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

Dec 2019

Project Reference Number

NIA_NGTO044

Project Registration

Project Title

Sub/Near Synchronous Instability in the GB Network

Project Reference Number

NIA_NGTO044

Project Licensee(s)

National Grid Electricity Transmission

Project Start

January 2020

Project Duration

1 year and 7 months

Nominated Project Contact(s)

Xiaolin Ding

Project Budget

£225,000.00

Summary

The GB electricity network is setting a fast pace of transition towards a net-zero carbon energy network. The system inertia and fault level are expected to decline continuously over time. Furthermore, the level of power electronic converters integrated into the electricity transmission network from renewable energy (e.g., wind turbines and photovoltaics), HVDC (High-Voltage Direct Current) links, traction loads, battery storage and FACTS (Flexible Alternating Current Transmission System) devices is going to increase dramatically and this will pose new risks to the electricity transmission network in terms of instability in the sub-synchronous and near synchronous frequency range. This is associated with transmission network resonant modes with power electronic converters time delay and control dynamics. The aim of this project is to understand the phenomena and assess the risk of sub-synchronous and near synchronous instability resulting from controller interaction with the sytem in future low carbon energy scenarios and develop an innovative mitigation measure to address it.

Nominated Contact Email Address(es)

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Problem Being Solved

The GB electricity network is making a fast pace of transition to a net-zero carbon energy future. The generation mix is changing dramatically with the closure of coal fired generation and its replacement by fast-growing renewable energy. As a result, the system inertia and fault level are expected to decline continuously. The fast increasing level of power electronic converters integrated into the electricity network from renewable energy (e.g., wind turbines and photovoltaics), HVDC links, battery storage and FACTS devices raises a concern on sytem instability. Instabilities of equipment connected to the grid can occur due to the interaction between their control systems and the grid, and control systems with generator shaft system resulting in a poorly damped oscillation. This can lead to the potential occurrence of multiple frequency oscillation modes in power systems, which could cause severe damage to users' equipment as well as to transmission plant, and unplanned trip of generation (including but not limited to synchronous generation and wind farms) and HVDC links. The Electricity Tansmission Network Owners (ETNOs) have the responsibility to provide a reliable and secure network. Nowadays, the ETNOs also begin to adopt the technology like FACTS, STACOMs and SVCs to effectively manage

the network. For example, NGET (National Grid Electricity Transmission) has planed to install a few STATCOMs in the south coast to address the voltage stability issue in the region. However, the physical phenomenon behind the interactions among electronic controllers and with the equipment connected to the grid is not clearly defined in the current state of art and the risk is not thouroughly understood as well. Moreover, there are no well-established efficient modelling and analysis approaches. Therefore, It is important to establish an effective modelling and analsyis approach to understand potential instability risk whilst realising the benefits of power electronic based technologies.

Method(s)

The project will conduct a literature review to investigate a suitable modelling approach and assessment methodology for subsynchronous/near synchronous oscillation analysis. The project will then develop a time domain network model in PSCAD for selected areas of the GB network which will be validated by RTDS (real time digital simulation) testing. If the suitable PMU measurements available in the selected areas of the GB network, the model will also be validated against the measurements. The analysis will then be carried out in the validated model to understand the controller-related subsynchronous or near synchronous instability risk on the selected regions in the GB network. Finally, the project will explore an innovative active measure to address the instability risk.

Scope

The scope of the work includes the following:

1) Investigate suitable modelling approach and assessment methodology

- Literature review on occurrence of subsynchronous/near synchronous oscillations worldwide in power electronic dominated power systems, particularly in the area of subsynchronous/near synchronous oscillations resulting from controller interactions.
- Evaluate range of modelling approach and analysis methodology used for oscillation/resonance characterisation and identification and provide recommendation.

2)Network modelling of the GB network

- Develop a network model for the selected future GB network for analysis of the resonance risk.
- Validate the model on a reduced GB model in RTDS.

3)Recommend screening methods and detailed analysis approaches applicable to GB network

- Perform detailed screening of controller interactions in the selected GB network.
- Analyse instability risk from the evaluation of the net damping condition of system resonances.
- Development of a toolbox for screening and analysis of resonance risk in the GB network.

4)Explore an active mitigation measure to manage the risk in sub/near synchronous instability.

Objective(s)

The objective of the proposed work is to develop an indepth understanding of the different forms of sub and near-synchronous oscillations and the associated instability risk in the future GB sytem. The work will provide recommendations on a suitable modelling approach and analysis methodology. Nevertheless, the work is also aimed at exploring an active mitigation measure which is capable of reducing multiple frequency oscillations to mitigate the instability risk in the transmission network.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

n/a

Success Criteria

The project will be deemed a success if it meets the following criteria:

- Provide a thorough review of available modelling and analysis approaches.
- Make recommendations on efficient assessment and modelling approaches which are applicable to the GB network.
- Develop and validate an analysis model for selected areas of the GB network.
- Explore an active mitigation measure caplable of reducing multiple frequency oscillation.

Project Partners and External Funding

None

Potential for New Learning

The outcome of the project will benefit not only NGET but other network licencees. The recommended analysis methodology will help network licencees to efficiently assess the risk of sub/near-synchronous instability in the future power electronic dominated low-carbon GB network.

Scale of Project

The project involves research, design, development and testing of a screening method and a tool for assessing the sub/near synchronous instabilities associated with power converter controller interactions in the GB network.

Technology Readiness at Start

TRL2 Invention and Research

Technology Readiness at End

TRL4 Bench Scale Research

Geographical Area

The project will be carried out through both desk-based simulations and an RTDS-based lab testing environment.

Revenue Allowed for the RIIO Settlement

None

Indicative Total NIA Project Expenditure

£225,000

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 project has the potential to deliver cost savings to customers via offering the following benefits:

- Establish a screening methodology analysis tool for effectively assessing and predicting the risk of subsynchronous and near synchronous instabilities.
- Reduce the risk of subsynchronous and near synchronous instability in the network
- Enable the optimisation of the design to minimise the requirement for investing in harmonic filters and reactive compensation.
- The cost of network instability and resulting loss of supply as well as the cost of filters and compensation equipment is significant but difficult to quantify exactly at this stage but will be several orders of magnitude higher than the investment in this innovation project.

Please provide a calculation of the expected benefits the Solution

As this is a research project, a cost benefit analysis is not yet applicable.

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

The effectiveness of the screening analysis and its adequacy in predicting the system resonance points, the key outcomes of this project will be applicable to all GB network licensees and disseminated with key stakeholders.

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

As this is a research project at a early stage of development, estimates are difficult to make, but this system would likely cost a few million pounds to implement across the whole transmission network.

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 outcome of the project can be used to quantify the controller interaction and resonance propagation in the network due to increased level of power electronic under different system scenarios. The findings of the project are applicable to the whole GB network licenses and also to manufacturers due to the coherence of the issues that are under investigation.

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

Managing Asset- Managing assets throughout their lifecycle

☑ 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 unnecessary duplication will occur as a result of this project. There is no similar projects found in the ENA portal to investigate the risk in sub/near-synchronous instability in the future power electronic dominated low-carbon network.

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

There is no specific framework or well established analysis methodology to assess the risk of sub/near-synchronous instability, resonant frequencies and their shifting pattern under different system strengths and connections. The project not only establishes the assessment methodology but also develops an active mitigation measure to reduce multiple frequency oscillation and optimise the investment for harmonic filters and reactive compensators.

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 applied research activities and methodologies proposed in this project have not been carried out before and cannot be carried out directly at NGET. The proposed analysis methodology and mitigation measures will need to be tested and validated in a simulated environment before it can be rolled out on the NGET network as part of business as usual activities, and disseminated for use by the wider electricity network licensees. At this early stage of research the outcomes of the work are uncertain and are therefore associated with a higher risk than would typically be carried by BAU activities.

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

NIA funding is the chosen funding route for this innovation project for the following reasons: 1. It will facilitate collaboration with the chosen innovation partner to access their specialist skills and expertise in a cost-effective and timely manner. 2. The problems investigated in this work are common to all network licensees. The new insights gained in this project to better understand and address the sub/synchronous instability risk in the electricity network will benefit all electricity transmission networks. 3. As the TRL level for this technologies considered are low the technical and hence commercial risk is high but the potential benefits resulting from this work are significant.

This project has been approved by a senior member of staff

☑ Yes