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

May 2025

Project Reference Number

NIA2_NGET0091

Project Registration

Project Title

Growing Renewable Engineering solutions by exploring New Polymer Rebars (GREEN)

Project Reference Number

NIA2_NGET0091

Project Licensee(s)

National Grid Electricity Transmission

Project Start

June 2025

Project Duration

1 year and 7 months

Nominated Project Contact(s)

Muhammad Shaban

Project Budget

£201,405.00

Summary

In alignment with National Grid Electricity Transmission's (NGET's) objectives of achieving net-zero construction, we aim to evaluate the suitability of polymer rebars as a sustainable alternative to traditional reinforcement used in concrete structures to demonstrate these materials' suitability. The aim of this project is to develop a proof of concept demonstrating that fibre reinforced polymer (FRP) reinforcement can be developed and utilised as an alternative to steel reinforcement for foundations within substations. This study will identify the most appropriate FRP material to meet substation load and atmospheric conditions, considering factors such as electric and thermal conductivity, fire resistance, resistance to oil, and impact resistance due to short-circuits.

Third Party Collaborators

Kelvin Construction Company Limited

Nominated Contact Email Address(es)

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Problem Being Solved

There are several problems with the use of steel, specifically in the context of its use in the electricity transmission industry:

- Significant mining requirement with limited resources available globally
- High energy-intensive process
- Additional considerations required to mitigate EMF current in certain structures-increase cost and time.
- Scattered geographical process and need for transport of materials at each stage, often between country transport
- High demand for the products in other industries (building, rail) and shortage of materials
- High asset management

- Exposure to change in raw material prices and price hikes

The above challenges all contribute to increasing the carbon footprint of electricity transmission projects. Using steel has a significant carbon footprint due to its energy-intensive production process, which involves mining, refining, and forming. These processes emit substantial amounts of greenhouse gases, particularly CO2. Additionally, the heavy weight of steel increases transportation emissions. Frequent maintenance and replacement due to corrosion further contribute to its carbon footprint, as do the high energy demands for heating and cooling buildings due to steel's poor thermal insulation properties. The use of alternative materials has not been explored in detail due to the availability of steel so far and the lack of focus on the asset life cycle’s environmental impact.

By leveraging FRP's lightweight properties, lower embodied energy, and reduced waste generation, this project aims to contribute to National Grid's commitment to sustainability and carbon reduction. The successful implementation of FRP reinforcement can lead to significant carbon savings, enhanced safety, and improved efficiency in substation construction and maintenance, ultimately supporting the transition to a more sustainable energy future.

Method(s)

n this research, the main proposal is to explore the use of FRP reinforcement in foundations through following main stages:

- Literature review- to study physical and mechanical properties and their evolution over the product’s design life
- Case studies
- Market research- supply chain, availability and cost
- Desktop analysis- In-house analysis to establish ULS and SLS characteristics, National
- Grid’s site requirement etc.
- Trial erection and testing

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.
Add any certifications or other processes if known

Low Risk
TRL Steps = 1 (1 TRL steps)
Cost = (£201,405)
Suppliers = 1 (1 supplier)
Data Assumption = 3 (Assumptions unknown to be explored and validated within project)

Scope

When compared to traditional steel reinforcement, FRP is comparatively lightweight, offering several benefits including easier transportation, reduced site risks, and overall carbon savings. FRP production is less energy-intensive than the processes required for steel, resulting in lower embodied energy. Additionally, FRP manufacturing generates less waste, and advancements in recycling methods are improving its recyclability.

Common Fibre reinforcements products available in the construction market:
GFRP- Glass based Fibre Reinforced Polymer
BFRP- Basalt based Fibre Reinforced Polymer
CFRP- Carbon based Fiber Reinforced Polymer

AFRP – Aramid based Fiber Reinforced Polymer
The project will be divided into three stages: Feasibility Study, Detailed Desktop Analysis, and Trial Erection Analysis and Recommendations.

1. Feasibility Study: The aim of the feasibility study is to establish the following results:
Identify the most appropriate FRP reinforcement material for substation structures.
Analyse different case studies and discuss any challenges and health and safety aspects.
Conduct a literature review to assess code compliance, design standards, higher-level carbon studies, and the physical and mechanical properties of FRPs. Identify limitations impacting design, procurement, and installation.
Determine short and long-term monitoring methods, both in-situ and laboratory, and gather feedback from relevant case studies.
Perform a market analysis to study material availability, suppliers, cost, and procurement chain across the UK. Also, analyse product health and safety certificates.

2. Detailed Desktop Study: With the chosen FRP from the feasibility stage, the most appropriate concrete elements will be identified in this stage. The following detailed analysis will be performed:

Conduct a strength and serviceability assessment according to relevant National codes and NG specifications.
Perform a detailed analysis of the fire resistance of the composite material.
Study the electric and thermal conductivity of the material.
Analyse substation safety during construction and throughout its lifespan, identifying any hazards.
Perform Life Cycle Analysis of FRP and concrete elements.
Provide overall recommendations on FRP and concrete elements.

3. Trial Erection Analysis and Recommendations: Once the first two stages are feasible, a trial erection and further site/laboratory testing will be conducted to verify all results. A detailed report will be produced.

Final report will be published with all the learning outcomes and will be shared with all the licensees. A dissemination event will present all the results to relevant stakeholders with the recommendations of certain technologies ready to use in business as usual (BAU).

Objective(s)

The work will be delivered in discrete stages each with a focus on different objectives linked to the overall aim to explore FRP reinforcement. This project is planned to take 18 months with the following major objectives:

- To develop an understanding of the different types of FRPs to allow for identification of usage cases, potential benefits, and readiness for construction trials.
- To review the technology and summarise the current state of knowledge, trends, challenges, and opportunities in utilising FRPs as alternatives to steel reinforcement.
- To review the current design codes and approaches to explore how they might be applied in the design of FRP reinforcement.
- Final recommendations to identify the potential benefits and implementation learning outcome.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

The project offers several key benefits, both in terms of technical performance and broader environmental and economic impact:

1. Enhanced Durability and Longevity: By using FRP materials, particularly in coastal and harsh environments, the project ensures better resistance to corrosion and environmental degradation compared to traditional steel reinforcements. This translates into longer-lasting structures and reduced maintenance costs over time.
2. Carbon Footprint Reduction: The use of FRP materials, especially during the construction phase, contributes to reducing carbon emissions. FRP’s lighter weight means less energy consumption during transport, and the material's longer lifespan reduces the need for frequent replacements, further decreasing the carbon footprint.
3. Cost-Effectiveness: FRP materials, while having higher initial costs compared to steel, can lead to significant long-term savings. The reduced need for maintenance, longer service life, and easier transportation help offset the higher upfront cost, making it a more cost-effective solution over the long run.
4. Improved Safety and Performance: FRP reinforcements offer superior tensile strength and flexibility, providing enhanced safety and load-bearing capabilities for concrete structures. The material’s resistance to chemical and environmental stressors reduces the risk of structural failures, ensuring greater safety in substations and other critical infrastructure.
5. Environmental Friendliness: FRP is not only corrosion-resistant but also recyclable, making it an eco-friendly alternative to traditional materials. This contributes to the overall sustainability of the project, supporting green building initiatives and reducing environmental impact.

6. Innovation and Future-Readiness: By adopting cutting-edge materials like FRP, the project positions itself as a forward-thinking solution, prepared to meet future challenges in infrastructure development. The research and testing conducted as part of the project will expand knowledge about the material, potentially influencing future industry standards and encouraging more widespread use of sustainable construction materials.
7. Optimized Material Use: The hybrid approach of using FRP for tensile strength and steel for shear strength may result in a more efficient design, optimizing material use and reducing unnecessary waste. This balance between the two materials maximizes performance while maintaining cost-effectiveness.

In summary, the project not only addresses immediate technical needs but also supports broader goals of sustainability, cost savings, safety, and innovation, benefiting both the construction industry and the environment.

Success Criteria

The project will be considered successful if the following stages are completed. The trials would consist of several stages to gain a full understanding of behaviour in this use and ensure all requirements have been met including workability, design, and practicality.

Stage 1: Feasibility stage (Identify appropriate FRP, analyse case studies, conduct literature review, market analysis).
Stage 2: Detailed Desktop study (Strength tests, fire resistance analysis, electric and thermal conductivity)
Stage 3: A General Arrangement Drawing (simple pad foundation only) for trial erection purpose.
Stage 4: Risk Assessment for trial erection
Stage 5: Trial results analysis and recommendation report
Stage 6: Supplier evaluation and selection

Project Partners and External Funding

Kelvin Power Structures (Vinci Energies) will conduct the study including the testing and trials completing all stages of the study. NGET is funding the project through NIA and is the lead network.

Potential for New Learning

Overall, FRP rebar's superior thermal, corrosion, and chemical resistance make it a potential sustainable alternative to steel reinforcements in foundations. Although all these benefits make this material very promising, further research is required to reach a conclusion as to whether the application of FRP reinforcements in foundations within substations is feasible.
The elastic properties of FRP materials differ significantly from steel, which can lead to concerns about sudden failure without the same warning signs typically associated with steel reinforcement. The detailed desktop study stage includes a detailed assessment of these ULS and SLS issues, with a focus on advanced modelling and testing to predict how FRP reinforcements behave under varying load conditions.
Fire resistance is another important factor, as FRP materials may not provide the necessary fire protection, same as steel, required for certain applications, particularly within fire damage zones. As part of the desktop analysis, it will be essential to assess the fire resistivity of the FRP materials, as well as to investigate potential solutions to improve this characteristic.
The long-term monitoring of FRP-based reinforcements is crucial to understanding how they perform over time, particularly with respect to potential degradation or failure. Issues such as creep, fatigue, and other environmental factors must be closely examined, and monitoring systems should be implemented to track performance throughout the lifespan of the structure. This monitoring aspect will be a key component of the literature review and discovery phase, informing future research and development efforts in this area.
Also, the market research as part of feasibility study will involve a review of available suppliers and an assessment of their capabilities in producing FRP reinforcements that meet project specifications. It will also explore potential collaborations with suppliers to develop new caging methods or explore different shape codes that expand the range of available FRP reinforcements for different applications.
Investigation of all the above mentioned points will generate new learnings and data for National Grid to influence technical specifications and guidelines.

Scale of Project

All work is strategically linked and designed to deliver the defined objectives. Therefore, the scale of the project is as specified, and the studies will be undertaken to explore the FRP options available to use. There will be additional testing and trials in this project that would be undertaken to establish some recommendations for final report.

Technology Readiness at Start

TRL4 Bench Scale Research

Technology Readiness at End

TRL6 Large Scale

Geographical Area

The study will be completed in different stages and all stages will be completed within the UK (England & Wales).

Revenue Allowed for the RIIO Settlement

N/A

Indicative Total NIA Project Expenditure

£181,265

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 project facilitates energy system transition by helping NGET to understand the environmental impact, in terms of carbon emissions arising from our construction activities while using steel as reinforcement. This project will conduct a feasibility study to explore whether fibre reinforced polymer (FRP) reinforcement can be developed and utilised as an alternative to steel reinforcement for foundations within substations. This will help us identify clear opportunities to reduce emissions and assist in commitments to reduce scope 3 emissions.

How the Project has potential to benefit consumer in vulnerable situations:

Developing an understanding regarding FRP is key in reducing the negative impact of GHG emissions arising from steel production and recycling. Reduction in emissions, material volume, and concrete used has huge societal benefit.

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

Total Concrete (tons) required for the post insulator foundations (1m3) in a typical substation: 191 (Steel reinforcement)
Total Concrete (tons) required for the post insulator foundations (1m3) in a typical substation: 179 (GFRP reinforcement)

Total rebar required for the asset (tons): 1.05 (Steel reinforcement)
Total rebar required for the asset (tons): 0.29 (GFRP reinforcement)

Approx Transport cost per 100 miles (£): 150 (Steel reinforcement)
Approx Transport cost per 100 miles (£): 38 (GFRP reinforcement)

Total Savings:

For a duration of 10 years and for 50 substation post insulator foundations, the below savings can be generated:
Concrete: 582 tons
Rebars: 38 tons
Transport: £5,625
CO2e: 3.4 tons

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

The developed methodology is of generic nature and would be applicable to all electricity network Licensees across GB, this would be inclusive of transmission and distribution owners. The outcome of the project will determine how much emissions can be reduced by the implementation of such materials. The success of the project will boost the confidence on the material reliability and safety practices.

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

If the project is successful, the method can be further developed to roll out across GB. The estimated cost will be reviewed at the completion of the project. Conservative estimates of costs have been made for the purposes of assessing the value of this project, they are based on the cost of polymer materials. There is some cost associated to changing the technical specification to allow the use of polymer materials in the business and across GB.

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 learning will be used in the planning and designing of new substations to reduce the carbon emissions. It is the learning that may be directly applied to other networks with similar assets at similar voltages. The disseminated results will be shared with all licensees so that the reasons for the conclusions may be understood. It will be the responsibility of others to determine to what extent it applies to other equipment types and different voltages but the underlying work from this project is likely to help.

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.

The initial feasibility assessment will focus on identifying the most suitable FRP material for concrete elements in substations. This phase will involve summarizing the benefits, limitations, cost comparison, and supply chain considerations associated with various FRP options. Additionally, a high-level carbon study will be conducted at this stage to evaluate the environmental impact.

If applicable, justify why you are undertaking a Project similar to those being carried out by any other Network Licensees.

The project intends to generate evidence to change the construction activities since the technical specifications do not allow such materials now hence, they are not utilised currently. There are no other projects in development looking at FRP as a reinforcement within concrete structures that can help reduce the emissions. The risk of duplication will be addressed through dissemination of progress with other licensees and being open to co-operate with licensees working in this space.

Additional Governance And Document Upload

Please identify why the project is innovative and has not been tried before

The use of alternative materials in the substation environment is very limited (where only steel, aluminium, and concrete are predominantly used). The need to explore new materials has been very limited up to now due to the availability of concrete, aluminium, and steel supply-chains and limited attention to assets carbon footprint. Current NG TS specifications may not allow for alternative solutions; hence, some of the proposed innovations could not have been tested and implemented in the past.
FRPs are innovative materials for reinforcements in foundations due to its advanced material properties, including superior corrosion resistance, lightweight nature, and durability. Historically, steel was the standard because of its established performance and availability. FRP's adoption into the construction industry was delayed due to the need for advanced material development, updates to industry standards and building codes, market familiarity with steel, high initial investment costs, and the requirement for extensive performance validation. As these challenges are being addressed, FRPs are now being recognised for its practical advantages and cost-effectiveness, when compared with steel, in foundation reinforcement.
There are currently no NIA/SIF projects looking at FRPs with potential trials within the UK. As a responsible business, NG need to cover the knowledge gap to address the issue and manage the expectation to meet the commitments of reducing the scope 3 emissions.

Relevant Foreground IPR

The foreground IPR will be the knowledge gained about the FRP reinforcement and the performance of different elements over one another as well as over steel reinforcement. The learning will be brought together for like for like comparison and development of some designs and structures to be tested at a location (Deeside) and gather some test data.

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

There exists no data that supports the evidence of using FRP as a reinforcement. A strong test data along with validation data is required to change the technical specification to utilise FRP widely within the business. There is a risk factor involved which needs thorough testing and trials before it can be adopted. The risk of alternatives not performing up to certain standards is also a possibility and that is why business as usual cannot fund such activities.
This project aims to update the technical specifications based on the data obtained through a series of testing. This is not a business-as-usual activity as there is considerable risk associated with the development and implementation.

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

Testing to date suggests that the work will be successful, but it cannot be guaranteed. If the feasibility study identifies more challenges than benefits, the project will not proceed to BAU and technical specifications will not be changed. The project is anticipated to generate sufficient benefit to justify the expenditure over 10 years. So, the success of the project will only become truly apparent over a longer period. During that time alternative, currently unforeseeable, solutions may arise that provide greater benefit.

There are technical risks associated with any innovation project as the proposed solution may not work. Replacing the existing materials like concrete has high risk requiring additional work like finding the unknowns about the material strength, exploring the supply chain, associated technical risks, validation, and verification of results, and identifying viable sources of relevant data and science. Therefore, considering the risks associated with the success of the project, NGET believes NIA funding is the best route for the project.

This project has been approved by a senior member of staff

☑ Yes