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 2022

Project Reference Number

NIA2_NGESO017

Project Registration

Project Title

Probabilistic planning for stability constraints

Project Reference Number

NIA2_NGESO017

Project Licensee(s)

National Energy System Operator

Project Start

January 2022

Project Duration

1 year and 7 months

Nominated Project Contact(s)

Sami Abdelrahman

Project Budget

£382,000.00

Summary

Continuation of the RIIO1 project - NIA_NGSO0036.

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.

Preceding Projects

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

Due to decline in traditional synchronous generators and increase in converter-based generation, the transmission system is expected to see more localised stability issues which are expected to drive costs on the networks in the future. Currently, National Grid Electricity System Operator (ESO) undertakes stability studies with focus on areas with known issues of stability or anticipated issues based on Future Energy Scenarios (FES) projection. The power system modelling tools and techniques that are currently used for stability studies are time consuming.

Due to this, it is not practical to study a wide range of network and generation background scenarios that reflect all the possible sources of uncertainty (e.g. interconnector flows) and variability (e.g. wind speeds) that can affect the network condition, or to assess every boundary in the system. This could mean that, in the future, ESO could overestimate or underestimate boundary transfer capability, where there are unforeseen stability issues, leading to higher and potentially inefficient constraint costs.

Method(s)

This project will be completed across four work packages.

1. WP1: Initiation & Review.
2. WP2: Development & Reduced-scale Testing.
3. WP3: Trialling on Full GB Model.
4. WP4: Future Roadmap & Plan for Implementation

Risk Assessment
In line with the ENA's ENIP document section 3.2, the risk rating is mostly scored Low (Score 1).

TRL Steps = Score 2 (four TRL step from 3 to 7)
Cost = Score 1 (£385,000)
Suppliers = Score 1 (one supplier contracted)
Data Assumption = Score 2 (scope known but will be refined during the project and appropriate standards and guidance will be identified during the project)

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.

Objective(s)

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.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

This project has been assessed as having a neutral impact on customers in vulnerable situations. This is due to the project being a transmission project.

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.

Project Partners and External Funding

The work will be undertaken by TNEIServices Ltd
There is no external funding.

Potential for New Learning

System stability

- Improve our understanding of how the system behaves with lower levels of inertia

Constraint management

- Explore sophisticated new tools and techniques for forecasting constraints of all types and in different scenarios of supply and demand
- Develop new tools and processes for decision making under uncertainty

The new learning will improve the ESO capabilities to better evaluate stability constraints in the annual GB transmission network long term planning.

Scale of Project

The project is desk-based.

Technology Readiness at Start

TRL3 Proof of Concept

Technology Readiness at End

TRL7 Inactive Commissioning

Geographical Area

The project activities will be desk based on the GB ESO area.

Revenue Allowed for the RIIO Settlement

None.

Indicative Total NIA Project Expenditure

£232,000 was spent under the RIIO1 NIA_NGSOO0036 project.

Network Innovation Allowance expenditure for this RIIO2 funded project: £150,000.

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:

Due to decline in traditional synchronous generators and increase in converter-based generation, the transmission system is expected to see more localised stability issues which are expected to drive costs on the networks as the energy system transitions to a zero carbon future. 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).

The power system modelling tools and techniques that are currently used for stability studies are time consuming, and not practical to study a wide range of network and generation background scenarios that can affect the network condition, or to assess every boundary in the system. This could mean that, in the future, ESO could overestimate or underestimate boundary transfer capability, where there are unforeseen stability issues, leading to higher and potentially inefficient constraint costs.

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

Not required.

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)

Proactive optimal decision making will help prevent future inefficient constraint cost. As an example, in 2019 the ESO spent ~£200m on RoCoF constraints. A 1% saving in a cost of this magnitude would mean >£10m NPV over 10 years. This project will help to assess the benefits more robustly.

Please provide a calculation of the expected benefits the Solution

The 1% saving quoted in the section above is an estimate based on the assumption the improved evaluation of stability will allow ESO to improve the network option selection which in turn reduce future constraint costs. These savings would be realised by Network companies and are difficult for the ESO to quantify, the example above indicates that even a small improvement in constraint costs would have a significant financial benefit.

More accurate estimates could be calculated by the ESO, by comparing the annual NOA CBA results of the improved NOA decisions after applying the enhanced stability analysis in the NOA 2021/22.

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

The project aims to deliver an efficient probabilistic stability assessment methodology/ies and tools that could provide improved outputs for all relevant ESO processes (e.g. NOA, stability pathfinder, other NIAs/NICs, etc). The tools can also utilized by TOs to evaluate stability in their networks.

It will be implemented by the ESO to improve the 2022 NOA process, which will inform system-wide investment decisions.

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

The project will identify and compare a number of probabilistic stability methodologies with different associated levels of cost (due to e.g. computational resource, time resource, data inputs etc) and accuracy, and develop, test and trial the most promising. As some of the project deliverables are software tools, a minor roll out cost might be needed, e.g. to increase hardware capabilities.

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

Not required.

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

This project fits against the following strategic priority areas as identified by the ESO in its Innovation Strategy published March 2020:

System stability

- Improve our understanding of how the system behaves with lower levels of inertia

Constraint management

- Explore sophisticated new tools and techniques for forecasting constraints of all types and in different scenarios of supply and demand
- Develop new tools and processes for decision making under uncertainty

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.

The following relevant academic work exists:

- Efficient statistical techniques applied to large and small disturbance stability assessment, probabilistic load flow analysis
- Screening of uncertain parameters based on sensitivity analysis applied to load classification, generator ranking, voltage stability assessment etc.
- Risk quantification of uncertain parameters affecting system operation
- Probabilistic modelling of demand and generation uncertainty

This project would look to build on the academic research in this area to develop a single model that addresses the challenges associated with year-round stability assessment across all the boundaries.

Existing implementations are mostly on small test networks. This project would look into applying these techniques on a real system. A selected set of techniques from the literature will be compared to assess their suitability in terms of accuracy, complexity, data requirements and computational burden when applied to a large network and within the context of the NOA process requirements.

Existing ESO probabilistic tools and stability assessment processes will be considered in the development of new models/tools for this project. The project will build on the learning from the following ESO pathfinders and existing NIA:

- Probabilistic analysis pathfinder
- Stability pathfinder – Phase 1
- Advanced Modelling for Network Planning Under Uncertainty NIA project
- Applications of convex optimisation to enhance National Grid's NOA process NIA 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 will explore multiple novel methods for improving probabilistic stability assessments, with the most efficient one/s being considered for the final model to be tested on a large network and then integrated into the NOA process. We have identified other innovation projects that are being undertaken in related areas including probabilistic assessment of voltage in the NOA, short term forecasting of frequency stability, and new stability analysis techniques being explored through the Phoenix NIC project. However, probabilistic analysis of stability for network planning is a gap that this project intends to explore. Another unique benefit is that among the methods considered, we will look at techniques from data science and machine learning, which gives the ESO an opportunity to enhance its capabilities in these areas.

Relevant Foreground IPR

The following Foreground IPR will be generated from the project:

1. 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)
2. reports detailing the development and demonstration of these methods
3. results from the models that are suitable for sharing with third parties (i.e. in NOA and ETYS publications)
4. a roadmap and evidence for further future development.

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

This project will explore multiple novel methods for improving probabilistic stability assessments, which is outside the scope of BAU funding available to improve the NOA process and is a higher-risk activity which isn’t guaranteed to be successful.

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

There is a technical risk that none of the novel methods are feasible due to complexity, insufficient accuracy and computation time. However, the learnings from the project on probabilistic methods would still be useful for future innovation studies across all networks.

This project has been approved by a senior member of staff

☑ Yes