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

Mar 2023

Project Reference Number

NIA2_NGESO046

Project Registration

Project Title

STARTZ (Stability Requirements Calculation Toward Net-Zero)

Project Reference Number

NIA2_NGESO046

Project Licensee(s)

National Energy System Operator

Project Start

March 2023

Project Duration

1 year and 6 months

Nominated Project Contact(s)

Tatiana Assis, Shurooque Baloch

Project Budget

£400,000.00

Summary

This project will review the current methods of calculating system stability needs and implement automation and machine learning to calculate system stability needs for the GB network at a granular level. This project will:

- Review the current methods of calculating system stability needs and identify areas of improvement.
- Perform the analysis on a sufficiently granular representation of the active and passive network components in the GB system.
- Apply automation and other necessary methods (machine learning) to manage additional computational burden of using detailed network representation.

Preceding Projects

NIA_NGSO0029 - Applications of convex optimisation to enhance National Grid's NOA process

NIA_NGSO0028 - Study of Advanced Modelling for Network Planning Under Uncertainty

NIA2_NGESO008 - Reactive Power Market Design

NIA_NGSO0036 - Probabilistic planning for stability constraints

Third Party Collaborators

TNEI Services Ltd

Nominated Contact Email Address(es)

box.so.innovation@nationalgrid.com

Problem Being Solved

The existing in-house developed tool to compute system stability needs (inertia, short circuit level) has limited interactions with detailed network models in the PowerFactory tool used widely in the Networks Options Assessment (NOA) and Electricity Ten Year Statement (ETYS) processes. The calculations are based on empirical formulas. For short circuit level, limited scenarios are studied in PowerFactory due to time and tools constraints. With the changing nature of the system, this approach may no longer be sufficient for future planning and more year-round analysis is required.

The current year-round analysis computes hourly generation and demand dispatches to identify the amount and the location of the stability services that need to be procured. These dispatches have a temporal variation which is captured through a time series analysis. The current tool is, however, unable to consider spatial uncertainty for inertia assessment, as the model is a lumped representation of the GB system.

Method(s)

This project, seeks to achieve three main objectives:

- Review the current methods of calculating system stability needs and identify areas of improvement.
- Perform the analysis on a sufficiently granular representation of the active and passive network components in the GB system.
- Apply automation and other necessary methods (machine learning) to manage additional computational burden of using detailed network representation.

These objectives will be achieved by breaking down the problem into smaller tasks. As an example, the inertia requirement of the system will be treated as a sub-problem. Not only the total amount of system inertia is directly connected to the frequency stability and robustness of the grid, but also its specific location, especially in low inertia systems. Considering the possibility of procuring inertia as a service, the fundamental question would be 'where to optimally place synthetic/rotational inertia in the system'. One approach to answer this question could be to calculate the electrical distance of all busbars from the Centre of Inertia (COI) of the system after a disturbance based on a Frequency Deviation Index (FDI). This would need to be repeated for every dispatch scenario. Based on the average improvement of the frequency nadir and RoCoF, a few locations can be identified where the system would benefit maximum from inertia services.

A similar approach can be adopted for short circuit level. Metrics like Weighted Short Circuit Ratio (WSCR), Composite Short Circuit Ratio (CSCR) and Equivalent Short Circuit Ratio (ESCR) with interaction Factors (SCRIF) can be used to identify the system strength at a particular location when there is a strong electrical coupling between nearby inverter-based resources. Repeating this process for several dispatch scenarios would provide a range of SCR and would provide an idea of the system needs.

The project will be delivered in three work packages:

- WP1 - Review of current methods
- WP2 – Apply Alternate Methods
- WP3 – Comparison with Existing Tool

<u>In line with the ENA's ENIP document, the risk rating is scored Low.</u>

- TRL Steps = 1 (2 TRL steps)
- Cost = 1 (£400k)
- Suppliers = 1 (1 supplier)
- Data Assumptions = 2
- Total = 5 (Low)

Scope

Decarbonisation is bringing technical challenges that include the management of potential stability issues caused by the reduction in inertia and short circuit levels. In order to overcome potential stability problems while keeping economic and secure operation, NOA Stability Pathfinder projects have been looking to find and procure alternative sources of stability support.

One key aspect to the NOA Stability Pathfinder project or any other future stability services procurement process is the calculation of future system stability needs. Overestimation or underestimation of system needs potentially represents, respectively, unnecessary costs for consumers or system vulnerability with increased risk of blackouts.
The current methodology to calculate the system stability needs is based on several assumptions, criteria and simplifications that should be revised and improved following network evolving and energy landscape transition. Also, since a number of future generation and demand dispatches are considered, a higher level of automation in the calculation process is required.

This project will review the current methods of calculating system stability and identify areas of improvement, performing the analysis on a sufficiently granular representation of the active and passive network components in the GB system. Bases on this analysis, It will apply automation and other necessary methods (machine learning) to manage additional computational burden of using detailed network representation.

Objective(s)

The existing tool to compute system needs is a standalone process and is not integrated with any of the NOA tools or ETYS models. The calculations are based on empirical formulas. At the same time, the year-round analysis computes hourly generation and demand dispatches to identify the amount and the location of the services that need to be procured. These dispatches have a temporal variation which is captured through a time series analysis. The current tool is, however, not able to consider spatial uncertainty for inertia assessment, as the model is a lumped representation of the GB system. This project, therefore, seeks to achieve three main objectives:

1. Review the current methods of calculating system stability needs and identify areas of improvement.
2. Perform the analysis on a sufficiently granular representation of the active and passive network components in the GB system.
3. Implement automation and other necessary methods (machine learning) to manage additional computational burden of using detailed network representation.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

The ESO does not have a direct connection to consumers, and therefore is unable to differentiate the impact on consumers and those in vulnerable situations. Benefits to all consumers are detailed below.

Success Criteria

The project will be considered successful if the following criteria are met:

- Creation of an improved methodology and associated new tools which will interface with the detailed DIgSILENT Powerfactory model of the GB system to allow year-round calculating of system stability needs.
- Development of the ability to perform granular calculations of year-round system stability needs by implementing a set of automation and machine learning techniques.
- Validation of the new tool’s output against accurate outputs from DIgSILENT Powerfactory and the measured values from ESO operation.
- Dissemination and training for learnings and tools developed in the project.

Project Partners and External Funding

TNEI will be carrying out the work. No external funding.

Potential for New Learning

The project will generate a significant understanding of the energy transition impact one stability-related requirements under different future energy scenarios (FES). The application of automation and machine learning techniques will enable the extension of the analysis considering different generation and demand conditions with a feasible computational process time. A significant impediment to an exhaustive search of potential scenarios of concern regarding the system stability is the inherent quantity of possible conditions and the associated computation required.

This project will also build on the learnings that have been gathered from other innovation projects in the area of stability, probabilistic modelling, forecasting and machine learning techniques. These projects have dealt with analysing a large number of scenarios and the methods adopted will provide a springboard to explore further scenario clustering and reduction techniques, which can be extremely relevant in this new development.

Scale of Project

The project spans 18 months with one project partner. The project consists of desk-based research and workshops with the relevant

ESO teams (including network and wider teams).

Technology Readiness at Start

TRL3 Proof of Concept

Technology Readiness at End

TRL5 Pilot Scale

Geographical Area

This project will be based upon the GB ESO area of operations.

Revenue Allowed for the RIIO Settlement

None

Indicative Total NIA Project Expenditure

£400,000

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 project will directly facilitate the energy transition as it will improve the calculation of system requirements in terms of stability; this an essential parameter to allow the integration of renewable generation onto the GB network. By understanding more accurately stability needs, it is possible to anticipate the technical solutions that will guarantee the system operates in a reliable and safe way, facilitating the transition to a zero carbon energy system while keeping the lights on.

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

Not required as this is a research project.

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

The project will aim to study the entire GB transmission system and the tools developed can be used across individual regions when relevant.

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

The cost of rolling out the method consists of the software license and the required hardware upgrades only, this is estimated to be £100k.

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

The learnings from this project can also be beneficial to Transmission Owners (TOs) concerning sub synchronous oscillation (SSO) identification in future connections and network development studies. The TOs use the same EMT software package, and the developed tool should integrate with their models seamlessly.

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.

We are aware of several other innovation projects that are now in delivery or recently completed, that will complement the work proposed here. Some of the projects are –

- **Applications of convex optimisation to enhance National Grid’s NOA process:** the project developed an optimisation tool (based on OATS – Optimisation and Analysis Toolbox for Power Systems) using new advancements in mathematical and computational techniques to enable year-round assessment of reactive power requirements in the GB system to comply with planning voltage standards for a given future network.
- **Study of Advanced Modelling for Network Planning Under Uncertainty:** the project identified potential alternatives for new planning methodologies and developed a tool to perform Least Worst Weighted Regret analysis for the NOA process.
- **Reactive Power Market Design:** The project delivered a reactive power market framework to lay the foundation for ESO to procure market-based solutions for voltage management in future networks.
- **Probabilistic planning for stability constraints:** TNEI has recently delivered this innovation project and has worked extensively with the ETYS model. Several automation features were developed to interface with the DIgSILENT model and a machine learning tool was developed to reduce computational time for year-round analysis. We have engaged with the various project teams and will continue to have regular catchups to share learnings throughout the project's progression.

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 will integrate automation and machine learning in calculation of system stability requirements and allow granular analysis of more scenarios in DigSILENT Powerfactory. It will be the first time that the GB system stability needs could be calculated at a granular level considering the existing and potential network changes and different year-round conditions.

In addition, the proposed approach is a collection of several advanced techniques. The individual techniques have been researched in academia for different applications and this project will look to utilise a combination of these techniques/methods for a particular application, i.e., system stability needs assessment. This has not been tried before in the GB system.

Relevant Foreground IPR

The following foreground IPR is expected to be generated in the course of the project:

- An improved methodology and associated new tools which will interface with the detailed DIgSILENT Powerfactory model of the GB system to allow year-round calculating of system stability needs.
- Training materials for learnings and tools developed in the project.

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:

1. 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 ESO already publishes much of the data arising from our innovation projects here so you may wish to check this website before making an application.
2. Via our Innovation website at https://www.nationalgrideso.com/future-energy/innovation
3. Via our managed mailbox innovation@nationalgrideso.com

Details on the terms on which such data will be made available by National Grid ESO can be found in our publicly available "Data sharing policy relating to NIC/NIA projects" at https://www.nationalgrideso.com/document/168191/download.

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

Due to the nature of the project and that it is researching potential future impacts to the grid based largely on assumptions, this does not fall into current business as usual (BAU).

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 project is in a complex area of power systems, and the TRL of the overall framework is low. Therefore, innovation funding is more suitable for exploring the project's potential and increasing the TRL before transferring into BAU activities.
- The methods are novel and have not yet been trialled on real networks.
- There are potential risks associated with the availability of required data and the acceptable performance of the methods.
- Standard procedures may also need to change to integrate the developed tool.
- Consideration of the practicality of the runtime and the need for high computational resources.
- There are risks associated with acceptable performance of the methods when applied to the detailed GB network model.

This project has been approved by a senior member of staff

☑ Yes