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

Jan 2022

Project Reference Number

NIA2_NGET0013

Project Registration

Project Title

Overhead Line Sagging Monitoring Using 5G Signals

Project Reference Number

NIA2_NGET0013

Project Licensee(s)

National Grid Electricity Transmission

Project Start

July 2022

Project Duration

2 years and 4 months

Nominated Project Contact(s)

Xiaolin Ding (box.NG.ETInnovation@nationalgrid.com)

Project Budget

£350,000.00

Summary

All overhead lines in the GB transmission network must maintain statutory clearances to ground. To maintain these clearances the line sag needs to be monitored. Also, if the line sag can be monitored easily and with great frequency (dynamically), it is possible to provide valuable inputs to the dynamic thermal rating of the overhead line. Current methods use either sensors installed on the line to directly measure temperature/sag or weather stations nearby to indirectly calculate temperature/sag. This project aims to design a new method by exploiting the fifth generation (5G) cellular signals to directly monitor and measure the line sagging but without sensor installation on the line.

Nominated Contact Email Address(es)

box.NG.ETInnovation@nationalgrid.com

Problem Being Solved

To enable the safe and reliable operation of the overhead line network, lines must maintain statutory clearances to ground, roads and other objects. OHL circuits in some area of the network often operate on constrained power transfer capability due to the risk of violation of the clearance limits. Thus, direct sag monitoring is important to understand the true operational condition of the circuits. This provides valuable inputs to the dynamic calculation of thermal rating to unlock the full capacity of lines.

Current monitoring methods use either sensors placed on the overhead line/tower or remote weather stations and require dedicated data communication channel. Sensor installation generally requires circuit outage and demands highly skilled engineers as well as access to land where the lines and towers are located. The access is sometimes very restricted and hence brings many challenges when apply. Although sensors can achieve high accuracy of monitoring, the cost is high. Weather stations do not require sensor installation but have similar limitations of installing equipment on the tower and have relative low accuracy. Hence, the research is to develop a nonintrusive sag monitoring method with high accuracy and low cost without the need of sensor installation and dedicated data communication channel.

Method(s)

The project investigates the feasibility of using 5G signals to monitor OHL line sag condition. It proposes an innovative method that using 5G signals to monitor the sag condition of the OHL line in a direct but non-intrusive manner. 5G radio waves travelling through the overhead line will create an image of the line due to reflection and diffraction. The method proposed is to propagate 5G signals through the OHLs to be monitored, and capture the image via the receiver and process the image to create the sag profile of the line. This allows monitoring sag condition of an OHL in a direct but non-intrusive way without installing any sensors. The high frequency characteristic of 5G signals enables the high resolution of the measurement. The wide coverage of the 5G signals in future will enable the application of wide area monitoring.

A dedicated active transmitter will be used to generate the 5G signals to illuminate the overhead line; the received signals will be processed by machine learning algorithms to extract the sag profile from the received 5G signals; Then the sag profile will be further processed to calculate the clearance-to-ground data of the OHL; the developed line sag monitoring methods will be tested on site to evaluate the accuracy of the methods.

Data Quality Statement (DQS):

- The project will be delivered under the NIA framework in line with OFGEM, ENA and NGGT / 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. Relevant project documentation and reports will also be made available on the ENA Smarter Networks Portal and dissemination material will be shared with the relevant stakeholders.

Measurement Quality Statement (MQS):

- The methodology used in this project will be subject to the 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 scope of the project includes the following:

1. Literature review on OHL sag monitoring.
2. Develop a methodology to monitor the line sag using 5G signals. This includes developing an algorithm to capture the image of the line, computer software package performing data acquisition and processing, and machine learning to extract sag profiles of the line monitored and calculate the clearance of the line.
3. Validate the developed method on a select span of an OHL in NGET network and compare with results from LiDAR data survey results available if possible, and evaluate the accuracy of the developed 5G line sag monitoring.
4. Recommendations for practices and further development works required.

Objective(s)

The objectives of the project are as follows:

- Develop a direct but nonintrusive method to monitor the line sag condition using 5G signals.
- Extract sag profiles of the monitored OHL using machine learning to deliver results.
- Test the developed method on site and prove the accuracy of monitoring results.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

The distributional impacts of this NIA project are independent of a consumer's dwelling and location, readiness for digital technology, personal and social factors. In addition, no detrimental technical and wellbeing impacts are expected.

Financial benefits, as shown in the business case, will be available to all consumers including those on prepayment meters. Although the absolute pound savings will vary with energy consumption, the percentage change in the bill (per MWh) will be the same for all consumers. As energy expenditure is a higher proportion of income for lower income households, the energy bill savings will be particularly valuable to vulnerable consumers in lower income deciles.

This project will have no direct technical impacts on vulnerable consumers and will not affect the way power is supplied, and the quality and choice of energy tariffs and suppliers.

Success Criteria

- Successful development of 5G settings for signal generation and machine learning algorithms for signal processing.
- Successful incorporation of the developed method to a span of a OHL circuit to verify the efficacy of the monitoring system in the electricity network.
- Successful dissemination of acquired knowledge to the relevant industry sectors and the licensees via workshops and/or publications.

Project Partners and External Funding

None

Potential for New Learning

This project will design a new overhead line sag monitoring method using 5G signals. The method can be applied to overhead lines in the transmission network in future if the developed methods is proved to be successful. The key findings of the projects will be shared with other transmission Owners via workshops and/or publications.

Scale of Project

The project aims to develop an innovative line sag monitoring method using 5G signals which can offer highly accurate sag condition monitoring. To achieve that the first stage will be desktop-based research focusing on the development of the methodology of the monitoring system. The second stage will be field test based analysis to evaluate and validate the developed method.

Technology Readiness at Start

TRL2 Invention and Research

Technology Readiness at End

TRL4 Bench Scale Research

Geographical Area

The research will be mainly desk based at Warwick University during the development of the methodology of the monitoring system. The validation of the developed methods will be field-based at National Grid sites.

Revenue Allowed for the RIIO Settlement

Not Applicable

Indicative Total NIA Project Expenditure

£315,000

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:

To manage the sag condition of the line to ensure that the circuit meets statutory clearance limits to ground, lines may be restricted to operate at lower capacity due to clearance restriction. Therefore real-time sag condition monitoring can play an important role to enable the line to operate at higher capacity.

This project supports the energy transition in a way that it will unlock the potential of increasing power flow of the line so more renewable energy can be transferred via the existing lines, reduce or delay the reinforcement needed. This project aims to design an innovative monitoring solution by using 5G signals to directly measure the line sag in real-time at high accuracy and low cost

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 (RIIO-1 projects only)

Not applicable

Please provide a calculation of the expected benefits the Solution

Not applicable. This is a research focused project with low TRL.

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

The research outcomes and the developed method are of generic nature and are applicable to overhead lines in all networks across GB.

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

The project is a reach project and if successful the methods can be further developed to roll out across GB. The estimated cost will be reviewed at the completion of the project.

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

The project outcome will be a new method of overhead line sag monitoring using 5G signals. The key learning will be shared with other Network Licenses. The developed method is applicable to all OHLs in the GB electricity transmission network.

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

Not applicable

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.

This is the first time that 5G signals are used to monitor overhead line sagging in the world so no unnecessary duplication will occur as a result of the project.

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

The commercial rollout of 5G system only started two years ago and 5G is expected to be the main cellular network in five years. The high frequency of 5G signals made it possible to measure an object with high resolution with advanced data processing algorithm. Using 5G signals business activity. to monitor overhead line sagging has never been explored before. The proposed methodology is innovative and does not require the installation of any sensors.

Relevant Foreground IPR

The project is expected to develop a software package that can extract sag profile from line measurements, and a guidance document

on settings of the developed monitoring system, technical report and any publications of Journal or conference papers related to the developed method for line sag monitoring using 5G signals. The default IPR position will be applied by National Grid. Any and all results created or acquired or otherwise developed during the project belong to National Grid and will be made available through the publication of the progress and completion reports on the ENA portal.

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

This project is in the early research stage to investigate the feasibility of using 5G signals to measure line sag. No relevant commercial product is available. NGET has not had any non-intrusive line sag monitoring system to monitor line sag in real time. It is not the usual

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 contains high technical and commercial risk in developing the monitoring system and algorithm to abstract the sag profile from the captured signals. The proposed methodology needs to be validated it and the risk of failure is high. Therefore it can only be undertaken with the support of NIA.

This project has been approved by a senior member of staff

☑ Yes