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NIA Project Annual Progress Report Document

Date of Submission

Jul 2021

Project Reference

NIA_NGSO0031

Project Progress

Project Title

DETECTS - Developing Enhanced Techniques to Evaluate Converter-dominated Transmission System Operability

Project Reference

NIA_NGSO0031

Funding Licensee(s)

NG ESO - National Grid ESO

Project Start Date

May 2020

Project Duration

1 year and 1 month

Nominated Project Contact(s)

Djaved Rostom

Scope

The work is to comprise:

1. Obtaining suitable high-fidelity models of converters in the area of interest and integrating these into a suitable advanced model for stability simulations. Drawing conclusions regarding the implications for future grid security and grid modelling.
2. Providing "guidance notes" for ESO on the use of advanced models and techniques for conducting detailed stability analysis.
3. Investigating tools that would give "early warning" of situations on the grid where advanced modelling techniques and detailed analysis might be required to ensure stability.
4. Investigating whether the representation of grid demand needs to be upgraded.

Objectives

- Validating the conclusions of NIA_NGET0187 regarding grid stability.
- Research into practical tools for the application of advanced grid modelling for system operations.

Success Criteria

- A report on the stability of the part of the grid examined, including lessons learnt in obtaining high-fidelity ("black box") models of converters.
- A report providing guidance on the practical use of advanced grid models.
- Reports describing research into tools to help identify situations where advanced stability models and more detailed analyses are

needed, and research into the representation of grid demand.

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 DETECTS – Developing Enhanced Techniques to Evaluate Converter-dominated Transmission System Operability- NIA_ NGSO0031 (“Project”) in a manner which is, as far as possible, objective, using information collected and compiled by NGESO 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 NGESO and the Project partners).

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Project Overview

The project is a continuation of a previous NIA Project titled “Transient Voltage Stability of Inverter Dominated Grids and Options to Improve Stability” (NIA_NGET0187) which identified that under the high penetration of converter-based generation, the transmission system may be subject to forms of system instability which cannot be accurately detected using traditional RMS (Root Mean Square) dynamic simulations and that more detailed Electromagnetic Transient (EMT) studies are instead required. The reports from this project can be found [here](#).

This project set out to get a better understanding of the scenarios where EMT studies would be required, the best practices for setting up and conducting such studies and the modelling considerations that need to be made. As EMT studies are computationally intensive and require a long run times, the project also sought to understand whether alternative techniques can be adopted instead of the EMT studies. Finally as the previous project was based on generic EMT models of converters and implemented a high-level presentation of the network, it was deemed useful to repeat the previous analyses using actual manufacturer EMT models and a more detailed representation of the network in order to verify whether the previous conclusions were still valid.

Project Plan

The project was split into 4 work packages as described below with an overall cost of £250,000.

Work Package 1 (WP1)

- Provision of manufacturer models for converters on South East Coast (or similar converters elsewhere) - May 2020
- Report into stability of the South East Coast. Studies to use available manufacturers’ model and also generic models which (where possible) have been validated using manufacturers’ models -Sept 2020

Work Package 1B

Update of report into the stability of the South East Coast, with the addition of all manufacturer’s models that have subsequently become available -March 2021.

Work Package 2 (WP2)

- A set of guidance notes for use by ESO staff seeking to identify scenarios at risk of inverter instability and a report describing the studies that were undertaken to support the guidance provided - Feb 2021

Work Package 3 (WP3)

- A report comparing alternative techniques for providing a warning of inverter instability without needing to use EMT simulation. Interim report - Dec 2020, Final report - March 2021

Work Package 4 (WP4)

- A report comparing the impact on the South East Coast's stability of active and passive demand models, along with recommendations on the demand model that should be used. Interim report Oct 2020, Final report: Jan 2021

The project was officially started in July 2020 following contract negotiations. NGENSO already has access to most EMT models required for the project, however obtaining the necessary approval from relevant manufacturers to share these models with a third-party consultancy i.e. Power Nova proved to be more complex than anticipated. To date, NGENSO have not yet been able to share the necessary models, which has therefore prevented WP1 from actually starting. Whilst negotiations for the provisions of manufacturer models have progressed substantially and are still ongoing, WP2 was carried out and completed. A report has been produced which is currently under review. The report for WP3 is currently being finalised by Power Nova and will be submitted for review at the end of July 2021. Work under WP4 has also started.

Project Activities

Work Package 1 (WP1)

The first step was to seek actual manufacturer black box EMT models. As mentioned above, EMT models for relevant interconnectors and Transmission Owner (TO) STATCOMs in the South East Coast were already available to NGENSO. However, most wind farm models and their associated STATCOMs were not available. Letters were sent out to various project owners in order to explain the nature of the project and for the projects where NGENSO already had the models, permission was requested to enable NGENSO to share the models with the consultants. Where the models were not available, the project owners were requested to provide an EMT model of their equipment and the modelling specification implemented by the Australian Energy Market Operator (AEMO) was referenced in case new models had to be produced or amended. The AEMO Model guidelines can be found [here](#).

Over the period from Sept 2020 – March 2021, various calls were arranged with the project owners to discuss the provision of models. As these models were commercially very sensitive, non-disclosure agreements (NDAs) were required between the equipment manufacturers, the project owner, NGENSO and Power Nova. These took several months to be drafted and agreed between all parties. As of July 2021, all the NDAs for the interconnector projects have been finalised and are in the process of being signed off by all parties. A windfarm model and STATCOM model has also been received. The TO STATCOM models available to NGENSO are open-sourced models and need to be black-boxed before providing them to the consultant and the equipment manufacturer has agreed to black box the models. An NDA for the TO STATCOMs has been drafted and is currently under review.

There are some wind farm models e.g. those based on doubly fed induction generator (DFIG) and some OFTO Wind farm STATCOMs that were not available. The best available models e.g. generic models will be used or where the performance of other equipment is similar in nature, the EMT models of such equipment will be used as a sensitivity study case even though they are from a different manufacturer.

As of the beginning of July 2021, the status of the model provision is as follows:

- 3 out of 3 VSC (Voltage Source Converter) interconnector models should be available by the end of July 2021 as the NDAs are signed off.
- 1 out of 2 LCC (Line Commutated Converter) should be available by the end of July 2021 as the NDAs are signed off. As a sensitivity, the same LCC model will be used for the other interconnector.
- 1 full converter wind farm model out of 2 has already been provided. The other is at the early stage of discussion as engagement with the project owner and manufacturer has been relatively slow.
- 1 DFIG wind turbine model is not available in EMT and the manufacturer has advised that producing one would be time-consuming and complex to validate. NGENSO is finding out from the manufacturer whether a similar model is available for a different project that can be used.
- The TO- owned STATCOMs are being black-boxed and are expected to be delivered by October 2021.
- 2 out of 3 OFTO/ wind farm STATCOM has been provided. The model provided was a generic model as the manufacturer model was not available. The third STATCOM model is from a different equipment manufacturer and NGENSO has been advised that an EMT model for the project is not available. Discussions are ongoing to find out whether a generic model can be provided.

It is expected that by October 2021, Power Nova should have access to all the available EMT black box models to proceed with WP1.

Work Package 2 (WP2)

A report has been produced detailing the recommendations of when EMT studies are required and how they need to be carried out. The following topics are explored in greater details with reasonings provided to support the recommended approach:

- Identifying circumstances where EMT tools should be used for stability assessment.
- The tools that should be used.
- The sources of data, in particular manufacturer's models for converters.

- The creation of “base case” datasets for planning and operational studies.
- The setup of suitable scenarios and cases for study.
- The interpretation of the results.

The report is currently being reviewed and will be published in due course.

Work Package 3 (WP3)

A literature review has been conducted to identify alternative techniques for providing a warning of inverter instability without the use of EMT simulation. The report is currently being finalised and will be submitted to NGENSO at the end of July 2021, following which it will be reviewed and uploaded on the Smarter Networks Portal.

Work Package 4 (WP4)

Work has started under WP4 to determine whether the explicit modelling of demand interfaced through converters will have an impact on the results seen at transmission level. So far, Power Nova has collected data on the volume of converter-based plants (predominantly solar) in the South East and developed a methodology to model the equivalent circuits to present the 132kV and 33kV system for a few Grid Supply Points (GSPs) in the South East. Work is still progressing in this area and should be completed by Oct 2021, although priority may have to be shifted back to WP1 if the manufacturer black box models are available sooner.

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

Changes to scope and approach

It was envisaged that, since not all manufacturer models would be readily available at the beginning of the project, the analysis would be carried out in two stages: firstly using models that are readily available and secondly models that would be obtained at a later date. As the provision of EMT models has been substantially delayed, it was decided that the minimum WP1 would be carried out with at least one VSC HVDC model, at least one full converter wind turbine model and at least one STATCOM. WP1B would then start when additional models are received.

As noted in the Project Activities section under WP1, the minimum number of models should be available by the end of July 2021 to enable WP1 to start. The analysis under WP1 is expected to take 6 months to complete. We will continue our discussions with the manufacturer to decide whether it is best to carry on with the two-stage approach or wait until all the models are available before starting the analysis. As noted above, it is expected that by October 2021, the EMT models required for the analysis should be available.

Where manufacturer models are not available, it was decided that the best representation available should be used. The preferred alternative is to use the detailed models of similar equipment where these are available even though they may be from different projects and or from different manufacturers. In case these are not available, the alternative, although not preferred, will be to use generic models.

For WP2, it was originally planned that the analysis which is part of WP1 would be used to demonstrate the instances of when EMT studies would be better than RMS studies. However, due to the unavailability of the manufacturer models, WP2 compared the use of generic EMT models versus RMS models.

Changes to cost

There has so far not been any changes to the cost of the project. It should be noted that NGENSO received quotes from equipment manufacturers to produce the EMT models for the OFTO/ wind farm STATCOMs. However, NGENSO did not consider it as an effective way forward from a cost, production time and complexity of model validation perspective.

Changes to programme

Due to the lengthy process of obtaining the manufacturer Black Box models, the programme has been substantially impacted. It is expected that, as a worst case, an extension of an additional year would be required to allow the models to be provided, for the analysis to be conducted and for the relevant reports to be produced. The expected finish date of the project is therefore estimated to be in May 2022.

Lessons Learnt for Future Projects

Model Provision and sharing

The process of requesting EMT models retrospectively has proven to be quite challenging especially for equipment that has been commissioned a long time ago and for which the appropriate EMT models have not been developed. Manufacturer models require a considerable amount of time and effort to be produced and validated and should ideally be requested at the point of connection to the network. This approach is currently being implemented more regularly as part of the Bilateral Connection Agreement (BCA) during the connections process. The Grid Code Working Group (GC0141) is also progressing a modification that should hopefully allow easier access to EMT models in the future. As the system becomes more complex, there will be a growing need to conduct EMT simulations and having accurate models that have been fully validated to represent the performance of equipment is a key component of the process.

The additional challenge which was faced in this project is that even though some EMT models were available to NGENSO, it was not possible to pass these on to a third-party consultant without an agreed NDA in place. Going forward, there may be a greater need to share black-box models across network connectees to verify the interaction between equipment and the use of standard NDAs where possible would help facilitate the process.

EMT Simulations

The outcome of WP2 provides useful recommendations on when and how to conduct EMT studies. The use of PSCAD has been recommended for conducting EMT simulations mainly due to the fact that most manufacturers have their equipment modelled in the PSCAD environment, that the software package allows simulations to be run using multiple CPU cores in parallel, and is used by at least two TSOs worldwide. This reinforces the need for the TOTEM project ([NIA_SHET_0032](#)) which is looking to develop an EMT model of the GB transmission system in PSCAD.

WP2 also recommends the use of short circuit ratio (SCR) to screen when EMT studies are required based on the recommendation from CIGRE TB 671 "Connection of Wind Farms to Weak AC Networks" – which sets out the current international consensus on studying converter-dominated grids.

System Instability is more likely to occur under high levels of non-synchronous generation and WP2 recommends the use of automated systems that can run through multiple generation and demand scenarios as well as contingencies. In this project, a script has been developed that allows an automatic dispatch of generation, running of simulations and extraction of results from PSCAD.

As mentioned above, the WP2 report is currently under review and will offer useful insights on the future tools and capabilities required to run EMT simulations that can be used for the planning and operation of the Transmission system.

Review of benefits case

Although the project is not complete, it has provided some valuable lessons on model sharing and the best practices for running EMT studies which will be very useful for the ESO and TOs.

Next steps

We are continuing our engagement with project owners and the equipment manufacturers to agree the NDAs required to enable the models to be shared with Power Nova. These manufacturer black-box models will be integrated in the EMT model of the network and verified. Once the models have been integrated the analysis for WP1 will be carried out and the results will be compared to the previous findings from project NIA_NGET0187 to understand the impact of using manufacturer models as opposed to generic models.

Work will continue under WP4 whilst waiting for the provision of the manufacturer models to understand the impact of demand modelling. The reports for WP2 and WP3 will be reviewed and uploaded onto the Smarter Networks Portal. The reports for WP1 and WP4 will be created following the analysis phase.

Dissemination

A paper titled "EMT simulation of the British Grid" has been submitted to the IET AC/DC 2021 conference which captures the work done to date discusses the importance of EMT modelling. The paper is available upon request.

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

Interim project outcomes

The project is still very much in the early stages. However, a few learning points have been achieved based on the work carried out to

date especially on the model provision and the practicalities of running EMT simulations.

Further information will become available ones the work packages once completed.

Data Access

Details on how network or consumption data arising in the course of a NIC or NIA funded project 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 <https://www.nationalgrideso.com/future-energy/innovation>

National Grid Electricity System Operator already publishes much of the data arising from our NIC/NIA projects at www.smarternetworks.org. You may wish to check this website before making an application under this policy, in case the data which you are seeking has already been published.

Foreground IPR

The project is still in its early stages, but the project outputs are expected to be released on to the Smarter Networks Portal.