nationalgridESO

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 2022

Project Reference

NIA2_NGESO009

Project Registration

Project Title

'D3' - Data-driven Network Dynamic Representation for Derisking the HVDC and Offshore Wind

Project Reference

NIA2_NGESO009

Project Licensee(s)

National Grid Electricity System Operator

Project Start

February 2022

Project Duration

2 years and 2 months

Nominated Project Contact(s)

Dechao Kong

Project Budget

£300,000.00

Summary

The GB electricity network is rapidly moving into a power electronic dominated one due to the installations of new HVDC and renewable generation systems. This brings considerable risks of control interactions between new power electronic equipment and existing ones.

Manufacturers/owners of new power electronic systems have obligations to adjust their control parameters to minimise the control interactions. To carry out this research, they will need to have detailed grid dynamic models from National Grid ESO (NGESO). However, it is difficult for NGESO to share detailed system information due to system models' complexity, confidentiality, and IP issues.

This project will aim to address these issues by developing advanced tools for obtaining accurate grid dynamic models which don't reveal confidential system data and can be shared with outside stakeholders.

Nominated Contact Email Address(es)

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Problem Being Solved

The GB electricity network is rapidly moving into a power electronic dominated one due to the installations of new HVDC and

renewable generation systems. This brings considerable risks of control interactions between new power electronic equipment and existing ones.

Manufacturers/owners of new power electronic systems have obligations to adjust their control parameters to minimise the control interactions. To carry out this research, they will need to have detailed grid dynamic models from National Grid ESO (NGESO). However, it is difficult for NGESO to share detailed system information due to system models' complexity, confidentiality, and IP issues.

Considering the size, complexity and fast evolving nature of National Grid electricity network, the key technical challenges can be identified: (1) the methodology to be used needs to be a generic one that can be applied to a power network regardless of the types of equipment in it; (2) the obtained grid dynamic model needs to be accurate over a wide range of frequencies; (3) the proposed D3 model has to apply data driven approach to consider multiple event data (based on multiple operating points) in order to enable a more robust model.

The risks of control interactions between power electronic systems are fundamentally different from interactions between conventional synchronous machines in that (1) power electronic systems from different manufactures can exhibit very different dynamic behaviours over a much wider frequency range and (2) the control systems for power electronic systems are ‘black boxes’ to the ESO and other manufacturers.

Method(s)

This project will look to undertake the following scope of work:

WP1: Development of power electronic integrated benchmark power system with HVDC and Wind Farm (4 months)

WP2: Development and validation of frequency-dependent power system model (8 months)

WP3: Development and validation of model reduction technique (6 months)

In line with the ENA’s ENIP document, the risk rating is scored Low.

TRL Steps = 2 (2 TRL steps)

Cost = 1 (£300k)

Suppliers = 1 (1 supplier)

Data Assumptions = 4

Scope

- Development of benchmark testing system in PSCAD/EMTDC Environment for complex power networks with integration of typical Power Electronics Based HVDC and Wind Generation systems.
- Development and validation of frequency-dependent power system model for identifying potential interaction risks.
- Development and validation of advanced model reduction technique to reduce the high-order frequency-dependent model to low-order power system one for system representation, to achieve a good balance between system accuracy and computational efforts via comprehensive data-driven simulations.

Objective(s)

This project will aim to bridge the current gaps, through the development of new models and technical reports which will mitigate risks when adding new power electronic equipment to the system.

The final outputs will be:

- Developed Testing system and models in PSCAD/EMTDC environment.
- Technical reports for each WP.
- Final project report
- International journal/conference publications.
- Dissemination event to share the outcomes of the project with stakeholders.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

The ESO does not have a direct connection to consumers, and therefore is unable to differentiate the impact on consumers and those in vulnerable situations. Benefits to all consumers are detailed below.

Success Criteria

The following will be considered when assessing whether the project is successful:

- Impact on ESO risk management processes
- Contribution to behind the meter DSR regulation processes
- The project delivers against objectives, timescale and budgets as defined in the proposal
- ESO's in-house capability is improved for addressing Control-Interaction challenges
- Knowledge and tools developed in this project can be replicated across network partners to facilitate the increased integration of HVDC and PE systems into GB Electricity Transmission System.

Project Partners and External Funding

University of Birmingham will be carrying out the work, no external funding required.

Potential for New Learning

The proposed project will be first of its kind to be investigated within GB electricity transmission system.

Project outputs will:

- Mitigate the risks of control interactions between new equipment and such as HVDC's and existing ones.
- Develop and validate an advanced model reduction technique to reduce the high-order frequency-dependent model to a low-order power system one
- Develop a best practice for system operators
- Provide generalized guidelines to ESO on identifying interaction risks using the developed frequency-dependent model.
- Provide technical recommendations to ESO on carrying out system stability analysis for new renewable and HVDC integrations.
- Help ESO engineer develop insight into the dynamics and stability of a PE-dominated power system
- Share learnings through international conference and journal publication

Detailed consideration and implementation of recommendations into other documents would form part of BAU (Business as Usual).

Scale of Project

The project spans 21 months with 1 project partner. It will be desk-based research.

Technology Readiness at Start

TRL3 Proof of Concept

Technology Readiness at End

TRL5 Pilot Scale

Geographical Area

This will be based upon the GB ESO area of operations.

Revenue Allowed for the RIIO Settlement

None

Indicative Total NIA Project Expenditure

£300,000

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:

The amount of new power electronic equipment such as HVDC and Wind farms is forecast to rise substantially over the coming years to meet demand. These new connections pose a risk when linking to existing equipment on the grid. This project will support the energy system transition by identifying risks, enabling National Grid ESO and wider stakeholders to better plan for these control interactions and help increase delivery. Therefore, the developed tool will contribute towards UK's net-zero target.

How the Project has potential to benefit consumer in vulnerable situations:

Not required.

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)

Not required

Please provide a calculation of the expected benefits the Solution

Not required as research project.

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

In regarding the UK's net-zero implementation, more and more wind farms (~40GW offshore wind by 2030) and HVDC systems (~18GW by 2030) will be integrated with GB electricity transmission system, the developed tool will support ESO to speed up project delivery. Therefore, the developed tool will contribute towards UK's net-zero target.

Furthermore:

- Based on the dissemination event to share the outcomes of the project with stakeholders, feedback and suggestions from stakeholders will be obtained.
- One or two manufactures will be selected to trial the proposed models and gain industrial experience so as to find the approach on how to share the models more effectively.
- Based on the above experience and feedback, more manufactures and project partners will be selected to trial the models proposed.
- Plans for Grid Code changes will be put forward.

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

As this is a research project, the final outputs of the project will aim to give an outline of the potential changes and costs to mitigate these risks.

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)

Not required.

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.

The proposed project will be first of its kind to be investigated within GB electricity transmission system.

If applicable, justify why you are undertaking a Project similar to those being carried out by any other Network Licensees.

Not applicable.

Additional Governance And Document Upload

Please identify why the project is innovative and has not been tried before

- The proposed project will be first of its kind to be investigated within GB electricity transmission system.

- The project considers comprehensive and complex scenarios (e.g. network configuration, frequency spectrum) in line with UK's ambition Net-zero targets, including emerging HVDC and Offshore applications.
- The data driven method is unique in delivering a theoretically advanced and practically applicable data-driven modelling methodology for NGESO e.g. State Space Equation in wider frequency spectrum (few Hz to KHz level).
- The proposed Data Driven approach can consider multiple event data (based on multiple operating points) and hence enable a more robust model in comparison to the traditional approach of considering only a single event (based on a single operating point).

Relevant Foreground IPR

The following deliverables will be generated as part of this project:

- Development of benchmark testing system in PSCAD/EMTDC Environment for complex power networks with integration of typical Power Electronics Based HVDC and Wind Generation systems.
- Development and validation of frequency-dependent power system model for identifying potential interaction risks.
- Development and validation of advanced model reduction technique to reduce the high-order frequency-dependent model to low-order power system one for system representation, to achieve a good balance between system accuracy and computational efforts via comprehensive data-driven simulations.

Data Access Details

Data for this project and all other projects funded under the Network Innovation Allowance (NIA), Network Innovation Competition (NIC) or the new Strategic Innovation Fund (SIF) can be found or requested in a number of ways:

1. A request for information via the Smarter Networks Portal at https://smarter.energynetworks.org, to contact select a project and click 'Contact Lead Network'. National Grid ESO already publishes much of the data arising from our innovation projects here so you may wish to check this website before making an application.
2. Via our Innovation website at https://www.nationalgrideso.com/future-energy/innovation
3. Via our managed mailbox box.SO.innovation@nationalgrid.com

Details on the terms on which such data will be made available by National Grid ESO can be found in our publicly available "Data sharing policy relating to NIC/NIA projects" at https://www.nationalgrideso.com/document/168191/download

Please identify why the Network Licensees will not fund the project as apart of it's business and usual activities

Due to the nature of the project and that it is researching potential future impacts to the grid based largely on assumptions, this does not fall into current BAU.

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 learnings from the project can be shared more widely to the Network Licensees which could not be achieved if deemed as BAU activities.

This project has been approved by a senior member of staff

☑ Yes