NIA Project Annual Progress Report Document

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Date of Submission

Jul 2023

Project Reference Number

NIA2_NGESO009

Project Progress

Project Title

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

Project Reference Number

NIA2_NGESO009

Project Start Date

February 2022

Project Duration

2 years and 2 months

Nominated Project Contact(s)

Dechao Kong

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.

Objectives

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.

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.

Performance Compared to the Original Project Aims, Objectives and Success Criteria

National Grid Electricity System Operator ("NGESO") has endeavoured to prepare the published report ("Report") in respect of 'D3' - Data-driven Network Dynamic Representation for Derisking the HVDC and Offshore Wind, NIA2_NGESO009 ("Project") in a manner which is, as far as possible, objective, using information collected and compiled by NG and its Project partners ("Publishers"). Any intellectual property rights developed in the course of the Project and used in the Report shall be owned by the Publishers (as agreed between NG and the Project partners).

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Project Aim:

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 (ESO). However, it is difficult for the ESO to share detailed system information due to system models' complexity, confidentiality, and IP issues.

The aim of this project is 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

The project investigates the risks of control interactions between new power electronic equipment and existing ones. The first phase of the project is to develop a benchmark system with HVDC and Wind Farm in PSCAD. The next phase of this project is to build up a frequency-dependent power system model using a harmonic injection and measurements module. The automation toolbox will help ESO engineers to develop insight into the dynamics and stability of a PE-dominated power system. The final phase is to use a data-driven method to reduce the order of the system under multiple operating points. The results of this project will be an advanced tool for obtaining accurate grid dynamic models which do not reveal confidential system data and can be shared with outside stakeholders.

Project Objectives:

The project objectives are:

- To develop a power electronic integrated benchmark power system with HVDC and Wind Farm.
- To develop and validate frequency-dependent power system model. The Multi Infeed Interaction Factor (MIIF) index is used for screening a large network to find potential risks between inverters. Then harmonic injection and measurements modules are developed as part of an automation toolbox. A more in-depth frequency domain impedance modelling tool has then been used so that control interactions and appropriate countermeasures can be identified to de-risk the network operations.
- To develop and validate the model reduction technique. The data-driven approach is adopted to build the reduced order model for the power system under multiple operating points/scenarios to achieve a good balance between system accuracy and computational efforts.

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

Required Modifications to the Planned Approach During the Course of the Project

No changes were required to the planned methodology.

Lessons Learnt for Future Projects

The conclusions from the frequency-dependent modelling of IBR-dominant power system can be regarded as potential reference if applicable for future projects in technical areas of control interaction and other relevant power system stability studies for the main purposes of:

- Network Operability Compliance
- Customer Connection Evaluation
- Post-incident Investigation
- Network Planning and Design

The state-of-the-art data-driven approach, as developed in this project, can be rolled out for future projects for power system stability studies whose successful outcomes are heavily dependent on large volume of data inputs e.g. comprehensive event data based on multiple system operating points/scenarios.

Note: The following sections are only required for those projects which have been completed since 1st April 2013, or since the previous Project Progress information was reported.

The Outcomes of the Project

The outcomes of the project to date are:

- Developed testing system and models in PSCAD/EMTDC environment.
- Harmonic injection and measurements module which is applicable for power electronic devices.
- Impedance-based stability analysis using an automation toolbox for identifying potential interaction risks.
- Development and validation of the model reduction technique. The data-driven approach is adopted to build the reduced order model for the power system under multiple operating points to achieve a good balance between system accuracy and computational efforts.

Data Access

Details on how network or consumption data arising in the course of NIA funded projects can be requested by interested parties, and the terms on which such data will be made available by National Grid can be found in our publicly available “Data sharing policy related to NIC/NIA projects” and www.nationalgrideso.com/innovation.

National Grid Electricity System Operator already publishes much of the data arising from our NIC/NIA/SIF projects on the Smarter Networks Portal (www.smarternetworks.org) and National Grid ESO Data Portal (data.nationalgrideso.com). You may wish to check these websites before making an application under this policy, in case the data which you are seeking has already been published.

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.