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

Jan 2016

Project Reference Number

NIA_NGET0176

Project Registration

Project Title

Feasibility study on the application of advanced materials

Project Reference Number

NIA_NGET0176

Project Licensee(s)

National Grid Electricity Transmission

Project Start

January 2016

Project Duration

1 year and 7 months

Nominated Project Contact(s)

Iliana Portugues

Project Budget

£160,000.00

Summary

The feasibility study will largely be a desk based with significant interaction between National Grid engineering staff, researchers working in the area of advanced materials and third party suppliers. In this phase, the following deliverables are expected at the end of the project:

1 Opportunity analysis and development

1.1 Identification of opportunities for the use of advanced materials (specifically graphene and other 2D materials) to improve the performance, life time, environmental impact and/or public acceptance of electrical transmission system technologies. This will be achieved by:

- Material scientists and other colleagues involved in the discovery of new materials leading workshops describing key material properties and matching these with an application area
- Electrical engineers and other colleagues involved in the design of power system equipment leading workshops setting out need cases and matching these with advanced material solutions
- Follow-on analysis that assess the opportunities that have been identified within the workshops against a number of criteria including engineering benefits, likely financial return, time to deployment, network risk and environmental impact.

1.2 The publication of a pathway that sets out the opportunities to apply new discoveries in advanced materials (including graphene / 2D materials) to electrical transmission system technologies along with the benefits they will provide to the system.

At the end of this project a road-map will be produced outlining recommendations on future phases of work in the area of alternative materials.

Nominated Contact Email Address(es)

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Problem Being Solved

Virtually all electrical transmission system equipment is limited in performance and lifetime by issues associated with the materials used in its construction. Improved materials would allow capital spend to be deferred as asset life times are extended / maintenance periods to be increased. Enhanced materials may also allow a reduction in the upfront cost of an asset.
Some of the typical challenges that exist across the electricity supply industry relating to materials include:

- Ageing of electrical insulation: The ageing of paper insulation within transformers and outdoor polymeric insulation both limit the life of the assets. Transformer ageing is load dependent while polymeric insulation is vulnerable to pollution. Materials that could stop ageing / repair ageing in existing assets would allow asset lifetimes to be increased.
- Corrosion free materials / corrosion protection: Assets, particularly those in outdoor locations, are vulnerable to corrosion and significant expenditure results from tasks such as tower painting. The use of materials that do not corrode / the development of coatings that could be applied once during the asset lifetime could significantly reduce costs.
- High temperature materials: Many assets have limited performance owing to temperature limitations. Circuit breaker contacts are vulnerable to damage during fault current interruption and have load current restrictions based on temperature rise. The maximum operating temperature of insulation limits the current that can be carried through a cable circuit. The development of materials that can operate at and withstand damage at high temperatures would allow existing asset corridors to carry more power / reduce the maintenance requirements in substations.

Method(s)

This work will identify opportunities to enhance the performance / extend the life of existing equipment and deliver more cost-effective new equipment with a lower environmental impact through the use of advanced materials (particularly those based on graphene / 2D materials). This first area of work will be primarily desk based, seeking to explore the potential applications of graphene and other 2D materials on assets found the in electrical transmission systems. Should promising opportunities be identified, work will move to carry out fuller assessments of these specific cases.

Evaluating the opportunity for materials to enhance the performance of assets cannot be carried out purely by looking at the properties of the materials. Knowledge of the materials must be combined with an understanding of the design of transmission system assets. For example, the development of a lighter yet stronger and more conductive overhead line conductor would give major benefits yet could worsen audible noise levels if not correctly applied. The ability to develop a thinner, more thermally conductive cable insulation would seem to be beneficial yet would have a negative impact on the circuit capacitance. This project will therefore focus on assessing the properties of graphene / 2D materials and the benefits they can provide by combining knowledge at the materials level with knowledge of the equipment / system level.

One of the materials that will be examined is graphene, first discovered in 2004. The behavior of this 2D material is unique, graphene is:

- Ultra-light yet immensely tough
- 200 times stronger than steel, but it is incredibly flexible
- Fire resistant yet retains heat
- A superb conductor and can act as a perfect barrier - not even helium can pass through it.

Graphene in combination with other materials is showing great promise. Recent work carried out at the National Graphene Institute has demonstrated that by combining graphene with paint, a unique graphene coating is formed which could signal the end of the deterioration of steels through rust. The work carried out was not targeted to any particular application yet the use of this on overhead line towers could reduce or eliminate the need for tower painting. Other researchers are highlighting the improvements in electrical conductivity and thermal conductivity that can be delivered using graphene. This research is, again, not specifically targeted to electricity transmission applications. There is, therefore, an opportunity to ensure that the benefits of graphene and similar 2D materials are fully understood and, where feasible, applied to improve the performance of equipment operating on the electrical transmission systems.

The project will identify the most promising applications for graphene and other 2D materials in electrical transmission systems and examine the feasibility of using these materials on the transmission system. The project will consider the likely financial benefits, likely time to market, specific application issues) and provide recommendations on the pathway for deployment.

Scope

The feasibility study will largely be a desk based with significant interaction between National Grid engineering staff, researchers working in the area of advanced materials and third party suppliers. In this phase, the following deliverables are expected at the end of the project:

1 Opportunity analysis and development

1.1 Identification of opportunities for the use of advanced materials (specifically graphene and other 2D materials) to improve the performance, life time, environmental impact and/or public acceptance of electrical transmission system technologies. This will be achieved by:

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At the end of this project a road-map will be produced outlining recommendations on future phases of work in the area of alternative materials.

Objective(s)

The completion of an in-depth analysis that identifies the feasibility and associated benefits that new advanced materials could bring to electrical transmission system equipment.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

n/a

Success Criteria

The delivery of a road-map that outlines the opportunities for the use of grapheme, 2D materials and other relevant advanced materials to electrical transmission systems. This road map to describe the engineering benefits, likely financial return, time to deployment, network risk and environmental impact.

Project Partners and External Funding

n/a

Potential for New Learning

n/a

Scale of Project

The feasibility study will largely be a desk based. However, significant interaction is required between National Grid engineering staff, researchers working in the area of advanced materials and third party suppliers. To include the following collaborative and research activities;

- Material scientists and other colleagues involved in the discovery of new materials leading workshops describing key material properties and matching these with an application area.
- Electrical engineers and other colleagues involved in the design of power system equipment leading workshops setting out need cases and matching these with advanced material solutions
- Follow-on analysis that assess the opportunities that have been identified within the workshops against a number of criteria including engineering benefits, likely financial return, time to deployment, network risk and environmental impact.
- Down-selection and prioritisation of the opportunities identified to take forward
- Appropriate limited laboratory based testing to carry out initial assessments of the advanced material solutions that are likely to provide the best return within a given time period will be carried out where it is clear that the solutions are close to market (for example, graphene based paints)
- Should any technologies be selected to move onto further phases of work, the scale and scope of work will likely increase to laboratory testing before demonstration and evaluation with the Deeside offline test environment.

Technology Readiness at Start

Technology Readiness at End

TRL2 Invention and Research	TRL3 Proof of Concept

Geographical Area

This project will largely be a desk based study with significant interaction between National Grid engineering staff, researchers working in the area of advanced materials and third party suppliers. Based primarily in the North and West Midlands with engagement at other locations as appropriate. Limited laboratory testing is anticipated.

Revenue Allowed for the RIIO Settlement

None

Indicative Total NIA Project Expenditure

Indicative NGET NIA expenditure: £160,000

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)

The roll-out of transmission equipment using advanced materials will deliver a range of savings for customers. Savings will be derived from; equipment with a lower capital cost; equipment with lower installation costs; equipment with longer asset lifetimes; equipment requiring less maintenance during its lifetime.
Full assessments of the financial benefits will be provided as an output of this project, but two examples can be used to illustrate the magnitude of savings that could result.

- Tower painting costs National Grid £6.85m pa with other utilities also incurring significant costs – The development of a graphene based paint that can be applied in a single application and prevents corrosion would eliminate this cost.
- Improvements that could result in improved overhead line / cable designs have the ability to reduce the cost per kilometer of new circuit. With these costs typically being in the order of £4m/km for overhead lines and £19m/km for cables, a modest (5%) reduction in the cost of the asset would have significant financial benefits.

Please provide a calculation of the expected benefits the Solution

Not required – research project.

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

The work on this project would be applicable to all the network licensees in the UK, although the benefits for distribution system owners would be based on larger volume, lower value applications.

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

This is a feasibility project in which part of the aim is to assess the costs of rolling out new, advanced material technologies through the GB system, and to compare these against the benefits that the technologies would provide. Therefore costs for rolling out are not known at this time. In the event selected technologies are taken forward to further phases of work, then a full cost assessment will be carried out.

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 work will highlight the opportunities associated with the next generation of advanced materials (including graphene and other 2D materials). This learning will allow the network licensees to either influence equipment suppliers to commercialise products based on such materials or carry out appropriate field trials depending on the maturity of the solutions.

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

☑ 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.

n/a

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

n/a

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

n/a

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

n/a

This project has been approved by a senior member of staff

☑ Yes