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# NIA Project Registration and PEA Document

### Date of Submission

Jul 2023

### Project Reference Number

NIA2_NGET0045

## Project Registration

### Project Title

Use of Innovative Materials and Construction Techniques in the Substation Environment to Accelerate Transition to Net-Zero

### Project Reference Number

NIA2_NGET0045

### Project Licensee(s)

National Grid Electricity Transmission

### Project Start

September 2023

### Project Duration

2 years and 1 month

### Nominated Project Contact(s)

Muhammad Shaban

### Project Budget

£950,000.00

### Summary

This project aims to examine the use of low carbon construction materials in detail both at feasibility and trial stage for the reduction in carbon emissions associated with construction activities. This will include research for alternative materials like polymer structure, bubble slab foundations, waffle slabs, and others. The project will be split between structures and civil elements, with 3 topics for structures and 4 topics for civils being explored. It is proposed to first have a feasibility study and proof of concept stage, then an implementation stage for the civil elements, mainly foundations and bunds, and then an implementation stage for structures, where these could be mounted on the foundations from the previous stage. Further, this project looks to leverage the latest advances in structures and civil elements technology to ensure that the right asset investment decisions are made for future generations.

### Third Party Collaborators

Kelvin Construction Company Limited

### Nominated Contact Email Address(es)

box.NG.ETInnovation@nationalgrid.com

### Problem Being Solved

The current materials used in the electricity transmission substation and overhead line are primarily steel, aluminium, and concrete. The use of concrete structures is reduced due to longer construction time required, but foundations are principally concrete. Both steel and aluminium products require raw materials to be produced (in sheets, or sections) at “mills” and later to be transported to “fabrication” workshop(s) to produce the specific items. The products are often heavy, and therefore even smaller items require craning, and larger transport means due to weight. 8% of the global carbon emissions come from concrete, so reducing this could have significant benefits.

There are several problems with the use of steel, aluminium, and concrete specifically in the context of their use in electricity transmission industry:

• Significant mining requirement with limited resources available globally
• High energy intensive process
• 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 (oxidation, cracks, deflection)
• Exposure to change in raw material price and price hike

The above challenges increase the carbon footprint of the electricity transmission projects. The use of alternative materials has not been explored in detail due to availability of the steel, aluminium, and concrete so far, and less focus on asset life cycle's environmental impact.

## Method(s)

We propose to explore the use of different materials in detail in the following stages:

• Availability of material and fabrication (supply-chain)
• Design requirements and changes in design compared to steel/aluminium/concrete
• Like for like comparison of end products (weight, carbon footprint, ease of construction i.e., reduced earthing, asset management, and decommissioning)
• Demonstration/testing of a product

Feasibility study and proof of concept stage will include research for materials. The project will be split between structures and civil elements, with 3 topics for structures being explored and 4 topics for civils being explored. It is proposed to first have a feasibility study and proof of concept stage, then an implementation stage for the civil elements, mainly foundations and bunds, and then an implementation stage for structures, where these could be mounted on the foundations from the previous stage. The following structures and civils options will be explored for feasibility study and proof of concept topics. Each topic has the purpose of choosing specific topics as explained below:

Weathering Steel for Structures – Weathering steel creates a layer of rust onto the steel surface which doesn't flake away over time and therefore protects the steel. If the steel can be bought in this form, it would save considerable time on fabrication, where the need for painting or galvanizing would be eliminated. There are also alleged sustainability benefits to using this method of steel protection. It is proposed to research into the feasibility of this material from a manufacture and delivery perspective as well as from a sustainability perspective.
Generative Design and 3D Printing of Structures – Generative design of structures creates the lightest structure possible given set parameters to work to. In the past generative design has been done, but manufacturing of these designs has proved too difficult and therefore simpler structures are often reverted to. With 3D printing technology, it could be viable to design, and 3D print a very lightweight structure, which could have cost, sustainability, transport, and installation benefits. The structures could be polymer/plastic or even 3D printed from steel powder.
Polymer Structures – Polymer materials (GRP and FRP) are already used in substations for light weight items including trench covers and platforms. We propose to use this material for equipment support structures.
Bubble Slab Foundations – Bubble slabs use hollow plastic balls to reduce the volume of concrete required for different foundation type. They provide a sustainable solution as less concrete is required and therefore less transport and labour.
Waffle Slab Foundations – Similar to bubble slabs, waffle slabs reduce the amount of concrete required for foundations by using grillages of concrete beams with a thin slab on top. Waffle slabs are common in industrial buildings but are rarely seen outside of this environment.
Ashcrete and Ferrock Foundations – Ashcrete replaces the cement used in concrete with fly ash, which is a by-product of burning coal and is therefore a recycled material. Ferrock replaces the cement with waste steel dust and waste silica, both by products of construction processes. These could be used for foundations and would provide a more sustainable solution than traditional concrete foundations.
Graphene Enhanced Concrete – Graphene enhanced concrete improves the strength of the concrete significantly so that less concrete volume is used overall, greatly reducing the carbon impact of any foundations that it would be used on.
Light-weight Foam Foundations – Foam foundations provide a quick and easy solution for foundations for fences, pedestrian segregation barriers, road signs and other light-weight structures, where an expanding foam is poured into the hole and expands around the fence post or structure. It could be more sustainable, is light weight so is easy to lift, has quick curing time and is easy to apply.

## Scope

The scope of the work is detailed below:

Work Package 1: Feasibility Study/Proof of Concept

Desktop study to explore different options with strong focus on supply chain of innovative materials for long run.

Work Package 2: Implementation, Trial on Site & Laboratory Testing

Alternative Solutions for Substation Structures
Site installation is involved for structures which includes design, site visits during erection/construction, follow up visits after installation, reports, and as built records of the trial stage for the structures. Laboratory testing with report of findings exposing steelwork to a corrosive environment to simulate seasonal/environmental effects to determine design life of steelwork as well as destructive testing of structures. Testing of reuse/recycling of above explored options will also be explored.

Alternative Solutions for Substation Foundations
Explore the light-weight Foam Foundations for Fence Post and the whole process will be conducted from procurement, delivery, and installation of fence post with light-weight foam foundation. Investigate bubble slab foundations with delivery and installation of the foundation for a typical substation structure. Waffle Slab Foundation Ashcrete, Ferrock and Graphene Enhanced Concrete Foundations will be studied for delivery and installation for typical substation structures.

Work Package 3: Testing and Reporting of Implementations

Demonstration and testing of the product at Deeside Innovation Centre will be implemented. Site visits will be conducted during erection/construction, installation and reports will be published on the ease of installation and outcomes from civil contractor. Reports will also include laboratory/Site testing with findings for bolt pull-out and shear testing, crack control testing and recommendations of application of each.

Work Package 4: Final report outlining recommendations to National Grid

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 work packages each with a focus on different objectives linked to the overall aim to explore low carbon materials used in Civils and structures. This project is planned to take 2 years with the following major objectives:

- Successfully explore the supply chain for availability assessment for materials and fabrication.
- Identify design requirements and changes in design compared to steel/aluminium/concrete.
- Like for like comparison of end products (weight, carbon footprint, ease of construction i.e., reduced earthing, asset management, and decommissioning).
- Demonstration and testing of the product at Deeside innovation centre.
- Final recommendations to identify the potential benefits and implementation learning outcome.

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

An assessment of distributional impacts (technical, financial and wellbeing related) for this project has been conducted using a bespoke assessment tool, which assesses the project as having a positive, negative, or neutral effect on consumers in vulnerable situations. To help inform the assessment, this tool considers the categories of consumers identified in the Priority Services Register. This project has been assessed as having an overall positive impact on consumers in vulnerable situations. The assessment has identified that this project will look to help NGET to invest on better construction structures and Civils which will reduce both cost and emissions for consumers.
For instance, the weathering steel or using polymer instead of steel reduces the weight of the material itself which not only reduces the emissions but also cost associated to the lifting, transportation cost, labour cost, and health and safety all are improved.

## Success Criteria

The project will be considered successful if the objectives are achieved, specifically:

- Successfully explore all the low carbon options available which can be used by NGET
- Understand the ability and value of design requirements compared to steel, aluminium, and concrete. Understand the potential impact of different factors like carbon footprint, weight, asset management, and decommissioning

- Make clear recommendations regarding the availability and possible development of the materials to achieve net zero targets.

Sufficient knowledge would be gained for overall low carbon construction material alternatives that can be utilised to reduce the scope 3 emissions associated with the construction.

## Project Partners and External Funding

The following project partners will be supporting the project:
Kelvin Power Structures (Vinci Energies) will conduct the feasibility study and develop the materials but are not contributing to the project financially.
NGET is providing all the funding for the project and is the lead project partner.

## Potential for New Learning

The following will be new knowledge expected from carrying out the project:

- Development of new learning around low carbon construction material supply chain and availability
- Operational performance data obtained for various civils and structures at Deeside centre for innovation
- Like for like comparison of innovative materials with existing materials like steel, aluminium, and concrete
- The outputs created from the project will be shared with the interested parties in energy sector especially the NGET construction working group.

## 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 demonstrate the testing of the materials developed. There will be additional field work in this project that would be undertaken at Deeside Centre for Innovation (DCI), Wales, UK to establish some recommendations for final report.

## Technology Readiness at Start

TRL4 Bench Scale Research

## Technology Readiness at End

TRL6 Large Scale

## Geographical Area

Feasibility study will be conducted at Kelvin Power Structures, Leicester, UK, and field implementation will be based at Deeside Centre for Innovation (DCI), Wales, UK. The overall geographical area is the UK

## Revenue Allowed for the RIIO Settlement

N/A

## Indicative Total NIA Project Expenditure

£855,000

# 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:

National Grid has a commitment with Ofgem for carbon neutral construction by 2026 and current National Grid technical specifications does not allow alternative materials hence an innovation trial like this will develop the case to change the specifications and implement other materials. Alternative material options ensure future upgrades to the network that avoid emissions while delivering an efficient and secure transmission system. This project is aligned with the National Grid climate transition plan which states “We have also identified our material hotspots for construction activities and will continue to work with partners across the industry for lower carbon alternatives”.

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

Developing an understanding regarding low carbon construction materials is important to reduce the negative impact of carbon dioxide emissions arising from construction. 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

The benefit of this project assumes that NGET will achieve low emission material performance. New materials like polymer and 3D printed ones will reduce the capital investment and replacement of steel with polymer will reduce the OPEX cost involved for mitigating corrosion and cracking. If this project is successful, over a 10-year period, £1.5M of Societal value will be created by saving 705 tons of concrete, 323 tons of CO2 and 62 tons of metals. The overall financial benefit is £2.7M including a saving of £1.5M on capital costs. The benefit ratio obtained from the project is 1:3.

## 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/tool 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 and upgrading the existing infrastructure 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.

This project explores new techniques and materials which have not been explored or implemented before. The project intends to generate evidence to change the construction activities since the technical specifications do not allow such materials at the moment hence they are not utilised currently. There are no other projects in development looking at innovative polymer materials or other alternative materials 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.

### 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

The current materials used in the electricity transmission substation and overhead line environment are primarily steel, aluminium, and concrete. The use of concrete structures is reduced due to longer construction time required, but foundations are principally concrete. NGET technical specifications do not allow use of any other materials at the moment. To change the specifications, we need learning data to support the evidence of alternatives. The use of alternative materials has not been explored in detail due to availability of the steel, aluminium, and concrete so far, and less focus on asset life cycle's environmental impact. Polymer materials and other innovative materials will directly address the risks and challenges NGET is facing. The maintenance cost can be saved due to reduced oxidation and rusting.

## Relevant Foreground IPR

The foreground IPR will be the knowledge gained about the availability & supply chain of low carbon alternatives. The learning will be brought together for like for like comparison and development of some of the materials to demonstrate at Deeside Centre for innovation and gather some 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 polymer materials in substation environment, especially in foundations and structures. A strong test data along with validation data is required to change the technical specification to utilise such materials. There is a risk factor involved that may be the materials have supply chain issues or the availability is not well defined. The risk of materials 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 specification 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

There are technical risks associated with any innovation project as the proposed solution may not work. Replacing the existing materials like concrete and aluminium 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