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

Nov 2018

Project Reference Number

NIA_NGSO0019

Project Registration

Project Title

Hybrid Grid Forming Converter

Project Reference Number

NIA_NGSO0019

Project Licensee(s)

National Energy System Operator

Project Start

November 2018

Project Duration

1 year and 1 month

Nominated Project Contact(s)

Can Li

Project Budget

£292,000.00

Summary

The increasing penetration of convertor fed generation leads to a variety of problems such as low system inertia, increased rate of change of frequency, loss of synchronising torque, high frequency instability and controller interaction.

Grid forming converter technology enables renewable generation to behave in a similar manner to conventional generation and hence offers a method of achieving higher renewable penetration in the energy market. PowerFactory Simulations in innovation project NIA_NGET0106 showed it is theoretically possible to run the GB transmission system with 100% renewables using grid forming converter technology.

The key aim of the proposed work is to inform National Grid of realistic ways that a power-park owner/operator might achieve levels of Grid-Forming capability compliance, through mixes of different device types placed in parallel as “hybrids”.

Third Party Collaborators

University of Strathclyde

Nominated Contact Email Address(es)

box.so.innovation@nationalgrid.com

Problem Being Solved

The increasing penetration of convertor fed generation leads to a variety of problems such as low system inertia, increased rate of

change of frequency, loss of synchronising torque, high frequency instability and controller interaction.

Experience gained from other electricity networks in other countries shows that a 60-65% limit for renewable generation is prudent with the remainder of the energy being supplied by conventional generation. As installed capacity of renewable generation increases on the GB system, either a very large amount of converter fed generation will be constrained off or additional synchronous plant (generators or compensators) will be needed to stabilize the system. Both options could carry significant costs.

Method(s)

Grid forming converter technology enables renewable generation to behave in a similar manner to conventional generation and hence offers a method of achieving higher renewable penetration in the energy market. PowerFactory Simulations in innovation project NIA_NGET0106 showed it is theoretically possible to run the GB transmission system with 100% renewables using grid forming converter technology.

The key aim of the proposed work is to inform National Grid of realistic ways that a power-park owner/operator might achieve levels of Grid-Forming capability compliance, through mixes of different device types placed in parallel as “hybrids”. The project will provide evidence either to support mandatory changes in converter fed generation performance, e.g. through Grid Code and/or Distribution Code modifications, or to support development of balancing service markets to value the abilities of grid forming converter generation.

The project activities include:

- Benchmark existing windfarm models
- Develop a reference offshore windfarm model
- Test alternative offshore windfarm models
- Investigate into control techniques which compensate for the coupling impedance between the Wind Farm, Grid Forming Convertor and POC
- Implement and demonstrate the strategy in the laboratory

Scope

The project will consider the behaviour of the Power Park Module in its totality from the Point of Connection with different combinations of generation. The existing windfarm models will be benchmarked and alternative offshore windfarm models will be tested with Grid Forming convertors and Synchronous compensators. The developed strategy will be implemented in the laboratory. The intention is to prove the concept of hybrid grid forming converters especially for offshore application to inform network requirements. Developing and testing a commercial product for field deployment is not in scope. The expectation is that manufacturers and developers will use the findings of this project and network requirements derived from it to develop and test their own commercial offerings.

Objective(s)

The objectives of this project are to:

- Understand the behavior of hybrid grid forming convertors seen from the point of connection
- Understand any risks or issues of the design and application
- Provide evidence either to support mandatory changes in converter fed generation performance, e.g. through Grid Code and/or Distribution Code modifications, or to support development of balancing service markets to value the abilities of grid forming converter generation.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

n/a

Success Criteria

To be a success this project would have developed and tested a hybrid grid forming converter design in software simulations and in the laboratory that is exhibiting the behavior of a voltage source behind an impedance.

Project Partners and External Funding

The Project Partner will be University of Strathclyde
There is no external funding.

Potential for New Learning

There are many aspects of grid forming converter technology we hope to resolve, improve or quantify. Equally we anticipate there may be unexpected results too. The previous project (NIA_NGET0106) highlighted many things we were unaware of e.g. some types of Synthetic Inertia can aggravate high frequency instability making the situation worse. Results and insights of this nature are extremely valuable to the System Operator in steering the development of hybrid grid forming converter technology, assessing its suitability for application on the electricity system and developing the commercial environment to incentivise its deployment. Manufacturers and developers may also use learning from the project to accelerate hybrid grid forming converter deployment in response to these commercial developments.

Scale of Project

This project will involve one supplier for a duration of 12 months. It will not deploy technology onto the network.

Technology Readiness at Start

TRL3 Proof of Concept

Technology Readiness at End

TRL4 Bench Scale Research

Geographical Area

This work is of potential benefit to synchronous areas with high convertor penetration such as the GB transmission and distribution system.

Revenue Allowed for the RIIO Settlement

N/A

Indicative Total NIA Project Expenditure

£292,000

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 estimated saving could be in the region of £150-600 million per annum.

Please provide a calculation of the expected benefits the Solution

The above figure is the annual cost of offering synchronous generation on and constraining converter fed generation off to reduce the penetration of converter fed generation. It is based on the IET paper "System Strength Considerations in a Converter Dominated Power System" with the cost of £50-200/MWh with the penetration limit of 75%.

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

Hybrid grid forming converter behaviour could be applied to new or existing wind converter fed generators as is used in most renewable projects. The extent of implementation would depend on whether it is implemented as a service and/or mandated connection requirement.

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

Hybrid grid forming converter solutions are attributed medium/low cost. In particular, there is a benefit for offshore wind hybrid solutions, where the grid forming convertor is located near the connection point near the onshore transmission system and the offshore systems are unaffected or only marginally affected. This reduces the risk to the developer. In addition it provides further opportunities for cost savings as the storage and additional convertor equipment are not at sea.

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 System Operator could use the results of the project to change converter fed generation connection requirements including:

- Proposing changes to the Grid and/or Distribution Codes to mandate grid forming converter behaviour in converter installations.
- Defining tests to validate compliance with these changes in connection requirement.
- Whether the changes should apply to existing as well as future installations.

The System Operator, Transmission Owners and Distribution Operators could use the results of the project to improve modelling of converter fed generation.

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 projects addresses the following challenges identified by the National Grid System Operator's innovation strategy: Managing volatility in a low inertia system; Enabling more non-synchronous connections and Optimising constraint management

☑ 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.

Researchers have proved the grid forming converter concept in the lab and in simulation models but not in a manner that facilitates operational scale assessment. To the best of our knowledge, no academic papers or manufacturers have demonstrated a fully-functioning hybrid grid forming converter (algorithm) that appears to be service-ready, i.e. able to deal with balanced and unbalanced faults; able to operate up to 100% penetration at transmission scale; able to share power seamlessly with other converters through droop settings and set-points; and provide system inertia, frequency support services and power quality mitigation.

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 VSM (and VSM0H) and "Grid Forming" approach to converter control is new at the distribution and transmission levels. While we have previously carried out simulation studies, and done basic lab experiments, no full-size commercially-available devices use these

methods within their control systems.

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 intention is to prove the concept in simulations and lab tests and derive network requirements from it. As This technology is still in its early development phase and National Grid currently does not have the technical specialty to carry our relevant analysis.

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 expectation is that manufacturers and developers will use the findings of this project and network requirements derived from it to develop and test their own commercial offerings.

This project has been approved by a senior member of staff

☑ Yes