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

Feb 2014

### Project Reference Number

NIA_NGET0129

## Project Registration

### Project Title

Investigation of sub-synchronous between wind turbine generators and series capacitors

### Project Reference Number

NIA_NGET0129

### Project Licensee(s)

National Grid Electricity System Operator

### Project Start

March 2014

### Project Duration

2 years and 5 months

### Nominated Project Contact(s)

Kahdim Hussein

### Project Budget

£305,000.00

### Summary

The scope of this project is to investigate and model the dynamic interactions between series capacitors and large wind farm generators and to identify controls to mitigate the impact of these interactions on the stability of the grid.

### Nominated Contact Email Address(es)

box.so.innovation@nationalgrid.com

### Problem Being Solved

Series compensation will be implemented on the GB transmission network in the near future in order to enhance the transfer capability of the Anglo-Scottish boundary. A possible risk associated with series capacitors is the occurrence of Sub-Synchronous Interactions (SSI) which are oscillations involving generator shafts and power electronic controllers. If not damped, these oscillations can potentially lead to component fatigue, life-time reduction of equipment and failures of both synchronous and induction generators. These affected generators will have to be withdrawn from the network thereby reducing the overall generation availability to meet the demand, compromising the security of supply and possibly delaying the achievement of renewable energy and carbon emissions targets.

In 2009 a Sub Synchronous Control Interaction (SSCI) event occurred in Texas, where a wind turbine generator was connected directly with a series compensated line during an outage. During this event the wind turbines were damaged through excessive current. The risk of occurrence of sub-synchronous interactions (SSI) in the future GB network as a result of increasing onshore series compensation can neither be confirmed nor ruled out unless in-depth technical studies are carried out. The GB network is very unique in nature with respect to its topology, the location of the series capacitors and that of the wind farms. The standard IEEE benchmark models are not suitable to provide an accurate representation of possible SSI in the GB system. An alterantive approach consisting of developing specific models is therefore required.

## Method(s)

**Research**

The Method that has been proposed for this project include:

- An investigation and analysis of the possible interactions of wind turbine generators (DFIGs and FCIGs) with series compensation in the GB system. This would involve the modelling of relevant network components in MATLAB and Simulink.
- A literature research into the mitigation of sub-synchronous interaction using a damping controller at the grid side converter of wind turbine generators with close proximity to synchronous generators suffering from sub-synchronous oscillations

## Scope

The scope of this project is to investigate and model the dynamic interactions between series capacitors and large wind farm generators and to identify controls to mitigate the impact of these interactions on the stability of the grid.

## Objective(s)

The objectives of this research project are to:

- Highlight any potential SSI issues that can occur between series capacitors and wind turbine generators
- Establish a control system that could be implemented as part of the wind turbine converters to mitigate any SSI issues

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

n/a

## Success Criteria

The project will be deemed successful if the above-mentioned objectives are delivered and when the full report detailing the research, modelling and results is delivered upon completion of the project.

## Project Partners and External Funding

n/a

## Potential for New Learning

This research project will identify whether there is a possibility of sub synchronous interactions between series capacitors and wind turbine generators on the GB system. As part of the deliverables of this project, a technical report will be produced, detailing the findings of the project. These will be shared with whole Electricity Industry and any other interested parties. The parameters of the control system and its building blocks will also be shared so that the system can be tuned to work on any network.

## Scale of Project

This project is based on modelling a specific part of the network where series compensation will be implemented. There is no need to model the entire network as the interactions between series capacitors and wind turbine generators are less pronounced with increasing electrical distance from the series capacitors.

## Technology Readiness at Start

TRL3 Proof of Concept

## Technology Readiness at End

TRL4 Bench Scale Research

## Geographical Area

The project will focus on the network around the Anglo-Scottish border. However the findings of the project can be applied nationally.

## Revenue Allowed for the RIIO Settlement

None

## Indicative Total NIA Project Expenditure

NGET NIA project expenditure is £305,000

# 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)

Should SSI become a problem on the GB system, wind farms may be constrained off in order to prevent damage to equipment. This operational measure is expensive for customers.

Prolonged SSI can also lead to system instability which may cascade into further problems eventually leading to the disconnection of load.

By undertaking this project, National Grid is aiming to keep the system secure at all times in order to avoid having to take costly remedial actions in operational timescales. The project will also ensure that customers' assets are can remain safely connected to the transmission network.

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

Not required for a research project

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

The findings of this project are applicable mainly to the electricity transmission network where series compensation is implemented.

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

The controller to be developed as part of the project can be fitted to the converters of existing wind turbines to damp sub synchronous oscillations. Discussions with the converter manufacturers will need to take place to understand what type of work would be involved to implement additional damping control functions to existing converters.

## 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

n/a

### 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 deals with maintaining system operability with respect to sub-synchronous resonance which is potentially a future challenge that has been identified by National Grid.

☑ 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.

An NIA project on Visualisation of Real Time System Dynamics using Enhanced Monitoring (VISOR) proposed by Scottish Power Transmission Ltd has received Ofgem's approval. The objective of VISOR is to develop and trial a wide area monitoring system and use phasor data to enhance the understanding of system dynamic performance, including SSR. However, VISOR only aims to monitor the phenomena, not mitigate it therefore there is no duplication with the project proposed here.

This research project is will enable any potential risks of sub-synchronous interactions between series capacitors and wind turbine generators to be identified and mitigated and therefore prevent any damage to generators and their associated controllers. The nature of this project relies on models being built specifically to reflect the GB transmission network. As such this work has not been carried out before and there are no risks of duplication.

### 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