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

May 2025

Project Reference Number

NIA2_NESO111

Project Registration

Project Title

Operational Application of Inertia Measurement Techniques

Project Reference Number

NIA2_NESO111

Project Licensee(s)

National Energy System Operator

Project Start

May 2025

Project Duration

1 year and 1 month

Nominated Project Contact(s)

Innovation@neso.energy

Project Budget

£344,000.00

Summary

Building on the Inertia Measurement Method Optimisation project (NIA2_NGESO023) which concluded in September 2024 and focused on developing a methodology to validate the accuracy of inertia measurements, this next phase will establish a methodology to incorporate the real-time measured inertia into operational techniques.

The phase will also continue analysis to include data that was not available during the original project timeline, enabling continued assessment of the accuracy of real-time commercial systems.

Preceding Projects

NIA2_NGESO023 - Inertia Measurement Method Optimisation

Third Party Collaborators

National Physical Laboratory

Nominated Contact Email Address(es)

box.so.innovation@nationalgrid.com

Problem Being Solved

The decarbonisation of the GB energy landscape is resulting in a decrease in inertia, resulting in additional spend on managing RoCoF. As conventional generation closes and is replaced by asynchronous plant, the percentage of residual inertia (that provided from distribution connection sources) is increasing. The inertia from synchronous plant is easy to specify, however the residual inertia contribution is less transparent to the NESO.

The ability to measure real-time inertia is needed to enable both the synchronous and residual inertia to be known, resulting in improved knowledge and better-informed decision making. More accurate inertia values, especially against different generation and demand use cases will reduce the risk of the system running insecure.

Method(s)

This project will be delivered through the following Work Packages (WP):

WP1: Analysis and comparison of inertia measurements from commercial systems

In this work package, data from commercial inertia measurement systems continuously collected over periods of months/year will be analysed and compared.

· Task 1.1 will consider regional inertia measurements

· Task 1.2 will consider GB whole system inertia measurements.

Data will also be compared with the inertia estimate calculated by NESO based on the inertia contribution of the synchronous generators connected at each period and estimated residual inertia. The results enabled a comprehensive validation of the plausibility of measured inertia data based on known transmission-connected inertia sources and NESO's operational experience.

The analysis and comparison will include quantifying differences and correlations between inertia measurements and estimations, calculating representative statistics, quantifying the variation of differences over time, calculating correlation to known influencing factors, including generation mix and demand scenarios. The analysis will also consider residual inertia as well as the extent of variation of measured inertia over short timescales (hours) will also be quantified.

The results from this work package will be compared with those from the previous project NIA2_NGESO023 to identify any changes in the performance of commercial systems and estimation method.

WP2: Development of a method to derive actionable information from inertia measurements

In this work package, a method will be developed to assess the plausibility of real-time inertia measurements and to provide a confidence metric which can be interpreted to facilitate operational decision making for inertia management. This method will be available to assess inertia data continuously to complement event-based field measurement verification.

- Firstly, information on control room requirements for operational decision-making based on inertia monitoring will be gathered to define the most useful output from the method (Task 2.1).
- Historical inertia data will be studied to define and evaluate relevant features (Task 2.2), e.g. relating to variation with time.
- That will form the basis for defining criteria to classify feasible vs potentially abnormal values (Task 2.3). This work will build on insights and results gained from analysis of inertia data in previous project NIA2_NGESO023.
- Based on the identified features and feasibility criteria, a selection of advanced data analytic techniques including machine learning will be trained and tested, with uncertainty quantification, to identify which approach has the best performance and lower uncertainty (Task 2.4).
- The selected method will be implemented as a proof-of-concept tool to demonstrate operational use of results for inertia management, and the related uncertainties will be reported. Based on the uncertainties, possible grid actions will be suggested (Task 2.5).

WP3: Event-based analysis and verification using field measurements

This work package will extend the verification of inertia measurements from commercial systems and NESO's estimate building on the methodology developed in previous project NIA2_NGESO023.

- Firstly, the verification method will be applied using NPL RoCoF measurements from additional frequency events whereby the RoCoF predicted from the inertia values is compared with the measured reference value (Task 3.1).
- Data from additional events and measurement locations will increase the statistical robustness of previous accuracy results. The verification method will also be adapted to utilise frequency/RoCoF measurements from existing PMUs to include measurements from additional grid locations and to lay the foundation for event-based verification beyond the duration of the innovation project (Task 3.2).
- In addition to frequency events published in the GC0105 System Incidents report, use of additional interconnector related frequency

changes will also be investigated to further increase the set of verification cases (Task 3.3).

Data Quality Statement

The project will use inertia measurement data from commercial systems, inertia estimations from NESO, historical data on wind generation, demand and embedded generation estimates from NESO, frequency measurements from NPL instruments and from existing PMUs, GC0105 system incident reports, and information on interconnector-related frequency changes. All data will be pre-processed to check for missing and inconsistent values and quality flags indicating invalid data. Particular attention will be paid to ensure alignment of timestamps considering local vs UTC time zones and BST clock changes. All documents that contain results will clearly specify the input data sources including date ranges. References to publicly available data sets will be included.

Measurement Quality Statement

Available confidence intervals from the commercial inertia measurement systems will be used in the WP1 comparison tasks when assessing the level of agreement between measurements and inertia estimates. This confidence data will also be used in the WP3 event-based verification tasks to assess agreement with reference RoCoF values, in addition to the measurement uncertainty from NPL instruments, existing PMUs, uncertainty due to limited time resolution of inertia measurements/estimations, uncertainty in power imbalance measurements and uncertainty due to the empirical nature of the algorithm for reference RoCoF determination. The uncertainty of measurements from NPL instruments is obtained from in-house calibrations against national standards of AC voltage and current. Uncertainty of existing PMUs will derive from commercial instrument specifications and the PMU standard C37.118.

In line with the ENA's ENIP document, the risk rating is scored **Low.**

TRL Steps = 1 (2 TRL Steps)

Cost = 1 (£344k)

Suppliers = 1 (1 supplier)

Data Assumptions = 1 (Low)

Total = 4 (Low)

Scope

This project will build on previous work to calculate synchronous and residual inertia. It will explore methodologies for measurement and calculation, considering two previously investigated commercial tools.

Based on the methodologies for measurement and calculation, project aims to deliver a proof-of-concept model to test the selected methodology for operational decision-making, while continuing to validate the output data from the two tools.

Not in scope for the project:

- Installation of additional PMUs by the TOs, extending the availability of real-time inertia data
- Productionising Proof of Concept (PoC) into the internal activities and running of the business.

Objective(s)

The objectives that are expected to be achieved are:

- Establish methodology to incorporate real-time inertia measurement and associated confidence intervals into operational decision-making tools
- Develop and document a proof-of-concept using this methodology.
- Assess the accuracy of regional inertia measurements using the analysis techniques developed for GB inertia comparisons
- Continue event based (RoCoF) verification using NPL measurement devices and algorithms
- Explore the expansion of the NPL algorithms to apply to RoCoF measurements of existing TO installed PMUs (Phasor Measurement Units)

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

Does not affect vulnerable customers

Success Criteria

The success criteria include:

- The project delivers against objectives, timescales and budgets as defined in the proposal.
- Proof-of-concept is implemented to incorporate real-time inertia measurements into operational decision making.
- Deeper understanding of system event-based analysis using the Empirical Mode Decomposition (EMD) method developed by NPL.
- Investigate expanding the Empirical Mode Decomposition method for RoCoF measurement to apply it to PMUs already installed on the electricity transmission system.

Project Partners and External Funding

National Physical Laboratory (NPL) are the supplier on this project and are contributing an additional £235k from their National Measurement System funding.

Potential for New Learning

- The accuracy of different innovative inertia monitoring tools including comparisons of regional values
- How inertia measurements and associated confidence intervals from the inertia monitoring tools will indicate plausible values and demonstrate how inertia measurements can be incorporated into operational decisions.
- The application of RoCoF measurement methodology to already installed PMUs.
- Relevant information will be shared in the final report and available on ENA Smarter network Portal

Scale of Project

Work will be carried out within NPL over a 12-month period using NESO through a combination of comparison of measurement, operational data, model simulation and specific site measurements made by NPL devices installed at key locations across the network.

Technology Readiness at Start

TRL4 Bench Scale Research

Technology Readiness at End

TRL6 Large Scale

Geographical Area

Will be based upon the NESO area of operations.

Revenue Allowed for the RIIO Settlement

None

Indicative Total NIA Project Expenditure

£344,000

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 decarbonisation of the GB energy landscape is resulting in a decrease in inertia and additional spend on managing RoCoF. As conventional generation closes and is replaced by asynchronous plant, the percentage of residual inertia (that provided from distribution connection sources) is increasing. The inertia from synchronous plant is easy to specify, however the residual inertia contribution is less transparent to the National Energy System Operator.

This project will provide further verification of real-time inertia measurements from two commercial tools, to determine their feasibility will enable both the synchronous and residual inertia to be known. In addition, developing and testing a methodology to apply inertia measurements in real-time, will result in improved knowledge and better-informed operational decision making. More accurate inertia values, especially against different generation and demand use cases, will reduce the risk of the system running insecure.

Managing RoCoF as a result of low inertia is costing approximately £200m per year, a more accurate measurement could result in a reduction in these costs and provide added transparency to decision making.

Improved measurement and forecasting capability will be able to feed into strategic and/or policy modelling (e.g. stability pathfinder and frequency response assessments), helping to define electricity system requirements, and potentially enable the future despatch of inertia services.

One of the key project outputs is extensive demonstration of a novel methodology for verification of inertia measurement systems and application of this methodology using conventional PMU measurements. The project team is working to include this method as part of a standardised framework for inertia management in power system, by liaising with CIGRE WG C2.45 and with the International Electrotechnical Committee (IEC).

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 method will use data from PMUs installed in the GB network, the outputs, reports, and process could be replicated for other regions subject to available tools and data.

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

At this stage the costs are unknown for rolling out foundation learning into further development.

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 project will outline new methods for evaluating the calculation of residual and synchronous inertia, which other network licensees may be able to use in their relevant operations.

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.

This project builds on a strong foundation of previous work, including Inertia Measurement Method Optimisation (NIA2_NGESO023) which looked into changing residual inertia in the GB electricity system, and was done in parallel with GB Inertia Forecasting with Regional Extrapolation (NIA2_NGESO048), which took a regional approach to inertia measurements with the use of Power Measurement Units (PMUs) and explored the possibility of developing a forecasting model to predict the inertia for the GB grid. GB Inertia Forecasting developed enhancements to area inertia forecasting but did not show successful extrapolation of results across the GB system. This project hopes to develop the methodology for this.

This current project builds on those, taking the learnings achieved by them to establish a methodology to incorporate the real-time measured inertia into operational techniques.

Inertia monitoring products have also been explored through:

- Reactive Technologies – SAMUEL & Project SIM NIA projects (NIA_NGET0119 & NIA_NGET0192)
- GE – MIGRATE European project WP2 (Massive InteGRATion of power Electronic devices | MIGRATE | Projekt | Results | H2020 | CORDIS | European Commission)
- Imperial College – Short term System Inertia Forecast (NIA_NGSO0020)

To date, multiple solutions have been implemented to address the challenges of decreasing inertia and rising RoCoF costs, these include:

- Stability Pathfinder Phases 1 & 2
- Accelerated Loss of Mains Protection (AcLoMP)
- Updated risk assessments via the Frequency Risk and Control Report (FRCR)

However critical gaps remain: the real-time understanding and forecasting of system inertia. This project aims to fill that gap by creating a standardised, accurate and operationally approved methodology.

Finally, as both measurement systems are first-of-their-kind operational installations, this project will enable them to help set the future for the industry and establish a standardised methodology for measurement and instrumentation.

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

Previous projects have concentrated on methods to validate spot values of inertia values, however Inertia Measurement Method Optimisation project (NIA2_NGESO023), showed there are significant short-term variations in the spot values from the two commercial systems. This project is looking to understand how inertia measurements and associated confidence intervals will indicate plausible real-time inertia values and how they can be incorporated into operational decisions in a timely manner. This is a new approach, involving the use of ML and AI.

The NPL developed EMD methodology to analyses Rate of Change of Frequency (RoCoF) has been designed to apply to NPL specific Phasor Measurement Units (PMUs). To utilise this across a wider range of sites, the project is looking to apply the methodology to data from existing, installed PMUs.

Relevant Foreground IPR

The following Foreground IPR will be generated from the project:

- Final report on the results of WP1.
- Final report on the results of WP2.
- Final report on the results of WP3.

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 Energy System Operator 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.neso.energy/about/innovation

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.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 using new tools and methodologies to apply the data from these new tools, this does not fall into current 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 TRL of the project is relatively low. Therefore, innovation funding is more suitable for exploring the project’s potential and increasing the TRL before transferring into subsequent development.
- Conducting this project with NIA funding will ensure that the project findings can be shared more widely with other interested Network Licenses.
- 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.

This project has been approved by a senior member of staff

☑ Yes