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# NIA Project Registration and PEA Document

### Date of Submission

May 2022

### Project Reference Number

NIA2_NGET0020

## Project Registration

### Project Title

Co-Simulation

### Project Reference Number

NIA2_NGET0020

### Project Licensee(s)

National Grid Electricity Transmission

### Project Start

July 2023

### Project Duration

3 years and 6 months

### Nominated Project Contact(s)

Xiaolin Ding (box.NG.ETInnovation@nationalgrid.com)

### Project Budget

£300,000.00

### Summary

With the rapid penetration of power electronic (PE) devices in the system, large network wide dynamic stability simulations conventionally performed using Root Mean Square (RMS) type simulations may not capture the correct system dynamic response. Electromagnetic transient (EMT) simulation can accurately capture the changing dynamic of the network. However, it requires a significant data modelling effort and has limitations when simulating large systems. Thus, a more effective and flexible future power system modelling approach is required to meet future modelling needs.

This project aims to develop an innovative co-simulation modelling approach between Digsilent PowerFactory (RMS type) and PSCAD (EMT type) which can effectively maintain the benefits to both types of mathematical platforms, reduce the data modelling effort for EMT modelling and efficiently perform reliable simulation studies.

### Third Party Collaborators

Manitoba Hydro International

### Nominated Contact Email Address(es)

box.NG.ETInnovation@nationalgrid.com

### Problem Being Solved

For large scale power system stability studies, Root Mean Square (RMS) simulation is traditionally adopted for the benefits of a simplified approach by representing the system in the phasor domain. RMS simulations have proved to give reliable results when power systems are predominantly based on synchronous machine based generation. However, with the rapid penetration of power electronic (PE) devices in the system, the dynamic performance of the system is likely to experience significant changes due to the characteristics of PE based devices that may not be accurately captured by RMS studies alone. The classical RMS model might not be adequate to accurately capture the dynamic behaviour of the network.

RMS simulation only provides a fundamental frequency representation of the network and does not calculate the transient response of the electric network that is known to impact inverter-based device response. In addition, certain system phenomena such as sub-synchronous oscillation needs to be studied in detailed electromagnetic transient (EMT) platforms as EMT offers accurate time domain response of the network and equipment connected to it and is capable of accurately capturing transient behaviour. However, this requires significant data modelling effort and therefore an EMT study is often restricted to a limited area of interest of the network. To do so, network reduction from the full RMS model is required. It is challenging to identify the effective boundary for network reduction. In some cases, with high penetration of PE devices, it may be required to represent a wide area of the network in the overall study. Furthermore, customers connecting to the transmission network via converters require adequate dynamic modelling to conduct studies required by Grid Code. However, sharing manufacturer specific control models with different customers is a great challenge, which may have a negative impact on the customer connection journey. Therefore, a more efficient, flexible modelling approach should be investigated to address these challenges.

## Method(s)

The project will evaluate the feasibility of a co-simulation modelling approach between Digsilent PowerFactory and PSCAD. This project aims to develop an innovative modelling approach which takes advantage of the existing full network RMS model and reduces the data modelling effort for EMT studies. The area of interest in the network (study area/s) will be modelled and analysed in detail in EMT time domain, while the rest of the network is modelled and simulated in an RMS simulation (splitting the network by regions). The benefit of such an approach is that the overall small- and large signal behaviour of the power system is preserved which is difficult to achieve when solely relying on a reduced network model implemented on EMT.

Data Quality Statement (DQS):

- The project will be delivered under the NIA framework in line with OFGEM, ENA and NGGT / NGET internal policy. Data produced as part of this project will be subject to quality assurance to ensure that the information produced with each deliverable is accurate to the best of our knowledge and sources of information are appropriately documented. All deliverables and project outputs will be stored on our internal sharepoint platform ensuring access control, backup and version management. Relevant project documentation and reports will also be made available on the ENA Smarter Networks Portal and dissemination material will be shared with the relevant stakeholders.

Measurement Quality Statement (MQS):

- The methodology used in this project will be subject to our supplier's own quality assurance regime. Quality assurance processes and the source of data, measurement processes and equipment as well as data processing will be clearly documented and verifiable. The measurements, designs and economic assessments will also be clearly documented in the relevant deliverables and final project report and will be made available for review.

## Scope

The overall project will be staged under three Work Packages (WP). The scope of the project includes the following:

**Work package 1: Develop and test Interfacing/Data exchange methods between PSCAD & PowerFactory**

- Review data exchange functionality in both PSCAD and PowerFactory software tools in facilitating co-simulation and communication (data exchange) with the other software.
- Develop custom 'interface' models in PSCAD and PowerFactory to enable representing the 'rest of the network' in each software. Establish and verify the data exchange mechanism between the two software platforms. The input to the source on the PSCAD side would be the instantaneous values of phase voltages (or currents). The input to the source on the PowerFactory side will be the magnitude and phase (of voltage or current).
- Determine and develop the mathematical methods to convert information of PowerFactory side to PSCAD and vice versa. The time varying information in RMS form, measured at the interface point (phase and magnitude) on the PowerFactory side is to be converted to instantaneous values to 'control' the 'Interface source' on the PSCAD side. The instantaneous values on the PSCAD side, measured at the interface point (instantaneous value of voltage or current) is to be converted to RMS quantities to 'control' the 'Interface source' on the PowerFactory side.
- Test and validate the developed "interfacing/data exchange" method in a small test model (IEEE 9 BUS or 14 Bus case is suggested). Refine the 'interfacing method based on tests performed on the small test system.
- Provide a technical report covering the developments, validation and refining of the methods under WP1.

(Note that the following work packages will only commence if work package 1 is successful.)

**Work package 2: Validation of Co-simulation approach in a reduced network**

- Develop a PowerFactory model of a reduced network of the GB system around an identified region which should have both

conventional plants as well as inverter-based connections. The total number of buses in this area should be kept to a reasonable number (recommended around 50 or less). Use the developed identical system model in PSCAD and benchmark the dynamic response results.

- Verify the co-simulation methods developed to test the accuracy of co-simulation. Selected areas of the system will be simulated in PowerFactory and the rest in PSCAD. The co-simulation should be able to facilitate multiple 'interface' points (i.e. not limited to radial connections).
- Produce technical report, summarise key findings.

**Work Package 3: Validate the co-simulation method in full GB model**

- Use a full GB model to further validate the co-simulation method: At this stage, selected areas will be represented in PSCAD while the rest of the GB network will be represented in PowerFactory.
- Identify any future work required for deployment / implementation and provide user guidance and training on the developed co-simulation approach if the developed co-simulation method is successful.
- Produce a project final report and organise dissemination events to share the key findings of the project.

## Objective(s)

The key objective of the project is to develop an innovative co-simulation modelling algorithm that enables a more efficient and flexible network modelling and simulation approach. This should improve the simulation efficiency, reduce the data modelling effort for EMT modelling, and enable easier access for our customers to access dynamic simulation models without infringing IP rights.

## Consumer Vulnerability Impact Assessment

An assessment of distributional impacts (technical, financial and wellbeing related) for this project has been carried out using a bespoke assessment tool, which assesses the project as having a positive, negative or neutral effect on consumers in vulnerable situations. To help inform the assessment, this tool considers the categories of consumers identified in the Priority Services Register.

This project has been assessed as having a neutral impact on customers in vulnerable situations. This is because it is a transmission project focusing on modelling only.

## Success Criteria

- Successful development of a data exchange algorithm to enable time data exchange between PSCAD time domain and PowerFactory RMS domain simulation.
- Successful development and validation of the co-simulation modelling approach between PSCAD and PowerFactory.
- Good quality of technical report and successful dissemination of acquired knowledge via workshops and/or publications.

## Project Partners and External Funding

NGESO, SSEN, SPEN are project partners. No external Funding support is required.

## Potential for New Learning

This project will develop a new simulation approach to enable more efficient and flexible network modelling to meet the need of future dynamic studies. The project will provide valuable insights on co-simulation of RMS based model in PowerFactory and EMT based model in PSCAD. The method can be applied to the system dynamic analysis if the developed method is proved to be successful. The key findings of the project will be shared with other Transmission Network Licensees and System Operator via workshops and/or publications.

## Scale of Project

The developed simulation approach will be initially tested and validated in the relatively small IEEE network model. Then it will be tested and validated on GB network model. If the Project were of a smaller scale, only in a small IEEE network, the developed co-simulation approach cannot be validated to ensure the method works in a complicated and large GB network.

## Technology Readiness at Start

TRL3 Proof of Concept

## Technology Readiness at End

TRL4 Bench Scale Research

## Geographical Area

The research will be mainly desktop based during the development and validation of the co-simulation approach. The models used are expected to cover all of the GB transmission system.

## Revenue Allowed for the RIIO Settlement

Not Applicable

## Indicative Total NIA Project Expenditure

£270,000

# Project Eligibility Assessment Part 1

## Requirement 1

Facilitate the energy system transition and/or benefit consumers in vulnerable situations

Please answer **at least one** of the following:

## How the Project has the potential to facilitate the energy system transition:

This project supports the energy transition in a way that it will develop a more flexible and efficient modelling approach to capture the dynamic performance of the network to better support future renewable connection and network planning and operation. The project will improve the accuracy of the modelling and benefit customers like renewables and interconnectors to have more accurate network models in studies and thus reduce the risk in design and planning.

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

Not applicable

## 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

Not applicable

## Please provide a calculation and/or description of the expected benefits of the solution

The developed co-simulation approach in this project will reduce the modelling efforts and improve the efficiency of the simulation on system dynamic analysis for large networks. It will also improve the accuracy of the modelling and reduce the risk in planning and design. Based on our cost benefit analysis, the estimated benefits of the project by 2030 in NPV (Net Present Value) will be around £272k if the project is successful.

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

The research outcomes and the developed method are of generic nature and are applicable to other transmission networks licensees and System Operator in the GB.

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

If the project is successful, the estimated cost to roll out the method across GB could be in the range of £100k and will be reviewed in detail after the completion of the project.

## Requirement 3 / 1

Involve Research, Development or Demonstration

Projects 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

Involve Research, Development or Demonstration - Please select all that apply

- ☐ 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

The project outcome will be a new modelling method that enables co-simulation between PowerFactory and PSCAD. The key learning will be shared with other Transmission Network Licensees and System Operator in the UK. The developed method will be applicable to all of the GB electricity transmission network.

Not applicable

### 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. Networks must explicitly mention similar projects that they have considered and how these differ.

### Please demonstrate below that no unnecessary duplication will occur as a result of the Project.

This is the first time that a co-simulation approach between PowerFactory and PSCAD is investigated and developed to enable the EMT and RMS simulation for power system dynamic analysis. There is a RIIO-T1 project NIA_NGTO048 titled “Future Power Network Simulation” which was set up to investigate something similar, but the project didn’t kick off and was terminated. There is another innovation project NIA_SHEY_0032 titled “TOTEM” which might also be relevant with focus of developing a whole GB EMT model. But the key focus of this project is to investigate a more effective co-simulation approach between the EMT and the RMS simulation. No unnecessary duplication will occur as a result of the project.

### 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 project develops an innovative co-simulation method in power system dynamic analysis which enables the co-simulation of RMS based model and EMT time domain between PowerFactory and PSCAD, which is not commercially available in the world and has never been thoroughly explored and validated before. Specifically, the proposed methods will be thoroughly tested for its subtility for application in the GB system.

### Relevant Foreground IPR

The project is expected to develop a data exchange code that enable the data exchange between PowerFactory and PSCAD. The project is also to develop a co-simulation algorithm which enable the co-simulation of RMS based model in PowerFactory and EMT

based model in PSCAD. The project will also produce technical reports, presentations and analysis results, and publications of Journals or conference related to the developed co-simulation method. The default IPR position will be joint owned by National Grid and the suppliers of the project. Key results created or acquired or otherwise developed during the project will be made available through the publication of the progress and completion reports on the ENA portal.

## 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:

- 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 already publishes much of the data arising from our innovation projects here so you may wish to check this website before making an application.
- Via our Innovation website at https://www.nationalgrid.com/uk/electricity-transmission/innovation
- Via our managed mailbox box.NG.ETInnovation@nationalgrid.com

The associated Network Licensees will adhere to industry codes in accordance with their license conditions. This will facilitate the models built under this project to be shared with other interested parties in accordance with the present protocols.

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

The co-simulation approach between PowerFactory and PSCAD is not commercially available in the world and has not been developed and examined for suitability of application in the GB system. Furthermore, the development of the innovative co-simulation method represents a considerable risk to the business. Therefore, it cannot be funded as part of its business-as-usual activities.

## 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 development of the innovative co-simulation method represents a considerable risk to the business and there is no guarantee of success for the algorithm developed. The methods developed will have to be specifically tested and adjusted to be applicable in the GB system.

## This project has been approved by a senior member of staff

☑ Yes