

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

Feb 2019

### Project Reference Number

NIA\_NGTO032

## Project Registration

### Project Title

Novel O-Ring Designs (NORD)

### Project Reference Number

NIA\_NGTO032

### Project Licensee(s)

National Grid Electricity Transmission

### Project Start

March 2019

### Project Duration

2 years and 5 months

### Nominated Project Contact(s)

Oliver Cwikowski

### Project Budget

£392,000.00

## Summary

Moisture ingress is a life limiting factor for many assets, due to the degrading nature that water has on the performance of electrical insulators. For oil filled assets, moisture can result in degradation processes being accelerated. This ultimately results in assets being replaced sooner in their lives, or requires that maintenance activities must take place sooner. Replacing an asset sooner in its life, results in the consumer paying more for non-load related works, while an increase in the maintenance activities increases the Whole Live Cost(WLC) of assets.

National Grid Electricity Transmission (NGET) has identified several families of bushings and Cable Sealing End (CSE) which are thought to have problems with moisture ingress. Many types of bushing and CSE use O-rings to prevent moisture ingress; however different designs appear to be more successful at keeping moisture out than others.

NGET also has evidence that moisture will naturally creep into these assets over time; based on existing data that shows a linear increase in moisture with the age of asset. As there are critical thresholds for bushings and CSEs in terms of the maximum moisture levels, understanding the performance of these seals and when these thresholds are likely to be exceeded is essential to effective condition based management of these assets.

### Nominated Contact Email Address(es)

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## Problem Being Solved

Moisture ingress is a life limiting factor for many assets, due to the degrading nature that water has on the performance of electrical insulators. For oil filled assets, moisture can result in degradation processes being accelerated. This ultimately results in assets being replaced sooner in their lives, or requires that maintenance activities must take place sooner. Replacing an asset sooner in its life, results in the consumer paying more for non-load related works, while an increase in the maintenance activities increases the Whole Live Cost(WLC) of assets.

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## Method(s)

This project will investigate the performance of different O-ring seal topologies, for a range of bushings and CSEs. The structure and performance of these O-ring designs will be investigated to understand how they operate and how their performance might degrade overtime. Ageing mechanisms such as mechanical & thermal degradation, elastic creepage, and chemical interactions will all be investigated. Once the ageing mechanisms have been reviewed and critical ones identified, a suitable synthetic test environment will be developed to test the performance. This synthetic test environment will be used to classify the performance of different O-ring designs.

Once the existing O-rings designs have been understood and benchmarked, novel O-ring materials and designs will be investigated for these applications.

## Scope

This project will investigate:

- 1 - Review of current designs, materials and existing relevant technology
- 2 - Characterise existing O-rings topologies
- 3 - Develop a testing methodology and test seals under representative conditions.
- 4 - Development of finite element model and its use to investigate seal performance.
- 5 - Investigate the potential for the use of new materials and assessment of improved designs

## Objective(s)

The objectives of the project include:

- 1 - To understand the performance and degradation of O-ring seals used in transformer bushings and CSEs.
- 2 - Develop a synthetic test environment to test O-rings, which replicates the in-service environment.
- 3 - Assess the application of novel materials for use in O-ring seals for bushings and CSEs.

## Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

n/a

## Success Criteria

This project will be deemed successful if:

1. The performance of different O-ring topologies can be better understood and benchmarked.
2. A synthetic environment can demonstrate the differences in performance. Novel designs or materials are proposed to provide an improved solution.

## Project Partners and External Funding

-

## Potential for New Learning

This project provides the potential to understand how the sealing arrangements impact the useful life of CSEs and bushings. This new learning can be used to improve the management of these assets; allowing more value to be delivered to consumers over the asset's

life.

## Scale of Project

The scale of this project was chosen to ensure that research questions can be answered in a reasonable time frame, ensuring that the outputs can be implemented into the business.

## Technology Readiness at Start

TRL3 Proof of Concept

## Technology Readiness at End

TRL4 Bench Scale Research

## Geographical Area

Desktop Study and Laboratory Testing

## Revenue Allowed for the RIIO Settlement

None

## Indicative Total NIA Project Expenditure

£392,000

## 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 project would help to prevent the early replacement of bushings and CSEs which are damaged by water ingress. This could be done in two ways. First, if we know how long the O-rings maintain a good seal we can schedule a mid-life refurbishment. This would prevent the replacement of the entire asset due to damage. Second, a novel O-ring design (if subsequently developed and manufactured) may allow certain designs to be retrofitted thereby extending the life of the asset through a minor intervention.

#### Please provide a calculation of the expected benefits the Solution

Presently, as CSEs are seal-for-life units, we must estimate their useful life based on the available information. The replacement of a set of CSEs is estimated to cost circa £100k. If the degradation of O-rings can be understood in more detail, this would allow assets to be retained in service for a longer period. Deferring a replacement by 10 years would save £50k per set. Given that NGET has a population of around 3000 CSEs, this provides significant opportunity to provide benefit to consumers.

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

This method would apply across the entire GB network and likely be useful to all licensees; as they all own bushing and CSEs.

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

The cost of an O-ring replacement will vary depending on the asset under questions. However, sharing the learning from this project could be done through a unified standard which could be adopted by all licensees. The cost of modifying the existing standards is estimated to be £25k per licensee.

### 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 trialed 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 outputs from this project could be put into a specification for bushings and CSEs; allowing good designs to be retained on the market and poorer designs to be excluded from further application in the network. This standard could then be adopted by all network licensees which own bushings and CSEs; which will include all distribution network owners (DNO) and transmission owners (TO) in the UK.

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

Managing Assets

- 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 projects registered on the ENA portal which are investigating O-ring designs for bushings and CSEs.

### 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 innovative as this has not been attempted previously. This is mainly due to historic asset performance of oil filled CSEs and bushing being good. However, recent experience has shown the need to understand these seals in more detail as they have started to impact a wider range of assets. Asset management strategies have also changed over the last few decades. As we extend the life of all assets beyond those which they were originally designed for, the network licensee requires more intimate knowledge

other assets and how different key elements, such as O-rings, degrade over time.

## 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

The research is attempting to investigate what is presently thought to be the most probable cause of moisture ingress within these asset types. However, there is no guarantee that the information gained will have an immediate beneficial impact to the business. The learnings will likely feed into a standard, which will provide value over a long period of time, but may take several years to recover depending on the outcomes of the research. Given these risks, it is not justifiable for the business to fund this work outside of the NIA.

## 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 risks are:

- No proven business case – While a value case has been defined for this project, it is contingent on obtaining an as yet unknown level of technical knowledge. No matter what the outcomes of this project are, these will be valuable to consumers, but in a more qualitative manner. However, the foreseen benefits are not sufficient for the business to justify the project's budget. Without the NIA funding these risks would never be mitigated, and the business would justifiably not research this area; resulting in the potential benefits never being obtained or investigated.

## This project has been approved by a senior member of staff

Yes