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.

NIA Project Registration and PEA Document

Date of Submission

Apr 2024

Project Reference Number

NIA_SHET_0045

Project Registration

Project Title

TOTEM (Transmission Owner Tools for EMT Modelling) 2

Project Reference Number

NIA_SHET_0045

Project Licensee(s)

Scottish and Southern Electricity Networks Transmission

Project Start

May 2024

Project Duration

0 years and 11 months

Nominated Project Contact(s)

Brant Wilson - Innovation Portfolio Manager

Project Budget

£100,000.00

Summary

This project is focused on the continuing development of innovative tools and resources for power system modelling and analysis. Following TOTEM and TOTEM Extension there is a model that can mimic large-volume power electronics and enable the formulation of mitigation measures to future-proof the GB network associated with the energy transition. TOTEM 2 will incorporate additional capabilities.

Preceding Projects

NIA_SHET_0032 - TOTEM (Transmission Owner Tools for EMT Modelling)

NIA_SHET_0035 - TOTEM (Transmission Owner Tools for EMT Modelling) Extension

Nominated Contact Email Address(es)

transmissioninnovation@sse.com

Problem Being Solved

This project is a continuation of NIA projects, NIA_SHET_0032 TOTEM and NIA_SHET_0035 TOTEM Extension. These projects provided a multi-party agreement that enables the GB Transmission Owners to work together to acquire and validate a new system model that will enhance, as well as de-risk the integration of new technologies.

With the current configuration and capabilities of the TOTEM tool, two aspects currently lead to additional time and effort being required. Firstly, file format conversions are required. Currently, Power Factory model files need to be converted into PSS/E format before they can be uploaded into TOTEM adding additional time and computational effort. Secondly, simulation speeds are considered long taking approximately three hours per scenario. If these additional capabilities aren't implemented, then we are not maximising the benefits that this tool has the potential to provide. The build-up of knowledge of the impact of control interactions will be

limited by the time taken to run a simulation and to convert file types to ensure compatibility. Knowledge of control interactions is vital as the potential for adverse interactions between control devices such as HVDC links and Flexible AC Transmission Systems (FACTS) devices is rising and needs careful consideration within the context of a potentially weaker GB system.

Method(s)

This project proposes to have Manitoba Hydro International (MHI) develop additional capabilities to the existing EMT model in PSCAD. This project is set to streamline the conversion process from PowerFactory to PSCAD, eliminating the need for intermediary Power System Simulator for Engineering (PSS/E) steps and associated software. This project will deliver a direct conversion process and additionally enhance the simulation speed through optimised network splits so that the overall network can be run more efficiently and faster.

Data Quality Statement (DQS):

The project will be delivered under the NIA framework in line with OFGEM, ENA and SSEN Transmission 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. Deliverables will be shared with other network licensees through the closedown reports on the Smarter Networks Portal.

Measurement Quality Statement (MQS):

The methodology used in this project will be subject to 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.

In line with ENA's Energy Networks Innovation Process (ENIP) document, the cumulative risk score is scored as 5 = LOW from the sum of the risk thresholds below:

TRL Steps – 5 TRL Steps – Medium (Score 2)
Cost – <£500,000k – Low (Score 1)
Number of suppliers – 1 – Low (Score 1)
Data – Defined assumptions and principles – Low (Score 1)

Scope

The incorporation of additional capabilities to the existing EMT model in PSCAD:

1. Re-Dispatch Tool Refinement - The contractor shall review and refine the existing model re-dispatch tool to enable direct use from Power Factory models, removing the need to convert to PSS/E format. The contractor shall create a comprehensive user manual to enable users to understand both how the tool functions and to apply the tool to re-dispatch network models.

2. Simulation Speed Improvement - The contractor shall review the simulation speed of the Scottish network model and make improvements. Optimisation of the model shall be carried out with the aim of simulation times of 10-15 minutes for a 30-second run on a high-performance computer (HPC). The contractor shall create a comprehensive user guide to demonstrate how the optimisation was carried out to enable users to optimise future network models.

Objective(s)

This project shall focus on priorities that will improve the use of TOTEM in the short term, specifically the following objectives:

1. Direct Conversion: Implementing a 'Direct-Mapping' from PowerFactory XML bypassing the requirement for using PSS/E (which is how the existing TOTEM project was developed).

2. Simulation Speed Enhancement: Aiming to accelerate the simulation process, with goals set on achieving approximately 15 minutes for a 30-second run on a HPC.

Task breakdown:

Task 1: PSCAD Model Development
❖ Objective: To develop a comprehensive PSCAD model that accurately represents the Scottish Grid, incorporating both passive and dynamic network components.

- Network Mapping: Direct mapping from PowerFactory XML for constructing the PSCAD network model. The PowerFactory model may require simplification prior to XML conversion. DPL and/or Python scripts are likely required to be applied in PowerFactory to simplify the network details.

- Synchronous Machine Modelling: Development and incorporation of dynamic plant models (e.g., AVR, PSS, GOV) following validation against PowerFactory.

- Dynamic Plant Model Integration: Integration of vendor specific PSCAD models into the network, if available. In their absence, available generic models (i.e. WECC models) the substitution library to represent the dynamic models as necessary.

- Model Validation: Validation of the PSCAD model against the PowerFactory equivalent through load flow, short circuit analysis, and dynamic response simulations (requires a running PowerFactory dynamic model).

- Re-Dispatch Method: Enhancement of the model's flexibility to accommodate a range of future system scenarios through a two-step process: initially, the network model will be exported from PowerFactory as a .xml file and then expanded within PRSIM. To perform a re-dispatch, a new .xml file (exported from PowerFactory) reflecting updated system conditions, will be imported into PRSIM. This updated .xml file will serve as the basis for expanding the network model in PRSIM, which will be subsequently exported to PSCAD to ensure it aligns with the latest network conditions.

Task 2: Validation Studies
❖ Objective: To validate the PSCAD model by comparing it with the PowerFactory model, ensuring the accuracy of the conversion methodology.

- Model Validation: PowerFactory and PSCAD model validation under both steady-state and dynamic conditions.

Task 3: Technical Guide Development
❖ Objective: To produce a detailed technical guide and user manual that outlines the conversion process, presents findings, and offers guidance for updating the network models under different re-dispatch scenarios.

- Methodology Outline: Detailing the conversion methodologies, including any simplifications, and scripting approaches.

- Findings and Results: Including simulation results to demonstrate and validate the accuracy of the PSCAD model compared to the PowerFactory model.

- User Manual: Providing a manual that guides users on how to update the network models for varying conditions.

Task 4: Simulation Speed Optimization
❖ Objective: To improve the simulation speed of the Scottish network model, aiming for enhanced simulation time (the aim is for approximately 15 minutes for a 30-second run) on HPC platforms.

- Model Optimization Review: Assessment of the existing network model to identify and address bottlenecks and areas for speed enhancement.

- Network Optimization Strategies: Implementation of network splitting strategies for speed efficiency and testing overall speed.

- Technical Documentation: Production of a technical note that outlines the optimization process (mostly network splitting and/or identify slower dynamic plant models), providing insights and guidelines for applying similar enhancements to future network models.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

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, meaning that it does not have any effect on customers in vulnerable situations. This is because it is a Transmission project.

Success Criteria

The project will be deemed as successful if all items in the scope, objectives and learnings are met which can be used to increase the effectiveness of the use of the TOTEM toolset.

Project Partners and External Funding

The project will be undertaken using NIA funding by Scottish Hydro Electric Transmission.

Potential for New Learning

The outputs of this project include a comprehensive user manual to enable users to understand both how the tool functions and to apply the tool to re-dispatch network models and a second comprehensive user guide to demonstrate how the optimisation should be carried out to enable users to optimise future network models.

This tool will enable the build-up of a database of information on assets, with learning about interactions between power electronics and control interactions.

Learnings from the project will be disseminated via internal and external stakeholder event which will be conducted during the project. The learnings will also be shared within the annual project report and at relevant dissemination events such as the Energy Networks Summit Conference.

Scale of Project

This project is designed to get maximum learning for minimal cost. This scale of project expects to provide sufficient learning to further enhance the use of the TOTEM toolset on future Transmission projects. Any smaller scale project would limit the ability to fully assess the suitability of the proposed solution.

Technology Readiness at Start

TRL2 Invention and Research

Technology Readiness at End

TRL7 Inactive Commissioning

Geographical Area

The project will be undertaken in the Scottish Hydro Electric Transmission licence area in Scotland.

Revenue Allowed for the RIIO Settlement

No allowance has been made for this type of development within the RIIO-T2 settlement. No savings are expected during project implementation; future savings may be possible depending on the outcomes of the project and future adoption of the created design(s).

Indicative Total NIA Project Expenditure

The total expenditure expected from the project is £100,000. 90% of which £90,000 is allowable NIA expenditure.

Project Eligibility Assessment Part 1

There are slightly differing requirements for RIIO-1 and RIIO-2 NIA projects. This is noted in each case, with the requirement numbers listed for both where they differ (shown as RIIO-2 / RIIO-1).

Requirement 1

Facilitate the energy system transition and/or benefit consumers in vulnerable situations (Please complete sections 3.1.1 and 3.1.2 for RIIO-2 projects only)

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

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

The transition to renewable generation is increasing the number of power electronic devices being connected to the transmission network. The close proximity of the power electronic devices is expected to also cause additional controller interaction, which is still unknown at the present moment, the additional capabilities that will be developed through this project will support the management of controller interaction with the increased number of power electronics devices over the coming years. The benefits of the outcome of this project are system-wide and will allow for investigation of connections prior to them being made and the application of mitigation strategies to alleviate any control interactions. This has the potential to prevent outages in the network due to, for example, voltage collapse in that local area.

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

N/A

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 (RIIO-1 projects only)

N/A

Please provide a calculation of the expected benefits the Solution

The CBA is based on the following assumptions:

• TOTEM 2 is expected to mitigate network black out, localised disruption and small wobbles. Due to the difference in scale of events, associated cost and probability, the system risks are split to be assessed.
• The risk value of localised blackout is estimated based on historical events which happened in England in 2019 and Edinburgh in 2021, the associated probability was assigning based on risk matrix, and adjusted to 5% to reflect the potential benefit associated with TOTEM 2 only.
• The risk value of black start event in Scotland is considered and associated risk probability is also adjusted to reflect the benefit linked with TOTEM 2 only.
• For small wobbles, the risk value is estimated based on wind curtailment and the associated cost to pay for generators. Assuming the wind curtailment is 200GWh per year.
• The value of risk reduction is estimated based on the depreciation of a transformer, assuming the asset life is 45 years, and using this tool might require replacing the transformers 5 years in advance.

Summary of Benefits:

• The benefit of this project is estimated based on systematic risk reduction and working hours reduction as a result of using this tool. As a result of using this tool, there is a minor probability that assets might need to be replaced in advance which has been accounted into the risk value.
• The risk-benefit analysis result in the estimated benefit of this project is £1m in 2018 real price. However, due to the risk associated

with this project, a risk factor of 30% has been applied which results in the low-level benefits of £694,952.
• The project has net benefit cost ratio of £14.93 which means for £1 spending, it returns £14.93. Annualised ROI: 6.19%.

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

All GB Transmission owners can utilise the project outputs to enhance their existing network models.

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

The costs of rolling out the method across GB are dependent on the operation and geography of the rest of the GB network.

Requirement 3 / 1

Involve Research, Development or Demonstration

A RIIO-1 NIA Project 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

RIIO-2 Projects

☐ 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

Relevant network licensees can use the learning from this project as PSS/E will no longer be required to generate simulation models. The simulation speed will also be increased allowing more simulations to be completed faster.

Or, please describe what specific challenge identified in the Network Licensee's innovation strategy that is being addressed by the project (RIIO-1 only)

n/a

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.

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

SSEN Transmission is leading the way with this development. Currently, the only other network in the world with a similar tool and functionality is the Australian network operator AEMO. However, SSEN-T's version is more advanced with interconnections and radial connections modelled. This project builds on the previous NIA projects - NIA_SHET_0032 TOTEM and NIA_SHET_0035 TOTEM Extension.

If applicable, justify why you are undertaking a Project similar to those being carried out by any other Network Licensees.

N/A

Additional Governance And Document Upload

Please identify why the project is innovative and has not been tried before

The project is innovative as it will develop a new untrialled design which will be subjected to a product design validation process and is expected to provide a new solution to resolve an ongoing problem.

Relevant Foreground IPR

No new Foreground IPR will be generated as part of the project. Background IPR – each TO has provided details of their network.

Data Access Details

For information on how to request data gathered in the course of this project, see Strategic Innovation Fund (SIF) and Network Innovation Allowance (NIA) Data Sharing Procedure at https://www.ssen-transmission.co.uk/about-us/innovation/.

Additionally, data from this project and all other projects funded under the Network Innovation Allowance (NIA), Network Innovation Competition (NIC) or the Strategic Innovation Fund (SIF) can be found or requested in the ways listed below:

• Via the Smarter Networks Portal at: https://smarter.energynetworks.org. To contact select a project and click 'Contact Lead Network.' SSEN Transmission 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: Innovation - SSEN Transmission (ssen-transmission.co.uk)

• Via our managed mailbox: transmissioninnovation@sse.com

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

This new way of modelling the Transmission system, coupled with the different way of interoperating how the electrical system will flex, is in the development stages and still requires validation and testing. There are business risks associated with implementing a solution making it unlikely to secure business funding.

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

This project can only be undertaken with the support of NIA due to the overall costs and timescales required. There is also commercial risk that the project may not deliver the expected benefits. NIA is the best mechanism to fund development projects such as this.

This project has been approved by a senior member of staff

☑ Yes