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NIA Project Registration and PEA Document

Date of Submission

Jun 2017

Project Reference Number

NIA_NGET0211

Project Registration

Project Title

Controllable Series Impedance at 275 and 400kV (CSI)

Project Reference Number

NIA_NGET0211

Project Licensee(s)

National Grid Electricity Transmission

Project Start

June 2017

Project Duration

0 years and 7 months

Nominated Project Contact(s)

Mark Osborne

Project Budget

£300,000.00

Summary

This project is divided into three phases with a clear stage gate at the end of stages one and two.

Stage 1 – feasibility study and Network Options Assessment (NOA) based cost benefit assessment. This will conceptually develop a solution capable of use at 275kV and 400kV, identify likely whole life costs (information about the costs will be commercially sensitive and will not be made public), identify network constraints where a QB is currently identified as an economic solution under the NOA and develop conceptual alternative solutions for comparison.

If the economic assessment at the end of stage 1 confirms that the solution is theoretically economically viable, then work will progress to stage 2. The Technology Readiness Level assessment TRL 3-4 below is based on stage 1. This will be updated if, and before, the project progresses to stage 2.

Stage 2 – demonstration at either 275kV or 400kV. This will include the purchase of a small number of units and trial at a suitable substation on the England and Wales transmission network with the objective of establishing real life construction costs, operational performance and reliability.

If the economic assessment at the end of stage 1 remains valid and the performance of the solution is proven to be satisfactory, consideration will be given to stage 3.

Stage 3 – testing the practicalities and economics of relocating the units. This will include planning and, if economically justifiable, testing the practical reality of relocating the units from the one site (the trial site) to another (either the Deeside test facility or an operational site at which additional impedance will be beneficial)

Nominated Contact Email Address(es)

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Problem Being Solved

The electricity network is changing at an increasing rate as more renewable generation and smart energy systems are connected. These changes in generation and demand are leading to changes in how power flows over both the transmission and distribution networks. This in turn is leading to the need for parts of the network to be reinforced with new network infrastructure. In some circumstances, if power flow can be controlled, the need for costly reinforcement can be avoided, or at least deferred.

At present, control over power flow can be achieved either by constraining generators connected at different points on the network or by using quadrature boosters (QB's) to modify the electrical characteristics of particular circuits on the network. The ability to modify the characteristics of circuits at different times, depending on demand and generation patterns, can release capacity on the network. Alternatively action can be taken to make a permanent step change increase in the capacity of constrained parts of the network by reinforcing the network.

A relatively new alternative solution to provide control over power flow has been developed by a US based company. It is designed for distribution voltages and is being trialled on distribution networks Ireland and the US. It may offer a lower cost solution than QB's in some circumstances at transmission voltages.

This project seeks to develop the following knowledge which will be necessary if this technology is to be adopted on the GB transmission network:

- Can the units be modified to operate at transmission voltage and current?
- How do the modifications affect the way the units are installed (at distribution voltages the units are designed to be clamped around the conductor without need for any other supporting infrastructure)
- On a like for like basis, is the solution economically competitive as a direct alternative to other constraint mitigating actions?
- Does the solution offer any other advantages compared to conventional approaches to power flow control or network reinforcement and if so how can these be exploited to provide added value to network customers?
- Is the solution robust and reliable in the GB context and what factors influence its reliability?
- How easy is it to install additional power flow control capability as the needs of the network change?
- Can the solution be removed from one site and installed at another, economically and without material loss of performance and reliability?

Method(s)

This project will examine the potential value, design compromises and risks, associated with modifying a controllable series impedance solution designed for distribution voltages, to be suitable for transmission voltages (275kV and 400kV). The project has been separated into three stages described more fully in the scope below.

The costs and timescales set out in this PEA relate to stage 1 only. If the project passes the stage gate at the end of stage 1, the information in the PEA will be updated with details of stage 2 before it progresses.

Scope

This project is divided into three phases with a clear stage gate at the end of stages one and two.

Stage 1 – feasibility study and Network Options Assessment (NOA) based cost benefit assessment. This will conceptually develop a solution capable of use at 275kV and 400kV, identify likely whole life costs (information about the costs will be commercially sensitive and will not be made public), identify network constraints where a QB is currently identified as an economic solution under the NOA and develop conceptual alternative solutions for comparison.

If the economic assessment at the end of stage 1 confirms that the solution is theoretically economically viable, then work will progress to stage 2. The Technology Readiness Level assessment TRL 3-4 below is based on stage 1. This will be updated if, and before, the project progresses to stage 2.

Stage 2 – demonstration at either 275kV or 400kV. This will include the purchase of a small number of units and trial at a suitable substation on the England and Wales transmission network with the objective of establishing real life construction costs, operational performance and reliability.

If the economic assessment at the end of stage 1 remains valid and the performance of the solution is proven to be satisfactory, consideration will be given to stage 3.

Stage 3 – testing the practicalities and economics of relocating the units. This will include planning and, if economically justifiable, testing the practical reality of relocating the units from the one site (the trial site) to another (either the Deeside test facility or an operational site at which additional impedance will be beneficial)

Objective(s)

The objective of this project is to:

- scope a solution suitable for application at transmission voltages (275kV and 400 kV)
- produce detailed designs of this solution to enable the manufacture, installation and commissioning of a proof of concept within a National Grid substation
- trial and demonstrate the reliability, performance and economic viability of this solution to mitigate network constraints.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

n/a

Success Criteria

The measures of success that will be used to inform the decision to continue with the project at each of the stage gates are:

Stage 1:

- A concept design for the solution that can be used at 275kV or 400kV,
- A NOA based assessment of economic viability based on concept design costs.

Stage 2 (if it progresses):

- Schedule of tests to be undertake to test performance and reliability of the units
- Specifications, design drawings, risk assessments and method statements for the construction and commissioning of the units,
- Objective evidence of the performance of the devices to add the designed impedance,
- Confirmation of actual construction and commissioning costs,

Stage 3 (if it progresses):

- Specification, risk assessments and method statements for the decommissioning and dismantling of the devices,
- Testing schedule to confirm devices remain fully functional after relocation and installation at another site,

Project Partners and External Funding

n/a

Potential for New Learning

n/a

Scale of Project

A demonstration project at least at 275kV in a real GB operational environment is necessary to acquire the knowledge needed to fully answer the questions set out in the problem statement above.

However, the project will progress in three sequential stages process, with the decision to proceed / not proceed being taken at the end of each stage.

Technology Readiness at Start

TRL3 Proof of Concept

Technology Readiness at End

TRL4 Bench Scale Research

Geographical Area

This work will initially be a desk based exercise during the scoping and design elements.

The trial installation, commissioning and demonstration of effectiveness will take place within a National Grid substation location to be confirmed at the end of stage 1.

Revenue Allowed for the RIIO Settlement

None

Indicative Total NIA Project Expenditure

Stage 1 estimated NIA expenditure £300,000

Stage 2 and Stage 3 estimated NIA expenditure not included at this stage. Both will be materially affected by the choice of trial site and the site to which the solution may be moved for a re-deployment trial.

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)

Our working hypothesis is that the controllable series impedance product could be an alternative to quadrature boosters or network reinforcement through reconductoring and could be:

- lower cost,
- faster to deploy, and
- re-usable if network need changes.

Network specific examples are to be assessed as part of stage 1 to establish the potential benefit of this as a new solution option for controlling power flow to release additional capacity on existing transmission circuits.

Please provide a calculation of the expected benefits the Solution

Stage 1 is research only, to investigate the modifications required to the product for use at transmission voltages and the affect these have on likely cost, performance and applications.

At 275 and 400kV the solution is anticipated to be significantly different (larger and heavier) that at distribution voltages, but the degree to which this affects the technical and economic viability of this product is not known.

The output from stage 1 will include quantified costs and benefits using the NOA approach. This section of the PEA will be updated with that output if the project progresses to stage 2.

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

The method this project is seeking to demonstrate is a novel power flow control device specifically for 275kV and 400kV networks. Review of NOA 2016/17 has identified 6 schemes that the NOA has recommend should proceed where this solution may offer an alternative. One of these will be investigated in detailed to establish whether the controllable impedance solution could be more economic and efficient than the conventional approach approved to proceed under the NOA.

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

The cost of rolling this method out would be dependent on the size of the solution required to provide the levels of impedance necessary to achieve the desired power flow control and can only be assessed on a case by case basis.

The way in which the economic viability of this solution can be assessed requires a different approach to the network options assessment. The nature of the solution is such that cost is expected to be closely related to the amount of impedance required, and this in turn can be varied in increments of 25 mohm. This is very different to the more binary economic decision making used for conventional options (reconductoring or installing a Quadrature Booster is either economic or not and a 'partial' solution is not a realistic option).

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

All GB electricity network owners may be able to design and develop their networks more economically and flexibly with the ability to readily control power flows on key circuits. This is a new piece of equipment that hasn't been deployed at GB transmission voltages anywhere in the world to date. Although lower voltage trials are underway in the US and Ireland, the equipment will need to be significantly modified to be suitable for high voltage applications and these modifications are likely to significant affect how it is deployed and the likely whole life cost.

The outcomes of this trial could be relevant to other network licensees, particularly at high or very high voltage.

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