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

Jul 2023

Project Reference Number

NIA2_NGET0042

Project Registration

Project Title

Analysis of the Thermal Influence of Cable Surroundings (AnTICs)

Project Reference Number

NIA2_NGET0042

Project Licensee(s)

National Grid Electricity Transmission

Project Start

September 2023

Project Duration

2 years and 7 months

Nominated Project Contact(s)

Siyu Gao

Project Budget

£597,400.00

Summary

The power flow capacity of high voltage cables is limited by the heat dissipation ability of their immediate surrounding environment. However, despite the large number of projects built in the past, the surrounding environment's thermal properties are often poorly understood. Typical assumptions are often excessively conservative, which may have led to excessively large cables costing extra. This project proposes to use expert geological and oceanographic analysis to build bespoke numerical models of cable systems, which can then be validated using Distributed Temperature Sensing (DTS) data. Current design approaches can be tested and establish if the level of conservatism in cable system design can be safely reduced. This project would also propose new methods to rate and size cable systems that can best inform business decisions.

Third Party Collaborators

University of Southampton

Orsted

Nominated Contact Email Address(es)

box.NG.ETInnovation@nationalgrid.com

Problem Being Solved

The power flow capacity of buried high voltage cables, both land based and submarine, is limited by the ability of their immediate surroundings to dissipate heat. However, despite the significant constraints imposed by the environment, its thermal properties are poorly understood. Typical assumptions are often excessively conservative, which may lead to unnecessary capital and operational expenditure. The recent deployment of Distributed Temperature Sensing (DTS) sensors gives an unparalleled opportunity to test the current design approach using existing datasets from operational installations, and establish if the level of conservatism in cable design can be reduced without risking the safety, reliability or resilience of the network.

Method(s)

The aim would be to use a combination of state-of-the-art thermal modelling, historical datasets, and geotechnical expertise, to update guidance on the future operation of cable systems, both pre-existing and planned. The investigations will cover: the thermal properties of sediments and soils; measurement of post-installation depth of lay and the natural variability in seabed depths due to sediment movement; and the spatial and temporal variation in air, groundwater and ocean bottom temperatures (which is vital to accurately quantify the influence of the burial environment on cable temperatures).

This project will compare conductor temperatures derived from FEA (Finite element analysis) models against actual DTS datasets recorded. Modelling will be undertaken with both the original environmental design parameters and the ones derived from available NGET and public data sources to establish discrepancies stemming from the use of historical assumptions.

Data Quality Statement (DQS):

- The project will be delivered under the NIA framework in line with OFGEM, ENA and NGET internal policy. Data produced as part of this project will be subject to quality assurance to ensure that the information produced with each deliverable is accurate to the best of our knowledge and sources of information are appropriately documented. All deliverables and project outputs will be stored on our internal sharepoint platform ensuring access control, backup and version management. Deliverables will be shared with other network licensees through following channels:
  - Closedown reports on the Smarter Networks Portal.

Measurement Quality Statement (MQS):

- The methodology used in this project will be subject to supplier's own quality assurance regime. Quality assurance processes and the source of data, measurement processes and equipment as well as data processing will be clearly documented and verifiable. The measurements, designs and economic assessments will also be clearly documented in the relevant deliverables and final project report and will be made available for review.

Scope

The project is scoped into 6 work streams (WS).

- WS1: Identification of case study site(s) and collation of available datasets
  - What electrical, environmental and monitoring data are available for each cable route?
  - What further information gathering is required for successful project delivery?
  - What case study sites are of interest to NGET strategically and are amenable to the installation of DTS systems?
- WS2: Development of flexible finite element cable thermal models
  - What model framework is amenable for use within NGETs inhouse tools?
  - Can heat dissipation from cables in partially saturated soils be properly captured in FE models?
  - How can groundwater movement be accurately modelled for onshore and offshore cable circuits?
- WS3: Analysis and potential re-calibration of DTS data
  - What are the key environmental parameters (ambient temperature at cable depth; thermal resistivity; and lifetime depth of cover change) for the chosen case study sites?
  - How do these values compare to those originally used in cable design?
  - What is the optimum site investigation approach for terrestrial, landfall and marine sites for future NG assets?
- WS4: Collation of environmental data for model input and model runs
  - Is the DTS data physically sensible based on known environmental conditions at each site?
  - What are the thermally critical locations for each case study?
- WS5: Comparison of DTS vs Model data and implications for future cable installations
  - Can FEA models accurately simulate DTS data?
  - What is the benefit of using suitable environmental parameters on cable ratings?
- WS6: Recommendations to National Grid
  - How can the proposed modelling framework and guidance by integrated into NGET BAU practices?
  - What lithological information should NGET be cognizant of for future installations?

Objective(s)

The objective of this project is to use advanced modelling combined with DTS data to improve sizing and rating methods for cable systems. The key aspects are:

- Flexible finite element cable thermal models that are capable of capturing heat transfer due to power flow and influence by the surrounding environment

- Validation of the finite element model using DTS data
- Identification of the most impactful environmental parameters on cable ratings and sizing post validation, and how they differ from past assumptions
- Recommendations on new cable sizing and rating methods

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

An assessment of distributional impacts (technical, financial and wellbeing related) for this project has been carried out using a bespoke assessment tool, which assesses the project as having a positive, negative or neutral effect on consumers in vulnerable situations. To help inform the assessment, this tool considers the categories of consumers identified in the Priority Services Register.

This project has been assessed as having a neutral impact on customers in vulnerable situations. This is because it is a transmission project.

Success Criteria

This project is deemed as successful if the objectives are achieved. In particular, the following outputs will be important when assessing the success of the project:

- Development and validation of the flexible finite element cable thermal models
- Identification of the benefit of using suitable environmental parameters on cable rating
- Improved methods for cable sizing and rating

Project Partners and External Funding

Potential project partner: Orsted is interested in participating this project by contributing data. They are not interested in funding contribution.

Potential for New Learning

The potential new learnings from this project are:

- The efficacy of the current methods for cable rating and sizing
- New methods for cable rating and sizing and the data requirement for these new methods

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

Scale of Project

The scale of the project includes the following:

- Data collection of the relevant cable schemes and sites
- Modelling and validation of selected cable schemes
- Detailed study, reporting and presentation

Technology Readiness at Start

TRL3 Proof of Concept

Technology Readiness at End

TRL5 Pilot Scale

Geographical Area

The project will mainly be carried out on the premises of the supplier. NGET sites will be accessed for assessment and data collection purposes as the project requires.

Revenue Allowed for the RIIO Settlement

N/A

Indicative Total NIA Project Expenditure

£537,660

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:

Demand for electricity is continuously growing at a rapid rate as the UK is becoming more and more electrified. New infrastructure is being built but cannot keep up with the speed of demand growth. This project will examine the thermal influence of cable surroundings in detail to determine whether capacity uplift could be achieved in situ since the methods used for cable sizing and rating were quite conservative and did not take into full account the environment surrounding the cables. If the project is successful then it would mean that the cable systems could be operated with higher ratings and thus accommodate more demand than they currently are.

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)

N/A

Please provide a calculation of the expected benefits the Solution

A CBA has not been carried out due to the project is at low level TRL (3, Research).

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

NGET owns about 2800 km of underground cables with new projects being built and planned. The new methods could apply to all these cables as well as other electricity networks.

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

The costs of deploying the new methods will depend on how the individual asset owners decide to incorporate them into their existing methods for cable sizing and rating.

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

Relevant licensees can use the new methods by this project to recalculate the cable ratings for their own system and determine how much capacity uplift may be achieved in their own system.

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

N/A

Is the default IPR position being applied?

☑ Yes

Project Eligibility Assessment Part 2

Not lead to unnecessary duplication

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

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

It is only in recent years that DTS data has started been used to calculate thermal ratings for cable systems. This area is still in its relative infancy. A search on the internet and the ENA portal did not return any project that had used DTS data with modelling of the surrounding environment for cable sizing and rating.

Any risk of duplication will be addressed through dissemination of progress with other licensees and being open to co-operate with licensees working in similar areas.

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 methods used for cable sizing and rating have been using the most conservative assumptions to account for the surrounding environment. There has not been any meaningful assessment study post installation to verify the environmental values used. This project will use DTS data in combination with FEA modelling of both the cable system and the surrounding environment to determine the best methods that can realistically account for the impacts from surrounding environment. This is an innovative approach that has not been explored before.

Relevant Foreground IPR

The foreground IPR will mainly be the models of the cable schemes, the simulation results and the proposed new methods for cable sizing and rating. The background IPR concerning the cable schemes and other relevant sites will be contributed by NGET and Orsted.

Data Access Details

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

- A request for information via the Smarter Networks Portal at https://smarter.energynetworks.org, to contact select a project and click 'Contact Lead Network'. National Grid already publishes much of the data arising from our innovation projects here so you may wish to check this website before making an application.
- Via our Innovation website at https://www.nationalgrid.com/uk/electricity-transmission/innovation
- Via our managed mailbox box.NG.ETInnovation@nationalgrid.com

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

It is currently unknown whether the proposed methods in this project would actually result in uplift in cable capacity or not. To validate the methods, it is estimated 30 months would be needed. This period is too lengthy and risky for BaU to accommodate and thus BaU is not the appropriate funding mechanism for this project.

Please identify why the project can only be undertaken with the support of the NIA, including reference to the specific risks(e.g. commercial, technical, operational or regulatory) associated with the project

he proposed methods in project are novel, unproven and needs further development. As previously explained, this project cannot be funded through BAU due to the risks involved. Therefore, NIA is the appropriate funding mechanism for this project.

This project has been approved by a senior member of staff

☑ Yes