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

Apr 2025

Project Reference Number

NIA2_NGET0084

Project Registration

Project Title

Low-carbon STrategic REplacement with Additive Manufacturing (L-STREAM)

Project Reference Number

NIA2_NGET0084

Project Licensee(s)

National Grid Electricity Transmission

Project Start

April 2025

Project Duration

1 year and 7 months

Nominated Project Contact(s)

Kerri Hayes

Project Budget

£599,455.00

Summary

There is a growing fleet of ageing assets without strategic spares in the event of failure. Blueprint and component information of legacy equipment are not always digitised. There is a growing challenge in terms of sourcing and storing strategic spares with potentially long lead-time. Traditional methods such as moulding and casting are cheaper when produced at very large quantities. For the power transmission industry, some of the critical products are produced in small volume, which result in much higher manufacturing cost per unit. 3D Printing, one of the most effective additive manufacturing (AM) techniques, is already a proven method used in high performance industries such as formula one and aerospace and ideal for making such parts.

Third Party Collaborators

The University of Manchester

Southampton University

Nominated Contact Email Address(es)

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Problem Being Solved

Traditional methods such as moulding and casting are cheaper when produced at very large quantities. For the power transmission industry, some of the critical products are produced in small volume, which result in much higher manufacturing cost per unit. Additive Manufacturing (AM), also known as 3D Printing, is already a proven method used in high performance industries such as formula one and aerospace. There is little ageing data or knowledge on long-term operational experience using components created through additive manufacturing. This is critical to the power industry as all components must be able to perform their duties (strength/capability) safely as per the Regulation 5 of Electricity at Work Act. Therefore, there is a need to ensure components fabricated using AM can attain equivalent or better performance. An additional aim of this project is to understand whether AM can overcome component

obsolescence to manufacture components that can no longer be casted or moulded through conventional manufacturing methods. This is a joint project of the University of Manchester (UoM) and the University of Southampton (UoS), whereby each partner leads one major Work Stream (WS), with WS2 being led jointly.

Method(s)

Workstream 1 – Development of suitable AM techniques for HV components (Lead: UoM)

The initial work stream will focus on literature review and data gathering required for the simulations and experimental work. This will highlight work that has already been done to assess dielectric properties of dielectrics prepared with additive manufacturing (AM) techniques, along with assessment of mechanical, thermal and chemical resistance based on literature. Particular interest will be in reports of field experience of AM materials in other disciplines related to medium to long-term ageing behaviour. This workstream will define the AM methods for further material selection in WS2.

Workstream 2 – Optimising the material selection for AM (UoM/UoS joint lead)

Assessing suitability of commercially available polymers for AM and limitations compared to the current state-of-the-art. We will explore layering of spatially graded materials on potential performance improvement. This will include assessment of dielectric permittivity (storage and loss), space charge behaviour and partial discharge analysis. The work will highlight the limitations of electric fields that can be safely applied in practical applications and will be used as reference point for further measurements in WS3.

Workstream 3 – Accelerated ageing investigation of AM produced components (Lead: UoS)

AM techniques have no track record when comes to long-term dielectric performance. Majority of AM applications are intended for relatively short-term use compared to what is expected in the power industry. It is envisaged accelerated ageing investigation of AM components will reveal their ageing behaviour and component integrity when compared to conventional components. Due to the nature of accelerated ageing test, this will require experimental investigation throughout the project duration. The same dielectric properties as established in WS2 will be recorded after 2, 4 and 6 months of thermal ageing. As UV resistance of some resins used for AM might be limited, this could also be investigated if a UV curable resin is selected in WS1-2.

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 our 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.

In line with the ENA's ENIP document, the risk rating is scored 7 = Medium.

TRL Steps = 1 (2 TRL steps)

Cost = 2 (£568,000)

Suppliers = 1 (2 supplier)

Data Assumption = 3 (Assumptions unknown to be explored and validated within project)

Scope

The need to deliver the 'Great Grid Upgrade' at pace requires Additive Manufacturing (AM) through:

i. Facilitate adaptable manufacturing demand and broadening of the supply chain.

ii. Minimise R&D costs for rolling out new technology to the network (different tooling, mould costs needed for initial

developmental and trial phases).

iii. Enable future solutions with enhanced functional performance through spatially graded materials.

iv. Reduce costs for future manufacturing.

Objective(s)

O1: Investigation of suitable additive manufacturing/3D printing approaches that can support the rapid material selection and characterisation necessary to support HV component design; and the ability to flexibly fabricate strategic spares.

O2: Optimising the material selection through rapid material testing and fabrication process to maximise the allowable working field stress in practical applications.

O3: Initial work on accelerated ageing investigations on various AM components in direct comparison against components fabricated through conventional means.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

N/A

Success Criteria

1: Determine suitable additive manufacturing/3D printing approaches that can support the rapid material selection and characterisation necessary to support HV component design; and the ability to flexibly fabricate strategic spares.

2: Define the optimisation of the material selection through rapid material testing and fabrication process to maximise the allowable working field stress in practical applications.

3: Complete accelerated ageing investigations on various AM components in direct comparison against components fabricated through conventional means.

Project Partners and External Funding

University of Manchester and University of Southampton

Potential for New Learning

The project will provide first evaluation of components fabricated using additive manufacturing (AM) can attain equivalent or better performance when compared to traditional manufacturing methods (moulding/casting). There is little ageing data or knowledge on long-term operational experience using components created through AM. This is critical to the power industry as all components must be able to perform their duties (strength/capability) safely as per the Regulation 5 of Electricity at Work Act.

Scale of Project

The work will be divided into 3 work streams focussed on the achievements of objectives, with each producing a clear set of deliverables. WS1 is led by the UoM (thus detailed in the UoM WRF), WS3 is led by the University of Southampton, while WS2 is jointly addressed.

Development of suitable AM techniques for HV components (Lead: UoM)

Optimising the material selection for AM (UoM/UoS joint lead)

Accelerated ageing investigation of AM produced components (Lead: UoS)

Technology Readiness at Start

TRL2 Invention and Research

Technology Readiness at End

TRL4 Bench Scale Research

Geographical Area

The research work will be carried out between Manchester University and Southampton University

Revenue Allowed for the RIIO Settlement

N/A

Indicative Total NIA Project Expenditure

£539,509.50

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:

The need to deliver the energy system transition at pace requires additive manufacturing (AM) through:

(i) Facilitate adaptable manufacturing demand and broadening of the supply chain;

(ii) Minimise R&D costs for rolling out new technology to the network (different tooling, mould costs needed for initial developmental and trial phases);

(iii) Enable future solutions with enhanced functional performance through spatially graded materials;

(iv) Reduce costs for future manufacturing.

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

N/A as low TRL research project

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

The project will be applicable to both distribution and transmission assets[KH1] [LC2]

[KH1]Does this work across both?
[LC2]Yes

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

N/A

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

Results will be shared with all licensees, however, NGET will focus on transmission assets for this project. It will be the responsibility of others to determine the extent to which the assessed technologies might be directly applicable.

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.

NGET is unaware of similar projects being undertaken and no other networks have made us aware of projects that might result in duplication.

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

Adopting additive manufacturing (AM) based solutions could provide the flexibility for customisation and optimisation in replacement components for legacy equipment to enable asset life extension. There is also potential of utilising sustainable and resilient materials in legacy equipment. This will improve network resilience and minimise unnecessary capital replacement, while strictly adhere to ever-tightening environmental standards.

Theoretical work demonstrated that a material with variable permittivity, respectively conductivity, could greatly improve performance by optimising the local electric field strength in insulating spacers, to reduce the design stress. So-called field-grading materials (FGM) have been topic of research for decades, they are impractical due to limitations of conventional production methods. AM allows layer by layer deposition of UV-curable resin, thus the potential of adding layers of varying permittivity and for the first time enabling widespread industrial use of FGM. AM can also minimise the requirement for strategic spares as just a base polymer and digital file for use with AM would need to be stored, with more freedom in creating the engineering design and materials.

Relevant Foreground IPR

N/A

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

Low TRL at the moment and we must first prove at a material level we can use additive manufacturing to achieve comparable performance vs conventional methods. Hence, this is suitable for an innovation 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

NIA funding is appropriate as it enables NGET to access learning about new technologies more quickly than if the market were to explore this potential use case. Without the project it is unlikely that any of the innovation suppliers involved would explore it and the improvements would not become available.

This project has been approved by a senior member of staff

☑ Yes