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

Dec 2024

Project Reference Number

NIA2_NESO088

Project Registration

Project Title

GFM Interaction

Project Reference Number

NIA2_NESO088

Project Licensee(s)

National Energy System Operator

Project Start

January 2025

Project Duration

1 year and 6 months

Nominated Project Contact(s)

innovation@nationalenergyso.com

Project Budget

£420,000.00

Summary

By 2030, a significant level of Inverter Based Resources (IBRs) will be installed in the GB transmission system. Grid forming control (GFM) of power electronic converters, which emulate synchronous generators, is an effective approach to address low inertia and fault level challenges in systems with high IBR penetration. GFM converters operate as internal voltage sources, mimicking traditional synchronous generators. However, the rollout of GFMs in the GB network may cause negative interactions with Grid Following (GFL) and Synchronous Generators. This project will analyze these interactions, especially those newly introduced by GFMs, and provide analytical methods and guidelines to mitigate potential risks, contributing to NESO's policy and strategy for GFM implementation.

Nominated Contact Email Address(es)

box.so.innovation@nationalgrid.com

Problem Being Solved

As Grid-forming (GFM) converters increasingly support the network, the likelihood of potential negative interaction risks, either between GFM's or caused by them, is expected to rise.
Key problems to address:

- **Interaction Limitations:** Identify the limitations in system performance and stability as the penetration levels of GFM-based converters continue to increase.
- **Analysis Methodology**: Develop a robust analytical method to identify and evaluate potential negative interactions between GFM converters.

- **Mitigation Guidelines:** Deliver a comprehensive analysis procedure to prevent and mitigate negative interactions related to GFM deployment

Method(s)

The project will be delivered in three work packages, over a period of 18 months:
WP1: Assessing the differences between the traditional synchronous generators and GFLs & GFMs, and establishing test systems for the interaction studies – model studies (4 months)
WP2: Development of analysis method and tool using Electromagnetic transient (EMT) studies and measurement-based approach to identify the fundamental system oscillation risks and investigate the interactions between GFMs, GFL and the GB electricity grid and the interactions between local GFMs. The project will investigate (a) the potential root cause of such interactions; (b) the impact of System Strength; (c) impact of system topology; (d) whether the interaction is sensitive to System Events (8 months)
WP3: Analysis approach will be investigated to coordinate the controls of GFM based plants so as toto mitigate the interaction risks. Guidelines and insights for minimising interaction risks will be provided and fed into future grid code development for GFM applications (6 months)
In line with the ENA's ENIP document, the risk rating is scored Low.
TRL Steps = 1
Cost = 1 (£398.5k)
Suppliers = 1 (1 supplier)
Data Assumptions = 1 (low)
Total = 4 (Low)

Scope

The project will develop methods to gain a fundamental understanding of the interactions between Grid-Forming (GFM) inverters, Grid-Following (GFL) inverters, and synchronous generators, particularly focusing on newly introduced interactions by GFMs.
It will also create analytical methods and guidelines to avoid potential negative interaction risks between Inverter-Based Resources (IBRs), supporting NESO's policy and strategy for the rollout of GFM technology.

Objective(s)

The project objectives are to:

- Assess the differences between the traditional synchronous generators and GFLs & GFMs from the perspective of interactions, and establishing test systems for the interaction studies
- Develop the analysis and testing method and tool using EMT and measurements-based approach to identify the interaction risks between GFMs, GFLs and the GB electricity grid and the interactions between local GFMs.
- Investigate the approach to coordinating the controls of GFM based plants to mitigate the interaction risks. Guidelines and insights for minimising interaction risks will be provided and fed into future grid code development for GFM applications.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

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

Success Criteria

The project can be deemed a success if the following criteria are met:

- Development of analysis and testing method and tool using EMT studies and measurement-based approach to identify the interaction risks between GFMs, GFLs and the GB electricity grid and the interactions between local GFMs.
- Guidelines and insights for minimising interaction risks will be created and integrated into future grid code development for GFM applications to support the rolling out of GFMs.
- Delivery of analysis, testing method, guidelines and insights for future GFM compliance procedure

Project Partners and External Funding

University of Birmingham will be carrying out the work over an 18-month period. No external funding is required.

Potential for New Learning

The main findings will help influence key internal stakeholders from NESO's Networks, Markets, Strategy and Regulation as well as external stakeholders (e.g. GB TOs, Developers, and OEMs) to define/update relevant industrial codes for future massive roll-outs of GB Grid Forming applications based on:

- Verbal/written communications for purpose of project progress reporting;

- This project's own knowledge dissemination events for wider internal/external stakeholders;
- Knowledge sharing in global/regional industrial forums e.g. The Global Power System Transformation (G-PST) Consortium was, International Council on Large Electric Systems (CIGRE).

The learning will be also captured as appropriate into Technical Report in public version and conference/journal papers for wider awareness and knowledge sharing.

Scale of Project

The project spans 18 months with 1 project partner. The project consists of desk-based research, stakeholder engagement with various network licensees and international TO's. At the end of each work package, internal dissemination events will be held to ensure that the results align with the wider business.

Technology Readiness at Start

TRL3 Proof of Concept

Technology Readiness at End

TRL5 Pilot Scale

Geographical Area

The project will be conducted in the UK.

Revenue Allowed for the RIIO Settlement

None

Indicative Total NIA Project Expenditure

£420,000

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 outputs of the project may support the large-scale deployment of emerging Grid Forming applications in GB by reducing the risks of negative interactions between GFMs, GFLs and synchronous generators. This project can bring potential positive outcomes for high penetration and event dominance of inverter-base resources for renewable energy which will support NESO to accelerate the net zero energy transition in GB energy system.

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 applicable as this is a research project

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

The methodology and tools developed through this project should be further refined and validated in alignment with practical business cases within the GB market.
Following completion of the project, we anticipate undertaking the following activities:
Dissemination of key findings from the project to inform and influence internal stakeholders, co-shaping suitable business models and relevant industry codes for emerging GB GFM applications within the nascent market.
Engagement in consultations with external stakeholders in the GB GFM value chain to raise awareness and gather feedback on NESO's future plans for designing business models and grid industry codes relating to the GB GFM markets under consideration.
The subsequent internal stakeholders will be engaged when looking at implementing the project findings into BAU:
Network Operability – Policy
Networks Operability – Operability Product
External stakeholders across the GFM-related value chain including but not limited to GBTOs, GFM developers/manufacturers, Academia, industrial forums e.g., G-PST, CIGRE and ENTSO-E.

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

It is not anticipated that there would be a cost of rolling out the method across GB.

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 learning in the format of project progress/final reports in appropriate version can be circulated to relevant Network Licenses (RNL) for purpose of awareness and guidance.
The RNLs will be also invited for knowledge dissemination events at different stages of this project for knowledge sharing purpose.
As some RNLs could be important players in the value chain of GB Grid Forming markets, following project learning, further collaboration and communications could be also considered for NESO's consultation purpose e.g. Industrial Code modification and other relevant activities to co-push forwards GB Grid Forming developments

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.

The negative interaction between GFM based converters has never been analysed from previous projects. All the other projects related to GFMs are based on their connections and installations. However, with the penetration level of GFM based converters increasing, there is a crucial need to understand and prevent such negative interaction risks. The outcomes of this project will directly influence all the relevant Network Licenses and wider external stakeholders in the format of NESO's industrial code change/update. Hence, further communications and engagements with them will be implemented for knowledge sharing and change management purposes. In this way, no unnecessary duplication would occur as a result of this project.

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 negative interaction between GFM based converters has never been analysed from previous projects.
- This project will provide analysis/testing approach and guidelines to avoid the negative interaction risks between GFMs to support the rolling out of GFM converters in GB Electricity Grid.
- Without root cause understanding and proper analysis and testing tools assessing the GFM interactions risks, there will be major concerns when planning and operating the network in higher penetration level GFMs.

Relevant Foreground IPR

- Technical Reports related to understanding and mitigation solutions of GFM interactions;
- Any related models & code and simulations of GFM interaction
- Technical Codes
- Future Stability Pathfinder requirements.

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’. NESO 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 Innovation | National Energy System Operator (neso.energy)
3. Via our managed mailbox innovation@nationalenergyso.com

Details on the terms on which such data will be made available by National Energy System Operator can be found in our publicly available “Data sharing policy relating to NIC/NIA projects” at https://www.neso.energy/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 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

- There are increased risks associated with the availability of required data and a high level of assumptions, which makes this project better suited to NIA.
- The TRL of the overall framework is relatively low. Therefore, innovation funding is more suitable for exploring the project's potential and increasing the TRL before transferring into BAU activities.
- Conducting this project with NIA funding will ensure that the project findings can be shared more widely with other interested network licensees.

This project has been approved by a senior member of staff

☑ Yes