Notes on Completion: Please refer to the appropriate NIA Governance Document to assist in the completion of this form. The full completed submission should not exceed 6 pages in total.

NIA Project Registration and PEA Document

Date of Submission

Sep 2025

Project Reference Number

NGED_NIA_083

Project Registration

Project Title

DIRT – (Direct Insulation Real-time Temperature)

Project Reference Number

NGED_NIA_083

Project Licensee(s)

National Grid Electricity Distribution

Project Start

September 2025

Project Duration

0 years and 7 months

Nominated Project Contact(s)

Scott Ball

Project Budget

£136,175.00

Summary

The project aims to address thermal limitations of underground distributions networks, particularly in HV/LV networks, by incorporating real-time temperature data to challenge existing cable rating methodologies. Existing cable ratings are based on assumed environmental factors, leading to potential over- or underestimation of network true capacity. The DIRT project will first conduct a feasibility study to explore temperature monitoring technologies, follow on value streams will then develop monitoring technologies through real-world trials to validate environmental assumptions and refine rating methodology. The goal is to optimize network capacity, thus reduce the need for costly replacement, utilising existing assets. whilst facilitating the installation of low-carbon technologies essential for achieving NetZero. The project will help identify thermal vulnerabilities within networks, informing future decisions that will improve the resilience and reliability of networks for customers whilst enhancing understanding of climate change thermal impacts. Success will be measured by the development of refined cable rating methodology and the demonstrated cost savings from more efficient network planning and asset utilisation.

Problem Being Solved

Underground cables are designed to operate at their maximum efficiency up to a maximum core temperature, the maximum core temperature is limited by the maximum conductor temperature specified by the cable manufacture/IEC.. Due to network design, HV/LV networks are at greater vulnerability to thermal exceedances and run hotter than EHV when normal running arrangements are considered.

Using cable rating software, thermal limits/cable ratings are calculated using the maximum core temperature and other environmental factors such as soil temperature and soil resistivity, however, these ratings on distribution networks are calculated using assumed potentially inaccurate environmental values as both real time climatic and conductor temperature data is currently unavailable, also significantly varying though out a cable route. Cable calculations assume that specific backfill materials are used with specified specifications, however, in reality these assumptions are not a true representation of real-world environments.

When considerations are made to the variance in assumed environmental factors due to location, climate, installation type, backfill material and changing load profiles, there is potential that maximum calculated load ratings (used for network design/operation) may not align with actual experienced conductor temperatures. During periods of high/exceeded load it is unknown what real time

conductor temperatures are, desk top assumptions that ignore external environmental factors could be over cautious masking hidden network capacity headroom, alternatively current desk top calculation could miss contributing factors resulting in cables exceeding thermal ratings resulting in both asset damage/ reduced asset life and reduced network reliability. For this reason, greater visibility and increased real time data of underground assets is required for an updated approach to cable ratings.

Load profiles are a defining factor in cyclic cable ratings commonly used on distribution networks. DSO research has identified that current load profiles may be redundant by 2035. If cable ratings are to move away from cyclic ratings to sustained ratings, periods of cooling would no longer be available further highlighting the need for thermal data to support cable rating review.

It is possible that in some scenarios maximum calculated conductor temperatures are not reached during periods of maximum demand due to lagging thermal properties and other environmental factors. This has previously been evidenced through international desk-based research projects, however, real-world evidence is required to achieve the confidence to inform rating methodology change to identify capacity headroom opportunities.

Method(s)

To address the problems described above, the project DIRT aims to find solutions to validate the accuracy of real-world cable ratings though the use of monitoring technology, the data collected will then be used to support rating methodology updates leading to areas of both opportunity and identified network vulnerability.

The initial Value stream of the DIRT project will be a feasibility study deep diving existing underground cable rating methodology, industry standards, ground data considerations, existing literature and existing available monitoring technologies.

The output of the initial feasibility study will provide an initial cost benefit analysis alongside a recommendation report advising next steps and proposed follow-on value streams.

Following a successful feasibility stage, follow on value streams will explore the development and implementation of selected temperature monitoring technologies through both test /real world network trials. Captured data will then be analysed against existing methodologies with outputs providing recommendations for next steps.

It is expected that data driven approach to cable ratings will allow for release of “locked in” network capacity increasing network headroom, thus reducing the requirement for network reinforcement and the use of larger/ more costly cables. Conversely, captured thermal data may also highlight areas of thermal vulnerability that would have otherwise remained undetected (fault rates/asset aging), learnings will also support potential benefits in other areas such as post fault cable ratings and losses.

Following successfully installation and wider roll out of monitoring technologies further value streams will look to further utilise captured thermal data. Following successful outcomes value streams will explore the development and deployment of dynamic underground cable ratings and explore learnings to support climate change adaptation pathways.

Throughout the project we seek to use knowledge drops to support and expand existing innovation projects.

Scope

Throughout RIIO ED2 NGED are forecast to spend £784m on load related expenditure, this total includes the replacement of UG cables.

The SILVERSMITH Network Study Result report, showed that by 2033, 5% of LV feeders will experience thermal constraints. By 2050, this will increase to 22%, approximately. Thermal constraints will become the dominant network constraint type, significant levels of interventions and thus investment will be required to alleviate thermal constraints particularly during the 2034-2040 and 2041-2050 timeframes. Such constraints could have significant impact on the customer and NetZero targets.

By 2050, it is estimated that a total of approximately 44,220 LV underground feeders on the NGED network will be impacted by thermal constraints. Conventional reinforcement of these feeders would result in significant cost and disruption to customers. Assuming an average feeder length of 300m and a cost of £100/m, overall replacement using current cable rating calculations and replacement methodology would cost c.£1.3b. This challenge is not unique to NGED proving a future challenge to other UK DNOs.

The Scope of the DIRT project begins by conducting a feasibility study to explore available temperature monitoring technologies, installation techniques, data accuracy, and the practicality of deploying such solutions in both new and existing cable installations. Additionally, a review existing studies will be carried out, assessment of thermal data requirements, and identify the most viable approach to improve understanding of cable temperatures and ratings via an indicative cost benefit analysis.

The Feasibility study aims to identify and highlight potential opportunities to be gained from the implementation of implementing real-

time underground cable temperature monitoring solutions to optimize and realise true network capacity, improve system reliability, and most of all reduce future reinforcement costs. By updating and informing industry approach to cable rating methodology, validating with real time thermal data, costly forecast network intervention volumes could be significantly reduced. This would benefit both the customer improving value for money and accelerating the road to NetZero.

The study will also provide insights into how future climate impacts can be managed through improved monitoring and support development of potential climate change adaptation pathways.

Objective(s)

The initial **feasibility study** will undertake the following objectives:

Value Stream 1: Mobilisation Workshop

- Confirm understanding of the specific challenges related to underground cable temperature monitoring.
- Confirm objectives, expected outcomes, and alignment with NGED priorities and timescales.
- Identify key stakeholders and technical experts within NGED that may be engaged during project delivery
- Agree framework for 'Next Step' decision making to influence future work including information required by NGED to make decisions
- Work through the project delivery programme and agreements around ways of working.

Review of Existing Research and Technologies

A thorough review of existing research and technologies will be carried out covering the following:

- Review of NGED existing applied cable rating methodologies and assumptions along with how they align against the latest standards (IEC 60287, IEC 60853, ENA ER P17, etc.).
- Understand how this approach aligns to knowledge of cable and circuit physiology and anatomy. Which parts of a cable or circuit are most likely to experience overheating and how does this need to be considered when monitoring circuit temperatures?
- Conduct a literature review on previous innovation projects and high TRL research into cable monitoring solutions (e.g., Customer Led Network Revolution, Real Time Thermal Rating Cables, etc.). The literature review will include international learning from countries where experience of a much warmer or wetter climate could inform findings.
- Assess the capabilities of existing and emerging monitoring technologies along with communication requirements, including LTE-enabled sensors, Distributed Temperature Sensing (DTS), and Power Line

Data Requirements and Network Impact Analysis

This task will assess the data needed for accurate underground cable rating calculations and explore how real-time monitoring can enhance network planning and operations;

- Define essential data points for accurate cable rating adjustments, including: Temperature data, seasonal and climatic variations on conductors, insulation, and surrounding soil temperature.
- Load data: Real-time and historical load profiles, peak demand.
- Geological data: Soil composition, moisture levels, and thermal resistivity variations across different locations
- Environmental factors: Groundwater levels, ambient air temperature, and potential climate change impacts on underground conditions
- Cable installation parameters: Depth of burial, surrounding material properties (e.g., backfill type), and thermal constraints in congested areas.
- Load profile assumptions: Evaluate the impact of load profile changes (e.g. Load Curve G evolution) on existing rating methodologies.
- Identify gaps and limitations in existing datasets, such as inaccurate environmental assumptions, that could be addressed by new monitoring technologies, assess existing datasets available internally and externally to NGED's systems to improve cable rating accuracy. Evaluate which emerging and commercially available monitoring technologies can build on these datasets.
- Once data needs and potential monitoring solutions are established evaluate the practical and technical feasibility of implementing.
- Sensor deployment challenges: Power supply constraints (battery life) and sensor placement for optimal coverage and data accuracy.
- Data transmission and integration suitability for underground networks.
- Voltage level differences: Assess feasibility across LV, HV, and EHV networks to determine where real-time monitoring is most beneficial.

These assessments will be presented as a technical and feasibility assessment report

Initial Cost-Benefit Analysis

The findings from all of the research will be compiled into a high-level cost benefit analysis to determine the viability and potential value that can be delivered from the installation of cable monitoring solutions. The analysis will compare against potential network planning benefits, including unlocked network capacity, deferred reinforcement, and improved asset health estimation whilst also considering dynamic network reconfiguration, active network management, flexibility service re-dispatch, etc.

Feasibility Study Report and Recommendations

A short report will be produced summarising findings and recommendations from the feasibility study. This will include recommendations for the most promising technologies and methodologies for each use case and outline potential next steps

Stage gate 1. – feasibility study recommendation report to inform next stage.

Proposed follow on value streams

Value Stream 2: Sensors

- Work Package 2 – Sensor Development
- The initial work stream will identify and develop underground sensors/monitoring devices
- Work Package 3 –Proof of Concept
- Install and test a range of monitoring technologies identified in WP2 in a controlled environment trial network / lab to identify best practice.
- Work Package 4 – Network Trials
- Using the best practice sensor / monitoring technique identified in WP3 identify live network trial sites, trial sites should included both new and old installations coving a range of both environmental and load scenarios to monitor real life conditions.
- 1–2-year network trials to capture large sample of real time temperature data. conditions / load profiles.
- Work Package 5 – validate
- Validate quality of collected data
- sensors installation outcome report

Value Stream 3: Data analysis-- cable rating methodology review

- Work Package 5 – Collected data analysis
- Review captured trial data giving consideration to;

    -Data quality (spacing of devices, frequency, granularity etc.)

    -Regional/Environmental trends/patterns

    -Load profiles

    -capacity head room/ rating exceedances

    -Further data opportunities

    -Accuracy of data

    -Risks

- This work package will require cable experts to review UG cable rating methodology real time cable data investigating accuracy of current rating calculations and assumed climatic values
- Real time conductor/soil temperature / load profile data will be compared against assumed values used within thermal cable calculations determining accuracy of existing cable rating calculations and highlight areas of opportunity
- Data analysis outcome / recommendation report
- Work Package 6 –revised cable Rating Methodology
- Use analysed date to develop methodology for updated/future cable ratings including consideration of;

- Cable thermal limits/ hot spots /thermal peaks

-Existing thermal calculations and assumed values

- Review of thermal calculations using captured real time data

-Installation techniques

-correction factors for vulnerabilities

-Demand profiles

-Environmental factors

-Network capacity release

-Revised cable ratings / dynamic ratings

- **Revised cable rating methodology recommendation report**

- Work Package 7 – Dynamic cable ratings
- Use outcomes of WP 5/6 to develop and recommendations for the use of dynamic UG cable ratings
- **Dynamic cable ratings learnings and recommendation report**

- Work Package 8 – Climate Change Resilience and asset health
  - This work package will review the relationship between weather/climate patterns and underground cables, investigating accuracy of existing assumed climatic values used within cable calculations, this will require input from cable/climate/ground experts.
  - Study of cable failure rate/ existing cable UG health/ replacement methodology projects (Prefix,Hi-5) vs conductor temperature/ climate/weather patterns /customer behaviours (demand profiles).
  - Study of DSO forecast load related cable replacement volumes and asset aging
  - The work package will explore variance in ground conditions/environments across all 4 licence areas for both today's climate and a range of future emission scenarios, highlighting areas of opportunity support climate change
  - Identify potential UG network climate change adaptations pathways

Value Stream 4: Integration and Cost Benefit Analysis

- Work Package 9 – Integration of enhanced / dynamic rating methodology into a cable policy/network planning
- Work Package 10 – LTE technology opportunities)
- Work Package 11 – Cost Benefit Analysis
  - Carry out CBA to confirm suitability for wider roll out
- Work Package 12 – Reporting
  - This work package will produce final reports and recommendations for BAU roll out.

Consumer Vulnerability Impact Assessment

Not applicable, as no vulnerable consumers would be impacted by this project.

Success Criteria

The first **feasibility value stream** of project will be deemed a success if the following criteria are achieved:

- Successfully assess and evaluate current cable methodology and assumed thermal considerations, identifying areas of opportunity that would be supported by real time thermal data
- Thorough review of existing literature and cable temperature research
- Identify, assess and suggest a range suitable UG monitoring and communication technologies
- Production of a technical and feasibility assessment report

- Production of a high-level cost benefit analysis to determining the viability and potential value that can be delivered from the installation of cable monitoring solutions
- Production of detailed recommendation report advising next steps and feasibility of proposed follow-on value streams

Subject to the output of the feasibility study the following success criteria could be realised by follow on **Value Streams** ;

- Development and installation of monitoring sensors in a test/trial environment, identification of suitable monitors for real-world network trials.
- Successful trial of monitors on a real-world network and collection of usable thermal data
- Analysis of captured data and validation of opportunities identified in value stream 1.
- Recommendations for cable rating methodology amendments supported by collect thermal data learnings
- Recommendations for implementation of new underground cable dynamic ratings supported by thermal data learnings
- Recommendations and implementation of climate change adaptations pathways supported by thermal data learnings
- Integration of cable monitoring technology into business as usual

Project Partners and External Funding

The following project partners will be engaged on this project:

- EA Technology

No external funding will be used to support the project.

Potential for New Learning

The learnings from DIRT will be relevant to UG cable rating methodology used by all UK DNOs. The project will improve network capacity allowing the installation of low carbon technologies on the UG network critical in achieving NetZero. The project will also improve knowledge around climate impacts, supporting climate change adaptation work for UG networks, relevant to all DNO's.

Scale of Project

The DIRT Feasibility value stream aims to assess the feasibility of implementing real-time underground cable temperature monitoring solutions to optimize network capacity, improve system reliability, and reduce reinforcement costs. The first stage is small scale desk based research to minimise project risk and to optimise future follow on projects.

The feasibility study will lay the groundwork for further value streams, the scale of which will dependent on the outcome of the feasibility project and follow-on stage gates, the scale of proposed follow-on Value streams are as below:

1. **Laboratory Testing** – Developing and validating monitoring technologies and methods under controlled conditions on a test network. This will be limited to small cable sample (<500m) of underground cable on a test or similar network.
2. **Field Testing** – Deploying solutions in real-world settings across UK UG networks. This will be limited to a small sample of feeder within each licence area
3. **Business as Usual Integration** – Scaling proven solutions into standard operational practices across all 4 licence areas and other DNOs

Ultimately, the study aims to guide the overall UK in adopting advanced cable monitoring approaches that enable smarter, optimised , data-driven network planning and asset management.

Technology Readiness at Start

TRL2 Invention and Research

Technology Readiness at End

TRL6 Large Scale

Geographical Area

The DIRT feasibility study is a desk-based study only. NGED will provide subject matter experts from all four licence areas to support the project

Follow value Streams geographical areas will be confirmed following successful project progression.

Revenue Allowed for the RIIO Settlement

None

Indicative Total NIA Project Expenditure

Total project budget is £136,175 NIA funding - £122,557.05 NGED contribution - £13,617.45

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 DIRT project is seeking to address something that has not been addressed before on UK UG distribution networks. It is essential that industry take a different view of to allow data driven approach to UG networks to optimise existing asset as well as ensuring networks are futureproofed as we move to the net zero future.

The reliance of electricity is forever increasing, therefore increasing the importance and need for a network data driven approach to support asset optimisation whilst maintaining a affordable reliable network.

This change represents a fundamental shift for Network Operators and as such establishing best practice based on the use of new and innovative monitoring technologies, - this has to be done in a way that ensures that the current service levels are maintained whilst new capabilities are embedded. The need for a more proactive accurate approach to network reinforcement is critical for coming years.

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

Not applicable

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

The DIRT project is a feasibility study with a low starting TRL, therefore at this stage it is not possible to provide an accurate estimate.

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

N/A- DIRT is a research project.

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

The outputs of the feasibility and recommendation report will determine how scalable future temperature monitoring will be. It is envisaged that monitoring technology would first be installed in thermal constraint hot spots highlighted through the SILVERSMITH Network Study Result report.

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

Unable to provide figure until feasibility study is complete.

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

Thermal constraints will become the dominant network constraint type for all DNOs, significant levels of interventions and thus investment will be required to alleviate thermal constraints particularly during the 2034-2040 and 2041-2050 timeframes. Such constraints could have significant impact on the customer and NetZero targets.

The learnings from the DIRT project aim to improve industry knowledge of underground cable ratings. The learnings will enable and provide methods to optimise existing UG assets therefore reducing future reinforcement volumes as well as supporting network reliability and resilience.

Our learning will be shared with the DNOs throughout and it would be our expectation that they can build and implement learnings themselves

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 the Smarter Networks Portal does not reveal any similar projects at distribution level within the UK, similar cable temperature monitoring projects have been carried out at a transmission level but not at a distribution level. While previous distribution studies have looked at cable temperature (CELSIUS), these were confined to small controlled areas with limited consideration to the wider cable rating methodology and assumed climatic values. DIRT aims to be a greater deep dive into cable rating methodology at a wider scale.

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 DIRT project is seeking to address something that has not been explored before. It is essential that the industry takes action to optimise existing assets and challenge/review historic methodologies that underpin key elements of DNOs.

Relevant Foreground IPR

This IPR will be made available to other GB DNOs on request or as part of the project Closedown Report and dissemination workshops. Foreground IP produced by the project will be the outcome and recommendations report produced via the project deliverables.

Enabling back ground IPR will be required for the following deliverables;

- Previous learnings/research report
- Technical and feasibility assessment -
- Cost Benefit analysis

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 several 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 Electricity Distribution 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.co.uk/innovation/

Via our managed mailbox nged.innovation@nationalgrid.co.uk

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

The DIRT project is not being funded as business-as-usual activities as the feasibility study involves significant research, development, and demonstration of new technologies and methodologies that are not yet proven. These innovative approaches, such as monitoring development and installation, require extensive testing and validation before they can be integrated into standard operational practice.

The potential benefits of DIRT, while promising, are still uncertain and need to be demonstrated through feasibility/development studies before the costs associated with widespread implementation can be justified.

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 DIRT project requires NIA support due to the extensive research and expertise required. While previous studies have looked at cable temperature, these were confined to small controlled areas, DIRT aims to be a greater deep dive into cable rating methodology at a wider scale. While there is compelling evidence that DIRT will have significant impact on capacity release there is a possibility that the learnings do not produce robust enough recommendations for follow projects or integration with BAU.

The project aims to validate unproven methodologies, which involves substantial financial risk. NIA funding enables the exploration and refinement of these innovations, ensuring successful integration into business-as-usual activities and achieving strategic goals for network efficiency and reliability.

This project has been approved by a senior member of staff

☑ Yes