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

Aug 2018

### Project Reference Number

NIA_NGTO017

## Project Registration

### Project Title

Voltage source converter based series controlled impedance technology

### Project Reference Number

NIA_NGTO017

### Project Licensee(s)

National Grid Electricity Transmission

### Project Start

September 2018

### Project Duration

0 years and 9 months

### Nominated Project Contact(s)

Robin Gupta

### Project Budget

£500,000.00

### Summary

A relatively new alternative solution to provide control over power flow has been developed using voltage source converter (VSC) in each phase. The VSC based series controlled impedance (SCI) technology has potential to offer the following advantages:
• Cheaper option than QB
• Optimized deployments of the technology can unlock more system capacity than traditional solutions such as QBs
• Provides more controllability
• Easy mobile redeployment
• Wireless control
The project will serve as a first step towards building our understanding about application of these VSC based SCI devices.

### Nominated Contact Email Address(es)

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### Problem Being Solved

The 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.

At present, control over power flow can be achieved either by constraining generators connected at different points on the network, by using quadrature boosters (QB's) or series reactors to modify the electrical characteristics of 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.

Once installed, QB's and series reactors cannot be moved or modified quickly enough to match the pace of change affecting the network, so they need to be either overrated compared to the initial requirement or replaced if the power flow over the network changes further, resulting in additional costs.

A relatively new alternative solution to provide control over power flow has been developed using voltage source converter (VSC) in each phase. The VSC based series controlled impedance (SCI) technology has potential to offer the following advantages:

- Cheaper option than QB
- Optimized deployments of the technology can unlock more system capacity than traditional solutions such as QBs
- Provides more controllability
- Easy mobile redeployment
- Wireless control

The project will serve as a first step towards building our understanding about application of these VSC based SCI devices. This project seeks to enable NGET to confirm adequate system performance can be maintained following a wide-scale introduction of this new technology. The project will undertake an in-depth system evaluation to fully model and demonstrate system performance under a full range of credible and extreme scenarios. If successful, this project will enable the technology to be considered for application to increase transfer capacity across transmission boundaries.

## Method(s)

A detailed simulation study will be carried out to address the risks related to dynamic interactions, power quality and interference with protection settings. At first, the desktop based electromagnetic transient (EMT) studies will be carried out. EMT studies provide a good idea about the control behavior of the device but they do not consider the limitations of its control hardware. Therefore, a further validation using real-time simulations will be performed on a real time digital simulator (RTDS) platform. For addressing the risk related to cyber security, a cyber penetration testing will be carried out in lab environment.

## Scope

Work Package 1: Simulation studies

1) Development of Network model for EMT studies

A reduced network model will be created for EMT simulations in PSCAD and RSCAD. The control system for the dominant devices in the 'kept' network will be represented in detail to capture the dynamic interactions. All the transmission lines and cables will be represented by frequency dependent models. The performance of the reduced equivalent model will be validated against the original network model, which will include both dynamic and steady state performance.

2) PSCAD Desktop based dynamic interaction studies

A detailed dynamic interaction study will be performed using the reduced network model and VSC based SCI device PSCAD model. Various dynamic events such as different type of faults, different operating modes and power levels will be simulated to understand the dynamic interactions. If dynamic interactions are observed, VSC based SCI device control tuning may be performed to damp the oscillations resulted from the dynamic interactions.

3) PSCAD Desktop based protection-coordination studies

Various fault cases will be simulated and the impact of VSC based SCI device protective bypass function will be assessed on the network protection settings.

4) RTDS studies

The real-time behavior of the device control system will be assessed using RTDS studies. A subset from desktop based simulation studies will be performed in RTDS and the results will be validated against PSCAD benchmark.

Work Package 2: Cyber resilience testing

A cyber Penetration testing will be carried out in lab environment. The impact of a potential cyber breach on the electrical networks will also be estimated

## Objective(s)

The project will undertake an in-depth system evaluation to fully model and demonstrate system performance under a full range of credible and extreme scenarios to assess the risks associated with VSC based SCI technology.

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

n/a

## Success Criteria

The project will be considered successful if the risk analysis and assessment of the technology from the project leads to an informed decision regarding the full-scale deployment of VSC based SCI technology to increase transfer capacity across transmission boundaries.

## Project Partners and External Funding

n/a

## Potential for New Learning

Transmission and Distribution networks are all under pressure to maximise the full potential of existing assets. The VSC based SCI solution has huge potential in terms of reducing cost and unlocking more system capacity than traditional solutions such as QBs. This project aims to evaluate the technical risks associated with this newly proposed technology and assess it's suitability for deployment within the GB network. Therefore, the learning generated will be relevant to other network licensees operating both transmission and distribution networks

## Scale of Project

The project has been chosen to this scale as it is a suitable length of time to assess the technical risk associated with VSC based SCI technology. A larger project is not presently required, and a smaller project would leave key questions unanswered or answers under developed.

## Technology Readiness at Start

TRL4 Bench Scale Research

## Technology Readiness at End

TRL6 Large Scale

## Geographical Area

PSCAD simulation study will be desktop based.

RTDS studies and cyber security testing will take place in lab environment.

## Revenue Allowed for the RIIO Settlement

None

## Indicative Total NIA Project Expenditure

£500,000

# 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 working hypothesis is that VSC based SCI solution could be a cheaper alternative to quadrature boosters or network reinforcement through reconductoring. The optimized deployment of the technology can unlock more capacity resulting in further cost savings. Studies have demonstrated that the transfer capability across the B7a boundary can be increased by circa 900 MW with a potential of £40m savings in capital expenditure.
This research project will assess the technical risk associated with the technology and will enable an informed decision regarding the deployment of technology to increase transfer capacity across transmission boundaries.

## Please provide a calculation of the expected benefits the Solution

N/A

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

As this technology, could be used at both transmission and distribution levels, this could be applied across the whole GB network. Any TO or DNO could directly use this technology.

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

The cost of rolling out VSC based SCI solution 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 project aims to evaluate the risks related to the technology and the learnings from the project can be rolled out across GB by sharing project outcomes.

## 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 using VSC based SCI. This is a new piece of equipment that hasn't been deployed at GB transmission voltages anywhere in the world to date and the project aims to evaluate the risks related to the technology before its deployment. Therefore, the outcomes of this project could be relevant to other network licensees.

All the information from this project that can be shared with GB Network Licensees will be made available after the completion of the project. Any commercially confidential information will be redacted from any output that is published, subject to any restrictions arising from competition law, additional material may be sharable with other GB Network Licensees under a suitable non-disclosure agreement.

### Or, please describe what specific challenge identified in the Network Licensee's innovation strategy that is being addressed by the project (RIIO-1 only)

This project fits within the (choose from the list below below) value area of the Electricity Innovation Strategy:
Efficient Build - Building new assets faster and at lower capital and whole-life costs
☑ 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.

No duplication project has been found. The two most similar projects have looked at different technical solutions to the same problem:

http://www.smarternetworks.org/project/nia_ukpn0027

http://www.smarternetworks.org/project/nia_nget0211

This project uses a different technology to utilise more of the existing transmission capacity, and is therefore not a duplication of research.

### 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

VSC based SCI technology has a huge potential to bring value to the customer by increasing transfer capacity across transmission boundaries. The project aims to de-risk the technology. VSC based SCI solution for individual phase is a new concept and therefore, such a project has not been tried before.

## 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

The nature of a research programme means it inherently carries a risk that the research may be unsuccessful and/or identify unforeseen barriers to implementation and National Grid is unable to consider research of this scale as business-as-usual. The NIA funding offers the most appropriate route for NGET to evaluate the risk associated with VSC based SCI technology.

## 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

The inherent risk of the project is detailed above and the learning from the project will be directly relevant to all Network Licensees. For this reason, NGET believe this project is appropriately funded through NIA.

## This project has been approved by a senior member of staff

☑ Yes