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 2018

Project Reference Number

NIA_NGTO015

Project Registration

Project Title

CSE fault analysis by 3D monitoring

Project Reference Number

NIA_NGTO015

Project Licensee(s)

National Grid Electricity Transmission

Project Start

August 2018

Project Duration

1 year and 9 months

Nominated Project Contact(s)

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Project Budget

£99,000.00

Summary

This project has set out to explore the use of 3D Infra-Red (IR) monitoring of cable sealing ends (CSEs). The project intends to use an existing test system at the University of Manchester to collect data on CSEs under various conditions, allowing the feasibility and potential benefits from a 3D IR scan to be determined.

Nominated Contact Email Address(es)

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Problem Being Solved

Condition monitoring of High Voltage (HV) assets is a way of identifying assets which have degraded. While Utility companies strive to perform condition monitoring at regular intervals, it is still a herculean task to be able to monitor all assets throughout their entire lifespan. This highlights the need for accurate and reliable measurements when condition monitoring is performed; to make sure the right information is obtained during a the relatively short time availble to monitor the asset. One way of identifying localised ageing and stress points is by monitoring HV assets for unusual thermal profiles and temperature perturbations during operation. Condition monitoring technicians use standard infra-red cameras to record thermal profiles from HV assets. The heat profile that is obtained from an Infra-red camera is affected by the local conditions; such as load, ambient temperature, wind speed, and sun light.
This makes spot checks of HV assets less accurate than a system that is both capable of constantly monitoring the HV asset for prolonged periods and also recording the environmental conditions. Dynamic changes within the loads and environment are also unlikely to be picked up by standard periodic condition monitoring techniques. Periodic condition monitoring techniques also rely on line of sight for thermal ageing and do not consider a 360° view of the asset.

Method(s)

A new method of temperature measurement is proposed here to investigate the thermal profiles of assets as part of the condition

monitoring process. This project will investigate the feasibility of a system that can consider environmental and loading factors, which can influence the readings taken to determine condition. This project will look into the feasibility of using data fusion algorithms to create a low cost, robust, 3D infra-red imaging system combined with environmental and load measurements. The project will demonstrate how the effects of the asset's health, environmental factors, and load level can be separated.

To measure a 360° thermal profile of an asset, first and foremost there needs to be sufficient clearances available. In cases where this prequisite is satisfied, there are two choices, either move the measurement device around the asset by human or robotic methods, or have multiple stationary measurement devices. Having multiple stationary measurement devices makes the data collection much simpler. However, if multiple measurement devices are required, then the overall system must be economically viable.

Since only small temperature fluctuations are expected, the selected camera must have a sub-Centrigrade resolution. The 3D thermal image can be superimposed upon a detailed 3D model. This proposed 3D imaging system will automatically monitor the asset over an extended period (e.g. weeks) while recording the environmental conditions. This will enable changes in the outer appearance of the asset, which can be hidden by environmental factors such as rain, and heating/cooling on only one side of the asset from wind or sun light, to be extracted from the measurement of the asset's condition.

The new measurement system will have very wide applicability to monitoring asset condition. However, a Cable Sealing End (CSE) will be used as an example for this project. CSEs in a laboratory environment will be monitored using the novel 3D thermal imaging system. High voltage and high current tests will be performed, and will be used to provide a measurement of the normal thermal profiles. One CSE will then have water Injected into it, and the differences in the 3D thermal profiles will be observed between the two CSEs. Ambient conditions will be monitored to take into account variations in climate in the interpretation of the results.

Scope

This project will:

1. Develop a prototype 3D infra-red imaging system that will be used to provide a new method of taking infra-red readings.

2. Perform long term monitoring of the CSE in a HV environment using a 3D infra-red scanning setup. This will allow the normal thermal profile of the CSE to be understood in more detail, under controlled laboratory conditions. Ambient laboratory conditions will also be measured to take into account any local variation in environmental conditions.
A moisture ingress test will be attempted to understand how the thermal profile of the CSE varies during the presence of water. Asymmetrical behavior will be looked for, which has not been previously investigated e.g. heating effect on one side of the CSE.

Objective(s)

The objectives of this project are to:

1. Understand the potential benefits that can be obtained from taking 3D IR images of assets.
Identify the impact that moisture ingress has on the thermal profile readings in the CSE.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

n/a

Success Criteria

This project will be deemed a success if:

· A demonstration of a multi-infra-red camera acquisition system with image stitch to provide a 3D asset image is developed.
Testing the CSE under different environmental conditions, including moisture ingress, is performed

Project Partners and External Funding

Not Applicable

Potential for New Learning

Asymmetrical thermal profiles in CSEs and other assets has been observed, which may be a function of ambient conditions or the behavior of a degradation mode, but has the potential to mislead technicians who are assessing an asset's condition. This project provides the potential to understand CSE degradation modes in more detail and provides an assessment of the benefits that can be obtained from 3D-IR scanning of assets; rather than taking a reading from a single side of the asset. 3D-IR scanning may provide a method of removing the impact that ambient conditions have on condition monitoring readings. The project's outcomes would benefit

all licensees who use condition monitoring practices that include IR cameras. The understanding on how degradation modes manifest and how 3D imaging can provide business value, would benefit all such licensees.

Scale of Project

A feasibility project was chosen to allow this new technology to be trialed and assessed before implementation is fully considered. The scale of the project was chosen as it answers key questions on how much information can be gained from these systems and the potential benefits.

Technology Readiness at Start

TRL2 Invention and Research

Technology Readiness at End

TRL3 Proof of Concept

Geographical Area

Based in the High Voltage Lab and desktop work.

Revenue Allowed for the RIIO Settlement

None

Indicative Total NIA Project Expenditure

Total Cost: £99,000

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:

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 could improve the accuracy and precision of our existing condition monitoring techniques. This would result in fewer false positives and false negative results, and may provide better leading indicators of condition. This could result in fewer cable sealing end replacements, which cost tens of thousands of pounds each, and improve safety.

Please provide a calculation of the expected benefits the Solution

Not Applicable

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

This could be used across the entire GB network in all substations.

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

To implement this method across the GB network, the following key elements of existing Condition Monitoring Survey (CMS) practices need to be updated, with approximate costs of:

1. New camera equipment (£20,000) per team
2. New CMS procedure (£50,000) per licensee
3. Training for existing staff (£100,000) per licensee
4. Data processing (£200,000) per licensee

This could likely cost approximately £3.85 million to rollout across the GB network (based on the adoption by 7 licensees and each licensee having 10 CMS teams on average). There would also be some ongoing costs to keep this system running, however, these are not presently seen to be significantly different to any existing operational costs from condition monitoring.

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 feasibility study will allow all network licensees to assess how they could use 3D-IR scanning technology to provide more information from their condition monitoring data. While this project is focusing on CSEs, this could be easily used for all other asset types; making the outcomes potentially applicable for all network licensees.

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 value area of the Electricity Innovation Strategy:
Managing Assets - Managing assets throughout their lifecycle

☑ 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.

There are no other 3D infra-red monitoring projects on the ENA portal.

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 is seeking to use infra-red cameras to obtain a 3D image of the asset, rather than a traditional 'single side – 2D image'. This may allow for ambient effects, which can influence condition monitoring readings, to be mitigated against. This would reduce the number of false positives and false negatives that are produced as part of the whole condition monitoring process. This may also provide significant further information about the condition of the asset, and allow for specific fault types to be identified. The use of infra-red cameras to perform condition assessments is a relatively new technology for the transmission system, and the extension to a 3D image has only become technically possible in recent years.

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

This technology is seen to have significant potential to provide value to NGET and consumers, but research is required to prove the technology and the benefits. There is a risk that no additional information can be reliably obtained from a 3D scan, or that the information that can be obtained from this type of scan costs significantly more than the benefits of transitioning to this new system. This makes the justification for business funds very difficult, as the money could be better spent in another area.

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 concept, prior to its use within the business. The main risks are: • No proven business case – While there is potential here to obtain significant value, it is not known what the exact monetary value of the additional information. This makes the justification for business funds very difficult, as proof-of-concept work is required to justify the assumptions that go into the business case. • Technical challenges - There are also significant technical challenges which need to be addressed before the value of this concept can be assessed and obtained. These are to do with data processing, and finding a simple method to formulate the 3D image and then identify the degradation modes. There is also the question of understanding how degradation modes manifest themselves, and how ambient effects can be removed from the readings. All of which require an initial assessment; which is the goal of this project. • Operational Practices – As the requirements for the equipment and the use of this equipment are not 100% clear, it is difficult to understand how the operational practices that we presently use for condition monitoring would need to be modified to include the use of a 3D system. This is an important part of understanding what additional (if any) operational costs the businesses would need to take on when implementing this type of technology. Before exact cost estimates can be made, the technology needs to be developed to a point where a high confidence estimate of operational costs can be made. Without the NIA funding these risks would never be mitigated, and the business would be unlikely to fund or adopt this type of technology; resulting in the potential benefits never being obtained or investigated.

This project has been approved by a senior member of staff

☑ Yes