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NIA Project Annual Progress Report Document

Date of Submission

Jul 2021

Project Reference

NIA_NGSO0036

Project Progress

Project Title

Probabilistic planning for stability constraints

Project Reference

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Funding Licensee(s)

NG ESO - National Grid ESO

Project Start Date

June 2020

Project Duration

1 year and 7 months

Nominated Project Contact(s)

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Scope

There is increasing uncertainty (e.g. load composition, line flows through interconnectors) and variability (e.g. wind speed) in power system operating conditions and parameters. The changes in the system operating conditions are happening faster, are more complex and are occurring in places where previously there were no issues. There is an expectation of more angular stability issues in the future due to reduction in synchronous generation and system inertia (e.g. as reported in the FES).

Lack of automation in the assessment of stability means that the ESO has to prioritise boundary calculation due to computation time – analysis can be very time consuming and so is focussed on specific areas of the transmission network. For long term planning, power system analysis is currently carried out using deterministic approaches (e.g. selected background studies such as Winter Average Cold Spell – ACS demand or summer minimum demand). These technical studies do not consider all the variability and uncertainty associated with future energy scenarios which could have a significant impact on stability. In the future, this might lead to under- or over-estimated transfer capabilities and sub-optimal techno-economic solutions.

In this project, we will explore, develop and test cutting-edge automated and probabilistic approaches for modelling of angular stability. This will enable year-round boundary capability calculation for stability accounting for a number of sources of variability and uncertainty and enabling ESO to consider the possible issues across the system. This work will be completed across four work packages:

WP1: In this initiation work package, we will review academic literature, review the overlap and available learning from existing and ongoing work, and identify any policy and practical barriers that could affect possible implementation. In this work package TNEI will engage closely with ESO during the annual ETYS/NOA cycle to understand how new angular stability modelling methods will fit into the process and ensure the development of fit for purpose tools.

WP2: In the development work package, we will trial the most promising methods on published test networks or reduced GB networks, to explore how different approaches perform in terms of e.g. accuracy, computation time. This will include methods for (i) screening the network to identify previously unforeseen stability issues, (ii) automated probabilistic evaluation of stability issues, (iii) quantify the uncertainty within the model and key model parameters, and (iv) development of a probabilistic model that captures correlations between demand and renewable generation.

WP3: In the trialling work package, we will engage with the Network Development teams during the 2021/22 Electricity Ten Year Statement (ETYS) and Network Operability Assessment (NOA) planning cycle, testing the most promising methods on the full GB electricity transmission system models. The learnings, where applicable, will also be shared with other relevant ESO teams like the Operability teams.

WP4: In the final work package, we will produce a plan for later implementing the tools into business-as-usual, and produce a roadmap for possible future changes (e.g. in regulation or planning standards) that could help deliver further value for GB energy consumers.

Deliverables: These will include (i) innovative automated tools to possibly be used in the ETYS and NOA, to carry out automated probabilistic stability analysis for stability evaluation processes (e.g. probabilistic demand and renewable generation conditions model, method to screen networks for stability issues, probabilistic tool that supports automated power system analysis using Powerfactory) (ii) reports detailing the development and demonstration of these methods (iii) results from the models that are suitable for sharing with third parties (i.e. in NOA and ETYS publications), and (iv) a roadmap and evidence for further future development.

Objectives

The objectives of this project are to explore the use of cutting-edge techniques (combining traditional power systems stability analysis and statistical modelling), and whether these allow the ESO to better understand the risk and uncertainty associated with angular stability on the GB electricity system. The result of this will be to produce automated tools to allow efficient stability evaluation for more snapshots and locations in the system.

This could help the ESO to make more optimal economic decisions with respect to secure and stable operation of the system.

Success Criteria

The project will be a success if the developed tools will provide the ESO the capacity to accurately and efficiently evaluate stability constraints for more regions and more snapshots, with a Roadmap to integrate the tools within the ESO existing tools for the planning cycle of 2022/23.

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

Project Overview

The objective of this NIA project is to explore the potential use of cutting-edge techniques, combining traditional power systems stability analysis with statistical modelling and automation, to allow the ESO to better understand the risk and uncertainty associated with angular stability on the GB electricity system. Outputs will be automated tools that allow stability to be evaluated and visualized efficiently, accounting for a broader range of conditions and uncertainties at more locations/boundaries in the system.

This will enable year-round boundary capability calculation for stability accounting for a number of sources of variability and uncertainty and enabling NGESO to identify possible stability constraints across the system. It will enable analysis of the current power system, but also future system models, as represented by the Future Energy Scenarios (FES), making a valuable improvement to the Networks Options Assessment (NOA).

Project Plan

An 18 months project, the project has 4 work packages delivering 5 main deliverables. WP1 involved project initiation with first deliverable WP1 report (Initiation and Literature review) delivered in December 2020. WP2 is about the development and testing of different screening and probabilistic evaluation methods in a reduced network. The WP2 interim report was issued in March 2021 and the WP2 final report and selected methods delivered in June 2021. WP3 focuses on rescaling the selected methods and demonstrating them in the full GB network. The WP3 deliverables will be the developed tools and the demonstration case study results and are expected by October 2021. WP4 is the implementation work, and the deliverables expected by December 2021 are implementation plan and future development roadmap.

Project Activities

In WP1 a comprehensive engagement between TNEI and the relevant ESO teams was carried out. Several meetings and discussions were organised with the Stability Pathfinder team, Network Development, Network Operability and Network Access Planning teams to achieve a better understanding of the current stability issues and the ongoing internal work of probabilistic modelling. Based on these discussions the overall problem statement and project objectives were captured in WP1 report, in addition to the literature review. A WP1 workshop was delivered by TNEI internally in the ESO to discuss the findings and obtain feedback as input to WP2.

In WP2 a Python based Stability Analysis Automation Tool was developed to automate almost all the activities in the NOA (Network Options Assessment) transient stability analysis using a 36-zone reduced GB model. Python tools were also developed and evaluated to explore different machine learning algorithms to predict the outcome of stability analysis. An active learning algorithm was explored to improve the machine learning classifier performance by running more detailed stability analysis for the snapshots where the confidence on the labelled snapshot is not higher than a predefined threshold. The proof of concept tools were validated using the reduced GB network model and utilizing historical renewables and demand data extracted from Elexon and projected over a selected scenario from the 2019 Future Energy Scenarios (FES) data. The tools were found to significantly improve the efficiency of the stability analysis as they enable around 2000 scenarios to be run in less than one hour.

In WP3 a full network model was shared with TNEI to rescale the tools and demonstrate performance on the full-scale GB network model. Further work is being done to align the tools and to ensure that accepted accuracy is delivered by the machine learning algorithm.

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

<u>Changes to scope and approach</u>

No changes in the project scope, however the project is currently running ~8 weeks behind schedule due to difficulties in collecting some inputs at the beginning of the project.

<u>Changes to cost</u>

No expected change in cost.

<u>Changes to programme</u>

Due to difficulties in the beginning of the project in collecting Elexon data, the activities regarding probabilistic modelling of demand were delayed by 3 weeks causing WP2 to start late and run longer than the original plan.

In the original programme, the activities of WP3 and WP4 were expected to be carried out by the TNEI team from the ESO offices in Warwick, due to the need to have access to the full GB model and the sensitivity of the data. However, this was not possible due to covid restrictions. New processes were followed by the ESO to be able to share the models and implement secure data exchange channels while maintain compliance. These processes delayed the project by further ~5 weeks.

Lessons Learnt for Future Projects

<u>Review of benefits case</u>

The developed tools have proved the concept of the practicality of doing probabilistic stability analysis by utilizing automation and Machine Learning techniques. This is a step forward towards the capability of running year-round stability analysis and to be able to run for more boundaries and contingencies in the network. The next steps are to ensure the scalability and accuracy of the tools in the full model, to align the tools with the existing planning tools in the ESO and to demonstrate the impact of the improved stability assessment in the long-term planning decision making (i.e., NOA). The final developed tools will improve the assessment of stability requirements across the network (ESO business plan deliverable D11.4) and will support the ESO ambition of being capable to operate the system carbon free by 2025.

Next steps

The following WP3 will explore the scalability of the tools and demonstrate case studies in the full GB model. The project will also deliver activities on the implementation of the tools and the incorporation with the existing ESO planning tools (WP4).

Dissemination

An abstract with the interim findings was accepted for paper submission in Cigre Paris 2022 session.

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

To improve the efficiency of the tools in terms of the total simulation time and to reduce the dimensionality of the problem which arises from the probabilistic modelling of demand and generation inputs, several techniques were analyzed and validated in the reduced GB network. Some of these techniques are based on power system modelling aspects like network reduction for dynamic equivalents, parallelizing simulation runs in multiple cores and incorporating engineering judgements for certain decision making into the tools while other techniques such as sequential ranking of network parameters focus more on the data engineering side of the problem.

The two main tools developed in WP2 are Stability Automation Tool (SAT), and Stability Classification Tool (SCT), each can run independently or together based on the user need. Both the tools are developed in python programming language. The SAT is a tool utilizes the DIgSILENT PowerFactory as an engine to run RMS simulations and performs transient stability analysis for a number of scenarios defined by the user. The scenarios are based on the market dispatch model used currently for the year-round probabilistic thermal analysis of boundary capabilities. A major contribution of the SAT is the automated identification of unstable scenarios based on the time domain response from RMS simulations. The SAT calculates a number of indices to identify the stable/unstable trend of the dynamic parameters (such as machine rotor angles) and evaluates stability margins for different scenarios under different credible contingency conditions.

The SCT is a Machine Learning based binary classifier which can label the input scenarios as stable/unstable without a need to run detailed stability analysis using a power system simulation tool. This is a very innovative and useful outcome of the project as running full RMS simulations otherwise would take unrealistic amount of time to study all the scenarios. The SCT queries the SAT to run a full RMS simulation only for the scenarios that cannot be classified with high confidence and learn from the outcome to improve classification for similar scenarios (Active Learning).

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 reports generated from this project will be made available following completion, and are expected to be released on to the Smarter Networks Portal.