non-intrusive methodology for improving understanding of low voltage (LV) network behaviour by estimating unknown cable impedance and indicative asset characteristics using existing data.

The project will:

- Develop methods to infer LV cable impedance and indicative construction type using smart meter voltage and demand data aligned with network topology
- Improve understanding of network behaviour at feeder and customer level, including service cable and loop impedance
- Apply power-flow modelling and data-driven techniques to estimate network characteristics where asset data is incomplete or uncertain
- Validate inferred outputs against known network data, including use of ground-truth comparison and representative feeder testing
- Quantify the accuracy, limitations, and confidence of inferred results, including provision of confidence metrics for planning use
- Assess the impact of improved impedance data on network modelling outcomes, including voltage performance, thermal utilisation, and reinforcement targeting
- Demonstrate how outputs can support planning and connection assessment, including development of Connection Readiness Indicator (CRI) capability
- Evaluate the scalability of the approach and define requirements for integration into planning tools and business-as-usual processes
- Quantify potential benefits in reducing uncertainty, improving network utilisation, and enabling more consistent connection decisions.

### Consumer Vulnerability Impact Assessment

The LUCID-LV project is not expected to have any direct adverse impact on consumers in vulnerable situations, as it is a data-driven, non-intrusive feasibility study that does not involve physical intervention on the network or changes to customer supply.

However, the project has the potential to deliver indirect benefits by improving the accuracy and consistency of network understanding and connection assessments.

Technical impacts:

- Improved visibility of LV network behaviour at a local level may reduce the risk of voltage-related issues, including those that can disproportionately affect vulnerable customers

- More accurate modelling of network capacity can support better planning decisions, reducing the likelihood of network constraints impacting service quality

Financial impacts:

- By enabling better utilisation of existing network capacity and reducing reliance on precautionary reinforcement, the approach has the potential to lower overall network investment costs, which ultimately benefits all consumers

- More efficient connection assessment processes may reduce delays and costs associated with new connections, including for low carbon technologies such as heat pumps

Wellbeing impacts:

- Faster and more consistent connection decisions can improve customer experience, particularly for those seeking to adopt low carbon technologies that support energy affordability and comfort

- Reduced uncertainty in connection outcomes may be particularly beneficial for vulnerable customers who are less able to manage delays or unexpected costs

The project will also improve understanding of customer-level network behaviour, which may help inform future approaches to identifying and addressing areas where network constraints disproportionately affect certain groups of customers.

## Success Criteria

The success of the LUCID-LV project will be evaluated against the following criteria:

### 1. Technical feasibility demonstrated

- Successful development of methods capable of estimating LV cable impedance using smart meter voltage and demand data aligned with network topology
- Evidence that the approach can be applied across representative LV feeders with varying characteristics

### 2. Accuracy and validation performance

- Demonstration that inferred impedance values show a reasonable level of agreement with known network data (where available)
- Quantification of accuracy, limitations, and confidence levels, including clear documentation of where the approach performs well or less effectively

### 3. Customer-level modelling capability

- Successful extension of modelling from feeder-level to customer-level connections, including service cable and loop impedance estimation
- Demonstration that outputs can support assessment at the point of connection

### 4. Practical applicability for planning and connections

- Evidence that the outputs improve network modelling inputs used for voltage, thermal, and capacity assessments
- Demonstration of how the approach can support more consistent and informed connection decisions, including alignment with Connection Readiness Indicator (CRI) requirements

### 5. Scalability and integration potential

- Assessment of the requirements to scale the methodology across larger parts of the LV network
- Identification of how outputs could be integrated into existing planning tools and processes

### 6. Value and benefit assessment

- Clear articulation of the potential benefits of the approach, including reduced uncertainty, improved network utilisation, and potential to defer or avoid reinforcement
- Comparison with alternative approaches such as physical validation or network surveys

### 7. Delivery of defined project outputs

- Completion of all key project deliverables, including methodology development, validation reports, and final recommendations
- Production of a clear pathway for future development, including potential follow-on project to scale and operationalise the approach.

## Project Partners and External Funding

National Grid Electricity Distribution (NGED)

NGED is the lead funding licensee and project sponsor, responsible for project governance, provision of network data, operational insight, and ensuring alignment with planning and connection processes. NGED will also lead dissemination and assessment of how project outputs can be integrated into business-as-usual activities.

#### Loughborough University (CREST)

Loughborough University (Centre for Renewable Energy Systems Technology – CREST) is the primary delivery partner, responsible for the development of modelling approaches, data analysis, and algorithm design. This includes power-flow modelling, impedance estimation methods, and supporting validation activities.

#### Potential collaboration and data sources

The project may engage with additional stakeholders during delivery, including:

- EV charge point (EVCP) providers, to explore access to higher-resolution demand and voltage data
- Internal NGED teams (e.g. Engineering Policy, System Modelling, and Field Operations) to support validation and application of outputs

These collaborations will support the robustness of the methodology and ensure relevance to real-world network conditions.

#### External funding

The project is funded through the Network Innovation Allowance (NIA). No additional external funding has been secured at this stage.

### Potential for New Learning

The knowledge dissemination activity will cover learning from the application of methods to infer LV cable impedance using smart meter voltage and demand data aligned with network topology. This will include how well the methods perform across different network conditions, and what factors influence accuracy, such as data quality, availability, and network representation.

Learning will be generated on the integration and use of multiple data sources, including smart meter data, network records, and derived datasets. This will assess whether combining these sources improves estimation accuracy compared to existing modelling assumptions, and how sensitive the approach is to gaps or inconsistencies in the data.

The project will also provide insight into the feasibility of extending modelling to customer-level connections, including service cable and loop impedance. This will include understanding the limitations of current data, the impact of aggregation and phase identification challenges, and the extent to which reliable outputs can be produced at this level.

Additional learning will focus on the validation of inferred outputs, including comparison against known network data and the development of confidence metrics to support planning use. This will help determine how suitable the outputs are for real-world application in connection assessment and network modelling.

The project will also generate learning on the practical challenges of implementing this approach, including data alignment, computational requirements, and integration into existing planning processes. This will inform the requirements for scaling and operationalising the methodology in a future phase.

Learning will be disseminated during the project externally via:

- One or two LUCID-LV webinars
- ENA Portal

Additionally, if slots can be obtained, further dissemination will take place via

- Energy Innovation Summit
- NGED Innovation Showcase

These dissemination activities will ensure that the knowledge gained from the project is shared with other Distribution Network Operators (DNOs) and relevant stakeholders, supporting wider adoption of data-driven approaches to improving LV network understanding and connection assessment.

### Scale of Project

The LUCID-LV project will be primarily desktop-based, using smart meter data and network records to develop and test methods for estimating LV cable impedance. The project will utilise a representative sample of LV feeders selected based on data availability, network characteristics, and suitability for validation.

The selection of study areas will aim to include a diverse range of network conditions to ensure robust testing of the methodology. This includes:

- Varied LV Network Types: A mix of urban and rural feeders, with different cable types, lengths, and configurations

- **Data Availability and Quality:** Areas with sufficient smart meter coverage and network topology data to support modelling and validation
- **Customer-Level Complexity:** Networks with varying levels of service cable visibility and differing degrees of data completeness
- **Low Carbon Technology Uptake:** Areas with both low and high penetration of technologies such as EVs, heat pumps, and distributed generation

The project will initially focus on a defined set of feeders to support method development and validation, before extending testing across a broader sample of LV networks. This approach enables both detailed analysis and assessment of how the methodology performs under different real-world conditions.

While the core study will focus on a manageable number of feeders, the project is designed to test applicability at scale, including assessment of how the approach could be extended across larger portions of the LV network.

By selecting a diverse and representative sample, the project ensures that the resulting methods and learning are transferable across different network configurations. A smaller-scale project would limit the ability to test variability in network conditions and reduce confidence in the general applicability of the results.

Overall, the scale of the project is proportionate to the level of complexity and the need to generate meaningful, transferable learning, while remaining significantly lower cost than alternative approaches such as large-scale physical validation or network surveys.

### Technology Readiness at Start

TRL3 Proof of Concept

### Technology Readiness at End

TRL5 Pilot Scale

### Geographical Area

The project will be primarily desktop-based and will utilise selected areas of low voltage (LV) networks. The selection of study areas will be based on the availability and quality of smart meter voltage and demand data, alongside network topology and asset records.

The project will apply its methods to representative LV feeders across multiple primary substations to ensure a suitable range of network conditions is captured. This will include a mix of urban and rural networks, as well as areas with varying levels of low carbon technology uptake.

The Funding Licensee area for this project is within the National Grid Electricity Distribution (NGED) regions. Study areas will be selected across NGED licence areas to ensure that findings are representative and applicable at scale.

### Revenue Allowed for the RIIO Settlement

The project is a feasibility study and does not directly release or displace any revenue allowed within the current RIIO price control settlement. At this stage, no surplus funding is expected as a direct result of the project. However, the learning generated has the potential to inform future network planning and investment decisions, which may lead to more efficient use of allowed revenue in future price control periods.

### Indicative Total NIA Project Expenditure

Total Project Cost	£	500,350
Agreed Partner Contributions	£	20,134
Sub Total	£	480,216
NGED DNO Contribution	£	48,022
Funding from NIA	£	432,194

# Project Eligibility Assessment Part 1

## Requirement 1

Facilitate the energy system transition and/or benefit consumers in vulnerable situations

Please answer **at least one** of the following:

### How the Project has the potential to facilitate the energy system transition:

The LUCID-LV project supports the energy system transition by improving understanding of low voltage (LV) network behaviour, enabling more accurate and consistent assessment of network capacity for low carbon technologies (LCTs) such as electric vehicles, heat pumps, and distributed generation.

By using smart meter voltage and demand data to infer network characteristics such as cable impedance, the project reduces reliance on assumptions and incomplete asset records. This improves the accuracy of network modelling and enables more informed planning and connection decisions.

Improved visibility of network capability at customer level supports faster and more transparent connection assessments, helping to reduce delays and uncertainty for customers seeking to adopt LCTs.

The project also supports the development of the Connection Readiness Indicator (CRI), enabling pre-assessment of connection capability at the point of connection. This is expected to improve customer experience and accelerate the uptake of low carbon technologies across the LV network.

In the longer term, the approach has the potential to optimise utilisation of existing network capacity, reducing unnecessary reinforcement and supporting a more efficient and cost-effective transition to a low carbon energy system.

### 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

n/a

### Please provide a calculation and/or description of the expected benefits of the solution

This project is a feasibility study and does not deliver direct quantified financial benefits within the project duration. However, it is expected to demonstrate the potential for significant net benefits to consumers through improved network planning and connection decision-making.

The current baseline approach relies on incomplete asset data and conservative assumptions, which can result in overestimation of network constraints and unnecessary or premature reinforcement. Typical LV reinforcement schemes range from approximately £250k to over £1m per project.

By improving understanding of network behaviour using existing smart meter data, the proposed solution has the potential to:

- Reduce uncertainty in network modelling and capacity assessments
- Enable more efficient utilisation of existing network assets
- Avoid or defer reinforcement where capacity is available but not currently visible
- Support faster and more consistent connection decisions for low carbon technologies

Even a small reduction in unnecessary reinforcement or improved targeting of investment across the LV network could deliver benefits

that significantly exceed the cost of this project.

The primary recipients of these benefits are electricity consumers, through more efficient use of network investment, reduced connection delays, and improved facilitation of low carbon technology uptake.

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

The method developed in this project is expected to be highly replicable across Great Britain, as it is based on data sources and modelling approaches that are widely available to all Distribution Network Operators (DNOs).

The approach primarily uses smart meter voltage and demand data, combined with network topology and asset records. As smart meter rollout is extensive across GB and continues to increase, the method has the potential to be applied across a large proportion of LV networks.

The solution is not dependent on specific hardware deployment or bespoke monitoring infrastructure, making it suitable for application across both urban and rural networks, and across a wide range of network configurations.

It is estimated that the method could be applicable to the majority of LV feeders across GB where sufficient smart meter data and basic network topology information are available. This represents a significant proportion of the LV network.

The project will also define the data and system requirements needed for wider rollout, supporting replication across all GB DNO licence areas and integration into existing planning and connection assessment processes.

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

The method developed in this project is expected to have relatively low rollout costs compared to traditional approaches for improving network visibility.

As the solution is based on existing data sources, including smart meter voltage and demand data and network topology records, no widespread deployment of new monitoring hardware is required. This significantly reduces capital investment requirements.

Rollout costs are therefore primarily associated with:

- Integration of the methodology into existing planning and connection assessment tools
- Data processing, storage, and system configuration
- Training and adoption within operational and planning teams
- Ongoing maintenance and refinement of models

These costs are expected to be modest and scalable, particularly when compared to alternative approaches such as large-scale field surveys or deployment of additional monitoring equipment, which can require investment in the range of millions to tens of millions of pounds.

The project will define the technical and data requirements for implementation, enabling a clearer estimate of rollout costs in a follow-on phase. However, it is anticipated that the cost of deployment across GB would be low relative to the potential benefits, particularly where it enables avoidance or deferral of reinforcement.

### **Requirement 3 / 1**

Involve Research, Development or Demonstration

Projects 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

Involve Research, Development or Demonstration - Please select all that apply

- 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 generated from this project will be directly applicable to all GB Distribution Network Operators (DNOs), as it focuses on improving understanding of low voltage (LV) network behaviour using widely available data sources.

The project will provide:

- A validated methodology for estimating LV cable impedance and indicative asset characteristics using smart meter data and network topology
- Insight into the accuracy, limitations, and confidence levels of data-driven approaches to network modelling
- Defined data requirements and quality thresholds needed to apply the method effectively
- Guidance on integrating outputs into existing planning and connection assessment processes

This learning can be used by other Network Licensees to improve the accuracy of LV network models, reduce reliance on assumptions, and enhance decision-making for network planning and customer connections.

In particular, the outputs will support:

- More consistent and transparent connection assessments
- Improved utilisation of existing network capacity
- Reduced need for intrusive surveys or additional monitoring
- Development of customer-level assessment tools such as the Connection Readiness Indicator (CRI)

As the approach is software-led and based on data sources common across GB, the methodology can be readily adapted and adopted by other DNOs with minimal modification.

Learning will be disseminated through standard industry channels, including innovation reports, stakeholder engagement, and industry forums, ensuring accessibility and uptake across the sector.

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. Networks must explicitly mention similar projects that they have considered and how these differ.

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

A review of relevant innovation projects has been undertaken to ensure that this project does not duplicate existing or completed work.

While there are related initiatives exploring network visibility, phase identification (e.g. SMITN, HV Pilot), and customer connection assessment (e.g. CRI-related work), LUCID-LV addresses a distinct and currently unmet need: the estimation of LV cable impedance and indicative asset characteristics using smart meter data.

Existing projects have primarily focused on:

- Phase identification and connectivity mapping
- HV or feeder-level analysis
- Customer engagement or high-level connection assessment frameworks

In contrast, this project focuses specifically on:

- Inferring impedance at both mains and service cable level
- Extending analysis to customer-level connections
- Combining power-flow modelling with data-driven techniques to estimate unknown network parameters

The project also builds on, rather than duplicates, previous work by leveraging outputs such as phase identification (e.g. SMITN) and integrating them into a broader methodology for network understanding.

Engagement with internal stakeholders and project partners, including Loughborough University, has confirmed that this work represents a novel extension of current approaches and does not overlap with ongoing or completed projects.

Therefore, the project complements existing innovation activity and contributes new learning rather than duplicating prior work.

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

Not applicable

## **Additional Governance And Document Upload**

### **Please identify why the project is innovative and has not been tried before**

Currently, LV network modelling relies heavily on incomplete asset records and standardised assumptions. There is no established or widely deployed method for estimating impedance at scale using measured customer-level voltage and demand data. As a result, planning and connection decisions are often based on conservative assumptions rather than observed network behaviour.

This project introduces a new approach by:

- Using smart meter voltage and demand data to capture real network behaviour at customer level
- Applying power-flow modelling to infer impedance by matching model outputs to measured data
- Incorporating data-driven and machine learning techniques to improve estimation accuracy where data is incomplete
- Extending analysis beyond feeder-level modelling to include service cable and loop impedance

While elements of this approach exist in isolation (e.g. smart meter analytics, power-flow modelling), their integration into a scalable methodology for inferring LV network characteristics has not been proven or implemented in operational environments.

The project also carries technical and data-related risks, including data quality limitations, uncertainty in network topology, and challenges in validating inferred results. These risks mean the approach is not yet suitable for business-as-usual application and requires a structured feasibility project to assess its effectiveness.

Therefore, the project represents a clear departure from current practice and constitutes an innovative approach to improving LV network visibility and connection assessment capability.

### **Relevant Foreground IPR**

The project is expected to generate foreground intellectual property in the form of methodologies, algorithms, data processing techniques, and analytical frameworks for inferring LV network characteristics, including cable impedance and indicative asset attributes, from existing data sources.

This includes:

- Methods for aligning and processing smart meter voltage and demand data with network topology
- Algorithms for estimating impedance and related electrical characteristics at feeder and customer level
- Techniques for quantifying uncertainty and assigning confidence metrics to inferred outputs
- Integrated modelling approaches combining power-flow analysis with data-driven methods

The foreground IPR will primarily relate to the application and integration of these techniques rather than the creation of entirely new underlying technologies.

The project is expected to build on background IPR held by project partners, including existing modelling tools, data processing approaches, and analytical methods developed by Loughborough University (CREST) and NGED. Access to this background IPR will be required to develop and apply the project methodologies.

All foreground IPR will be managed in accordance with NIA governance requirements, with the intention of enabling learning to be shared across GB network licensees while protecting commercially sensitive elements where appropriate.

## Data Access Details

The project will utilise a range of existing data sources, including smart meter voltage and demand data, network topology information, and asset records. Where required, all data will be de-sensitised and aggregated to ensure compliance with data protection, commercial confidentiality, and security requirements.

Access to project data and outputs will be managed in line with NGED's data governance policies and the RII0-2 NIA Governance Document. Interested parties will be able to request access to appropriate datasets, methodologies, and results via standard NGED data sharing processes.

Where possible, non-sensitive outputs will be made available, including:

- Method descriptions and analytical approaches
- Aggregated or anonymised datasets
- Summary results and validation findings
- Reports and learning outcomes

Certain datasets, such as raw smart meter data or detailed network topology, may not be shared directly due to:

- Data privacy and GDPR constraints
- Commercial sensitivity
- Critical national infrastructure and security considerations

In these cases, equivalent anonymised, aggregated, or representative datasets will be provided where feasible to support replication of learning.

Project learning and outputs will also be disseminated through established industry channels, including published reports and innovation events, ensuring that the benefits of the project are accessible to all GB network licensees and relevant stakeholders. Further details on data access and sharing arrangements are available through NGED's publicly available data sharing policies.

## Please identify why the Network Licensees will not fund the project as a part of its business and usual activities

The Network Licensee is not funding this project as part of business-as-usual activities because the proposed methodology is unproven and carries a number of technical and data-related uncertainties.

Current BAU processes for LV network planning and connection assessment rely on established modelling approaches and standard assumptions. While these methods have limitations, they are well understood and do not carry the same level of risk associated with adopting new, unvalidated techniques.

The approach proposed in this project involves:

- Inferring network characteristics from smart meter data, which is not currently used in this way at scale
- Applying new combinations of power-flow modelling and data-driven techniques
- Estimating parameters where underlying asset data may be incomplete or uncertain

There are inherent risks associated with data quality, model accuracy, validation of results, and integration into existing systems. These uncertainties mean that the methodology cannot yet be relied upon for operational decision-making.

As a result, it would not be appropriate to fund this work through BAU activities, where expenditure must be justified against proven solutions and low delivery risk.

NIA funding is therefore required to enable structured development, testing, and validation of the methodology in a controlled environment. This will establish whether the approach is sufficiently robust and beneficial to justify future deployment as part of BAU processes.

## 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

The project requires NIA support because it involves a number of technical, data, and implementation risks that make it unsuitable for funding through business-as-usual or commercial investment.

From a technical perspective, the project seeks to develop and validate a novel methodology for inferring LV network characteristics, including cable impedance, using smart meter data. This approach is unproven at scale and there is a risk that data quality, model assumptions, or network complexity may limit the accuracy or applicability of the results.

From a data perspective, there are uncertainties relating to the completeness and alignment of smart meter data, network topology records, and asset information. Challenges such as phase identification, time synchronisation, and missing or inaccurate records introduce additional risk to the reliability of the methodology.

From an operational perspective, the integration of new analytical approaches into existing planning and connection assessment processes is not yet defined. There is a risk that outputs may not be sufficiently robust, interpretable, or compatible with current tools and workflows.

From a commercial perspective, the benefits of the project are uncertain at this stage and depend on successful validation of the methodology. As a result, there is no established business case that would justify investment under BAU funding mechanisms, which require proven outcomes and low delivery risk.

Finally, from a regulatory perspective, the use of inferred data and probabilistic outputs in connection decisions represents a departure from current practice, and may require further development and validation before it can be adopted within regulatory frameworks.

NIA funding is therefore required to enable the controlled development, testing, and validation of the methodology, reducing uncertainty and establishing whether the approach can deliver sufficient value to justify future deployment at scale.

### **This project has been approved by a senior member of staff**

Yes