NIA Project Close Down Report Document

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.

Network Licensees must publish the required Project Progress information on the Smarter Networks Portal by 31st July 2014 and each year thereafter. The Network Licensee(s) must publish Project Progress information for each NIA Project that has developed new learning in the preceding relevant year.

Date of Submission

Jul 2024

Project Reference Number

NIA2_NGESO040

Project Progress

Project Title

DETECTS II

Project Reference Number

NIA2_NGESO040

Project Start Date

March 2023

Project Duration

1 year and 0 months

Nominated Project Contact(s)

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Scope

The work is to comprise:

- Licensing of software and model.
- Setup of software and model on ESO computer.
- Training of ESO employees to use the model of the South East Coast.
- Use of the model to determine stability limits of South East Coast; includes ongoing technical support by Transmission Excellence.

Objectives

The objectives of this project are to:

1. Deliver practical tools for the application of advanced grid modelling for system operations.
2. Validate the stability limits in the South East Coast by utilising suitable high-fidelity models of converters and applying EMT based analysis.
3. Deliver training and support to the ESO in the use of the advanced modelling tools developed.

Success Criteria

This project will be regarded as successful if:

1. The software is successfully installed on ESO equipment and training is provided to all relevant ESO employees.
2. The software enables the ESO to more accurately calculate the stability limit(s) for the South East Coast.

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 II, NIA2_NGESO040 (“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).

Project Overview

The DETECTS II project aimed to advance the prototype system developed in the original DETECTS project to a pilot demonstration stage. The project focused on the analysis of stability in the South East Coast using an integrated software and model approach. This system combined commercial software (PSCAD), independently developed software (TXSims), and a comprehensive PSCAD model of the GB grid, including "black box" models integrated by Transmission Excellence. The primary objective was to license the software and model to ESO, set up the tools on ESO computers, and provide training to employees for using the integrated analysis system. The project was scheduled to last one year, starting in March 2023, with a budget of £150,000.

Work Package 1: Licensing of Software and Models

The first work package successfully met its original aims and objectives. ESO licensed the TXSims software, and the detailed model of the GB grid was created by Transmission Excellence Ltd. This step ensured that ESO had the necessary tools and intellectual property rights to use and further develop the software and models for stability analysis. The licensing process was straightforward and completed on time, allowing the project to proceed to the next phase without delays.

Work Package 2: Installation and Testing

Work Package 2 was divided into two key deliverables. The first deliverable focused on the installation of the software and models on ESO computers and their subsequent testing. The installation process was completed efficiently, with TXSims being installed on various ESO machines, primarily large multi-core computers designated for complex PSCAD studies. Although TXSims was initially written to run with PSCAD version 4.6, modifications were made to ensure compatibility with PSCAD version 5 at ESO's request. Testing revealed some issues with PSCAD version 5, but the software ran as expected with PSCAD version 4.6 on ESO's machines. The necessary debugging and modifications were carried out to ensure the system's functionality aligned well with the project's success criteria.

Work Package 2: Training and Support

The second deliverable under Work Package 2 involved comprehensive training and support for ESO employees. Multiple training sessions were conducted, concluding in November 2023. These sessions equipped ESO staff with the knowledge and skills required to effectively use TXSims and the integrated models for stability analysis. Detailed documentation describing the models and software was provided, along with a catalogue of modelling assumptions and potential improvements. Ad-hoc technical support was also offered during and after the installation and training period, ensuring that any emerging issues or queries were promptly addressed. This deliverable met its objectives by ensuring that the ESO team was well-prepared to utilise the new tools in their operations.

Conclusion

In conclusion, the DETECTS II project successfully advanced the original prototype system to a pilot demonstration stage. The licensing of the software and models, the installation and testing on ESO computers, and the comprehensive training and support provided to ESO employees were all completed effectively. These efforts have laid a solid foundation for improved stability analysis on the Southeast Coast and have equipped ESO with advanced tools and knowledge to enhance its network planning and operational capabilities. The project not only met its original aims and objectives but also provided valuable insights and practical solutions that will benefit future initiatives in the field.

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

The software ("TXSims") and the EMT model of the GB grid provided by Transmission Excellence were initially designed to function with PSCAD version 4.6. However, to streamline operations and reduce the number of PSCAD versions in use, ESO requested these be upgraded to PSCAD version 5. This migration necessitated several modifications to the TXSims software due to significant changes in PSCAD's Python API between versions 4.6 and 5.0. The API, or application programming interface, consists of a set of commands and data structures that allow a Python program to communicate with PSCAD and control its simulations.

Transmission Excellence updated parts of their TXSims software to align with the new PSCAD API. Despite these efforts, it was discovered that at least one manufacturer-provided model, known as a "black box model," did not function correctly in PSCAD version 5. Consequently, the model and software could only be reliably run on PSCAD version 4.6. This issue was particularly troubling because the black box model appeared to compile and run normally without generating any error messages. However, when executed in version 5, its behaviour deviated significantly from its performance in version 4.6 and from the expected behaviour of the physical device it emulated, a Statcom.

A Statcom, or Static Synchronous Compensator, should respond to high post-fault voltages by absorbing reactive power. While the black box model correctly exhibited this behaviour in PSCAD version 4.6, it behaved anomalously in version 5. For a few hundred milliseconds following a system fault, despite voltages being above normal levels, the Statcom model injected reactive power, thereby exacerbating the problem. This inconsistency posed significant risks for the accurate simulation and planning of grid stability.

The inability to port manufacturer-provided models seamlessly between software versions underscores a critical challenge for the ESO and other network licensees. This issue highlights the need for robust validation processes when updating simulation tools and the importance of maintaining compatibility over the lifecycle of grid assets. It also suggests that future projects must account for the potential difficulties in software migration and ensure thorough testing to prevent similar issues. Addressing these challenges will be crucial in advancing the reliability and effectiveness of grid management systems.

The implications of this for the ESO are as follows:

- The TXSims software and model are currently only useable with PSCAD 4.6.
- All black box models provided to ESO for use with PSCAD 4.6 (or earlier) should be tested thoroughly before they are deployed in any studies using PSCAD version 5.
- If it is essential to use the latest version of PSCAD, then it may be necessary to go back to manufacturers and ask them to create modified black box models that work correctly in version 5. It is unclear if the work needed to achieve this is limited to recompilation or if redesign would be needed.
- In the longer term it will not be possible to avoid using newer versions of PSCAD, and manufacturers may no longer be able or willing to modify models of equipment they stopped making years ago. Given that equipment like statcoms is designed to last for decades, this is a serious threat.
- The ongoing “NeuralBB” research project provides a possible solution. If successful this project may show how to create surrogate models that replicate the black box models with a reasonable degree of accuracy, but which can be modified and recompiled by ESO to ensure their compatibility with the latest simulation tools.

Lessons Learnt for Future Projects

The inability to port at least one manufacturer-provided ("black box") model from one version of PSCAD to another highlights a significant issue. This discrepancy underscores the tension between the rapid evolution of computers and simulation software and the expectation that manufacturer-provided models should remain usable for the lifespan of the underlying asset, which can span several decades. Future projects with Transmission Excellence will aim to address this challenge.

Moreover, the training requirements for this project were more extensive than anticipated, necessitating four sessions of approximately four hours each. This experience demonstrates that future projects should not underestimate the complexity of EMT models, and the substantial time required to thoroughly discuss and communicate the numerous features inherent to such models.

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 project has equipped the ESO with advanced tools to assess grid stability, particularly in the South East Coast, under minimal or no fossil-fueled generation conditions, which will become common from 2025 onwards.

Key outputs include the delivery of the PSCAD GB Grid model and a suite of Python scripts. The PSCAD model provides a detailed representation of the GB grid, incorporating essential "black box" models for components like HVDC systems, offshore wind farms, and STATCOMs. The Python scripts automate simulation processes, enhancing the ability to perform comprehensive and efficient analysis.

ESO personnel received thorough training in model development and Python-based simulations, ensuring they can independently conduct detailed electromagnetic transient (EMT) studies. This training enables ESO to evaluate the stability of the South East Coast area under various operating conditions, including high renewable penetration and low inertia scenarios.

These tools and training allow ESO to perform precise stability assessments, predict grid responses to disturbances, and optimize operations to maintain reliability. As the energy landscape shifts towards renewable sources, the PSCAD model and Python scripts are now crucial for ESO to manage this transition effectively.

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 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

No foreground IPR expected to be generated in the project.

Planned Implementation

Based on their experience of installing the software, testing the model and providing training, Transmission Excellence have provided a list of potential improvements to the model and software. These are being considered by ESO.

The issues found with manufacturer-provided (“black box”) models led Transmission Excellence to propose a project to develop non-black-boxed “surrogate” models using machine learning techniques. This concept is now being taken forward as a separate NIA project titled **Neural BB.**

Other Comments

The Project outcomes and results contain confidential information and intellectual property rights that cannot be disclosed in this Report due to their proprietary nature. Should the viewer of this Report (“Viewer”) require further details this may be provided on a case by case basis following consultation of all Publishers. In the event such further information is provided each and any Publisher that owns such confidential information or intellectual property rights shall be entitled to request the Viewer enter into terms that govern the sharing of such confidential information and/ or intellectual property rights including where appropriate formal licence terms or confidentiality provisions. Dependent upon the nature of such request the Publishers may be entitled to request a fee from the Viewer in respect of such confidential information or intellectual property rights.

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