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

Dec 2018

Project Reference Number

NIA_NGTO027

Project Registration

Project Title

SMART GEO GRID

Project Reference Number

NIA_NGTO027

Project Licensee(s)

National Grid Electricity Transmission

Project Start

September 2018

Project Duration

0 years and 4 months

Nominated Project Contact(s)

Judith Robinson

Project Budget

£55,095.00

Summary

The material surrounding buried electrical cable is required to dissipate heat at a sufficiently high rate to prevent thermal overloading. In design, conservatism can be applied to attempt to prevent critical situations from arising. For example, the cable spacing can be chosen with an appropriate factor of safety. However, soils are highly complex materials, possessing material properties that are not constant but rather vary temporally and spatially, sometimes by several orders of magnitude. Envisaging and accounting for all eventualities is a highly challenging and potentially costly task. As an example, both the thermal and electrical resistivities of soils are highly dependent on water content; in the event that a soil mass dries out, both its thermal and electrical resistivities will rise considerably, limiting its capability to dissipate heat and electricity.

This project has the following objectives:

1. Develop numerical models of the soil condition and link this to the thermal loading of underground cables.
2. Validate the models with experimental results from an equivalent laboratory setup.
3. Train software to provide predictions of the soil condition; allowing a forecast to be made.
4. Develop a costed proposal for deploying this technology in the GB network.

Nominated Contact Email Address(es)

box.NG.ETInnovation@nationalgrid.com

Problem Being Solved

The soil in which electrical cables are buried performs a number of vital functions that are important for safety and successful asset maintenance. The surrounding soil backfill is required to dissipate heat at a sufficiently high rate to prevent thermal overloading. In design, conservatism can be applied to attempt to prevent critical situations from arising. For example, the cable spacing can be chosen with an appropriate factor of safety. However, soils are highly complex materials, possessing material properties that are not constant but rather vary temporally and spatially, sometimes by several orders of magnitude. Envisaging and accounting for all eventualities is a highly challenging and potentially costly task. As an example, both the thermal and electrical resistivities of soils are highly dependent on water content; in the event that a soil mass dries out, both its thermal and electrical resistivities will rise considerably, limiting its capability to dissipate heat and electricity. In the context of a future that necessitates embracing the

challenges imposed by climate change – in particular, the potential for longer, drier summers – the necessity to safeguard against scenarios like this, without recourse to imposing ubiquitous and costly conservatism, is considered to be highly important.

Method(s)

A novel approach is proposed to account for the uncertainty in predicting the behaviour of soils and their consequential impact on the safe functioning of key assets. At the heart of the proposed approach is the idea of integrating autonomous data logging with data input from modelling and GIS-based informatics to enable decisions to be made to improve safety and preserve the lifespan of assets. This approach was envisaged from the recognition that, while modelling is highly important in predicting future trends, it is limited by uncertainties associated with site-specific conditions. On the other hand, data acquisition from site provides an invaluable insight into the local conditions of the relevant soil mass, but when used in isolation requires potentially erroneous extrapolation to predict future trends. Combining the two offers a highly effective approach to allow for mitigating action to be taken before a critical condition is reached.

Scope

This project will cover the following work packages:

WP 1: Modelling through numerical simulations
Typically, thermal dissipation calculations are carried out in which the thermal resistivity is prescribed as a constant value, chosen by the user. Different scenarios are then considered; for example, analyses are carried out using representative values of thermal resistivity corresponding to “dry” and “wet” soils. It is proposed to carry out a more fundamental analysis, in which thermal resistivity is not prescribed as an “input value” but rather is considered a function of parameters defining the underlying soil’s behaviour (in particular, the porosity of the soil and the degree of saturation, which itself is permitted to vary with time).

WP 2: Experimental investigation
At the heart of SMART GEO GRID is the idea that simulations alone are not sufficient since any simulation is only as good as the chosen values for the material/constitutive parameters (as well as the initial and boundary conditions). Instead, future predictions must be made conditional upon the measurements recorded at site through sensor acquisition. Only then can trust truly be placed in the simulation results and sufficient confidence gained with regard to the option to de-rate. It is proposed that a laboratory based set-up consisting of apparatus in which a short (i.e. “plane strain”) section of cable is mounted in a soil, which is to be instrumented with temperature and water content sensors. Heating elements mounted inside the section of cable will simulate the heating induced by the flow of electricity. The subsequent water content variation and temperature profiles throughout the soil mass will be measured with the intention of providing a set of data, experimentally obtained, against which the simulation results can be “trained” to provide accurate predictions.
WP 3: Parameter estimation: combining the experimental investigation and simulation results
The key aspect of our proposal is the uniting of numerical simulations and data acquisition. The third work package considers this important aspect, specifically addressing the question: how should the simulations be adjusted in light of the measurements to facilitate accurate future predictions? This work package will principally involve software development, using algorithms to “train” the simulations in response to the acquired data. Initially, the study will just focus on material parameter tuning, aiming to develop robust software that can adjust the appropriate material and constitutive parameters in a fully automated way to allow for faithful future predictions. Software will be developed using synthetic training data initially (i.e. data generated from numerical simulations) before attempting to apply it to the results of our laboratory experimental testing programme.

WP 4: Costing and practicality report
A desk study to investigate all of the practical aspects of deploying this sensor acquisition approach proposed in this project will be undertaken; allowing the full costs of the system to be understood.

Objective(s)

The project has the following objectives:

1. Develop numerical models of the soil condition and link this to the thermal loading of underground cables.
2. Validate the models with experimental results from an equivalent laboratory setup.
3. Train software to provide predictions of the soil condition; allowing a forecast to be made.
4. Develop a costed proposal for deploying this technology in the GB network.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

n/a

Success Criteria

This project will be considered a success if:

1. Validated numerical models are developed and trained to provide forecasts of ground condition.
2. If the forecast ground condition is translated into a time varying rating for the cable system
3. A costed proposal for deploying this technology is generated and one or more avenues for future benefits are assessed.

Project Partners and External Funding

n/a

Potential for New Learning

This project has the potential to provide the following new learning:

1. Models and or methods to forecast what the ground condition surrounding the cable is now and will be in the future; these can be used to dynamically rate the cable and alleviate constraints.
2. A deeper understanding on the behaviours of the soil surrounding underground cables.
3. A clear assessment on the costs of implementing this system in the network and where further work is required to develop this technology.

Scale of Project

The scale of this feasibility study was chosen to obtain essential information, which will allow a proper assessment of this innovation to take place; This will inform the decision to proceed with further work, without committing significant amounts of innovation funding.

Technology Readiness at Start

TRL2 Invention and Research

Technology Readiness at End

TRL3 Proof of Concept

Geographical Area

Desktop and Laboratory based trial at Cardiff University.

Revenue Allowed for the RIIO Settlement

None

Indicative Total NIA Project Expenditure

£55,095

Project Eligibility Assessment Part 1

There are slightly differing requirements for RIIO-1 and RIIO-2 NIA projects. This is noted in each case, with the requirement numbers listed for both where they differ (shown as RIIO-2 / RIIO-1).

Requirement 1

Facilitate the energy system transition and/or benefit consumers in vulnerable situations (Please complete sections 3.1.1 and 3.1.2 for RIIO-2 projects only)

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

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

n/a

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

n/a

Requirement 2 / 2b

Has the potential to deliver net benefits to consumers

Project must have the potential to deliver a Solution that delivers a net benefit to consumers of the Gas Transporter and/or Electricity Transmission or Electricity Distribution licensee, as the context requires. This could include delivering a Solution at a lower cost than the most efficient Method currently in use on the GB Gas Transportation System, the Gas Transporter's and/or Electricity Transmission or Electricity Distribution licensee's network, or wider benefits, such as social or environmental.

Please provide an estimate of the saving if the Problem is solved (RIIO-1 projects only)

This project is a feasibility study, which will provide key information on how live data streams can be used to change the thermal rating of underground cables. The ability to improve the static ratings of underground cables has significant value for consumers, as this could delay or defer investment in new infrastructure. This could also alleviate constraint payments in a very short period of time.

Please provide a calculation of the expected benefits the Solution

N/A

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

The method is general, and can be used by any Licensee that owns cable systems; which will be the majority.

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

Depending on the route to implementation, this technology could cost anywhere from £50,000 per licensee to several million. This depends on how general the outcomes of the project are and how widely they can be applied.

Requirement 3 / 1

Involve Research, Development or Demonstration

A RIIO-1 NIA Project must have the potential to have a Direct Impact on a Network Licensee's network or the operations of the System Operator and involve the Research, Development, or Demonstration of at least one of the following (please tick which applies):

☐ A specific piece of new (i.e. unproven in GB, or where a method has been trialled outside GB the Network Licensee must justify repeating it as part of a project) equipment (including control and communications system software).

☐ A specific novel arrangement or application of existing licensee equipment (including control and/or communications systems and/or software)

☑ A specific novel operational practice directly related to the operation of the Network Licensees system

☐ A specific novel commercial arrangement

RIIO-2 Projects

☐ A specific piece of new equipment (including monitoring, control and communications systems and software)

☐ A specific piece of new technology (including analysis and modelling systems or software), in relation to which the Method is unproven

☐ A new methodology (including the identification of specific new procedures or techniques used to identify, select, process, and analyse information)

☐ A specific novel arrangement or application of existing gas transportation, electricity transmission or electricity distribution equipment, technology or methodology

☐ A specific novel operational practice directly related to the operation of the GB Gas Transportation System, electricity transmission or electricity distribution

☐ A specific novel commercial arrangement

Specific Requirements 4 / 2a

Please explain how the learning that will be generated could be used by the relevant Network Licensees

This project will benefit all licensees that own cable systems. The information from this project will allow Licensees to make their own assessment on whether or not to adopt this method of identifying the soil parameters.

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

This project fits within the 'Service Delivery'+ value area of the Electricity Innovation Strategy:
☑ Has the Potential to Develop Learning That Can be Applied by all Relevant Network Licensees

Is the default IPR position being applied?

☑ Yes

Project Eligibility Assessment Part 2

Not lead to unnecessary duplication

A Project must not lead to unnecessary duplication of any other Project, including but not limited to IFI, LCNF, NIA, NIC or SIF projects already registered, being carried out or completed.

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

A search on the ENA portal identified no duplication and discussions with subject matter experts highlighted no previous work in this area.

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

This project seeks to predict the behaviour of a variety of soils and their consequent impact on the safe functioning of assets under a range of temperatures and conditions. This study will assess the feasibility of integrating autonomous data logging with data input from modelling and GIS based informatics. If successful, and with more focus on risk based asset management, this type of work may have more significance in future by improving the capability for cable asset safety and replacement decisions.

Relevant Foreground IPR

n/a

Data Access Details

n/a

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

There is an opportunity for this research to be used to provide value to consumers, by reducing replacement works and deferring investment. The project is a feasibility study and therefore relatively low cost, but there is a risk that the proposed integration of data may not yield a reliable dataset which will inform decisions in predicting soil behaviours.

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 can only be funded through the NIA as there are significant risks which warrant further investigation and development of this research area, prior to its use within the business. The main risk is: • It is not certain that this method will prove feasible – While a value case has been defined for this project, it is contingent on obtaining an as yet unknown level of technical knowledge. Whatever the outcomes of this project are, they will be valuable to utilities managing their assets. However, these benefits are not sufficient for the business to justify the project's budget. Without the NIA funding, we would be unlikely to investigate this methodology to gain further knowledge of heat dissipation in soils, resulting in the potential benefits not being explored or exploited.

This project has been approved by a senior member of staff

☑ Yes