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

Sep 2022

Project Reference Number

NIA2_NGESO023

Project Registration

Project Title

Inertia Measurement Method Optimisation

Project Reference Number

NIA2_NGESO023

Project Licensee(s)

National Energy System Operator

Project Start

September 2022

Project Duration

2 years and 1 month

Nominated Project Contact(s)

Anna Blackwell

Project Budget

£371,000.00

Summary

Changing generation is resulting in lower system inertia and increasing costs, with residual inertia making up a larger percentage of the total system inertia. The ability to measure real-time inertia will enable both synchronous and residual inertia to be known, improving decision making and reducing the risk of the system running insecure. There is currently no best practice or standardisation for measuring system inertia. This project will analyse and verify data from new commercial inertia monitoring tools and compare to NGESO operational data, establishing different generation and demand scenarios for inertia and Rate of Change of Frequency (RoCoF). Through development of measurement parameters and specifications for reference instrumentation, the project will build on existing data and use cases with the goal to establish standardisation for inertia measurement.

Preceding Projects

NIA_NGET0192 - SIM - Samuel Inertia Element

NIA_NGET0119 - Project Samuel - Grid Data and Measurement Systems

NIA_NGSO0020 - Short-term System Inertia Forecast

Third Party Collaborators

National Physical Laboratory

Nominated Contact Email Address(es)

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Problem Being Solved

The decarbonisation of the GB energy landscape is resulting in a decrease in inertia and additional spend on managing RoCoF. Historically inertia has been estimated based on Balancing Mechanism Unit (BMU) contribution and proportion of demand, however residual inertia is now making up a larger percentage of the total system inertia as conventional generation is replaced by asynchronous plant. Managing RoCoF as a result of low inertia is costing approximately £200m per year.

The ability to measure real-time inertia will enable both synchronous and residual inertia to be known, improving decision making and reducing the risk of the system running insecure. However, there is currently no best practice or standardisation for measuring system inertia.

Method(s)

Work Package 1: Analysis and comparison of inertia measurements from commercial systems

In this WP, data from commercial systems continuously collected over periods of months/year will be analysed and compared. Data will also be compared with the calculated inertia derived from the inertia contribution of the synchronous generators connected at each period. In addition to this, correlation to known influencing factors on inertia will be analysed, including generation and demand scenarios.

For data from the commercial systems, at least one system provides standard-deviation based confidence data and this will be used to calculate the type-A measurement uncertainty. Other information will also be used, such as data error flags to reject data from the comparison and manufacturer's accuracy specification data.

In comparing the results, the combined estimated uncertainty from all the systems will be used as a bench-mark expectation of agreement from which to judge whether the systems agree at a given period.

Deliverables: Presentation review of interim results from WP1, and final report on the results of WP1.

Work Package 2: Assess regional differences in frequency and RoCoF for GB systems

This WP is a calculation and modelling based activity which will determine expected differences in the values of frequency and RoCoF for different areas of the GB grid and assess the suitability of different regional inertia representations.

The sensitivity of the model output to changes in assumptions and variations of the inputs will be assessed to estimate the uncertainty of the model outputs.

Deliverables: Presentation review of interim results. Final report on the results of WP2.

Work Package 3: Development of reference framework

At the present there is no reference standard for inertia, it is an operationalist measurement and validity of this measurement must be assessed as a metric in the context of the given use case.

Using the outputs of WP1 and WP2, and knowledge of the operational scenarios of the power system, a set of use-cases will be developed along with a standard set of power system frequency characteristics representative of common power system inertia measurement scenarios. These characteristics will be used to develop and test inertia measurement methods and instruments.

Frequency and RoCoF algorithms will be adapted and developed to account for the influencing factors such as system noise, voltage modulation (flicker), phase steps and low frequency inter-harmonics. Testing and assessment of the algorithms against various influencing factors for given use cases will be made to ascribe an accuracy to each measurement scenario.

Deliverables: Document proposing a reference framework for inertia measurement including test cases and methods. This document and deliverable 4 will be sent or presented to standards committee IEC TC8 JWG8.

Work Package 4: Development of reference instrument

This WP will implement algorithms in software to run in real time on existing NPL PMU instruments. The instrument (hardware and software) will be calibrated against national standards of AC voltage and current, and a measurement uncertainty will be estimated.

The consequences of imperfections in the instrumentation for the measurement of frequency and RoCoF will be assessed in the context of the waveforms expected in each use case.

Deliverables: Document providing technical specifications for reference instrument. Exploitation plan for reference methods and instrument developed in WP3 and WP4, respectively.

Work Package 5: Comparison with NPL reference instruments

The final WP will install 3-6 NPL PMUs in the power grid at selected locations in parallel to NGESO's frequency and RoCoF measurement systems for 6-12 months. A comparison between commercial RoCoF measurements and the reference instruments will be made, including during abnormal events on the power system.

The uncertainty of the reference instrument will be known from WP4, and taking into account the statistical data from the on-site measurement, an uncertainty can be calculated for each measurement and combined with the statistical (and other) uncertainties of the commercial system to give a combined uncertainty as an expectation for the comparison.

If there is a reason these PMUs cannot be installed, an alternative option is to use NPL laboratory testing of NG frequency and RoCoF instruments.

Deliverables: Review meeting with presentation of interim measurement and validation results. Final report on the results of WP5. Test protocol for on-site verification of inertia measurement systems.

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

TRL Steps = 2 (3 TRL steps)

Cost = 1 (£371k)

Suppliers = 1 (1 supplier)

Data Assumptions = 2

Total = 6 (Low)

Scope

- Understand the accuracy of the inertia monitoring systems and dependencies on different generation / demand profiles.
- Understand regional differences of inertia.
- Establish standardisation methodology for measuring inertia and RoCoF.
- Clarity on accuracy of inertia measurement will feed into specification for inertia products with both Control and planning timescales.

Objective(s)

Using the metering data from the two new inertia system tools developed following earlier innovation and IT projects, along with the existing NGESO inertia "estimate" and operational data, the project will:

- Analyse and verify the quality of the data from these new tools through comparisons to the existing NGESO estimation.
- Establish different scenarios / use cases for inertia and RoCoF, for example based around levels of synchronous and renewable generation and demand.
- Compare the different solutions based on the established use cases.
- Identify regional inertia variations and representations.
- Develop measurement parameters and specification for reference instrumentation.
- Build on data and use cases to establish standardisation for inertia measurement by comparing measured results to modelling.

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.

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

Success Criteria

The following will be considered when assessing whether the project is successful:

- The project delivers against objectives, timescales and budgets as defined in the proposal
- Verification of the innovative real-time inertia monitoring solutions
- Deeper understanding of how different generation scenarios impact the inertia on the network
- Deeper understanding of regional inertia variations across GB
- Standard methodology developed and documented for assessing inertia measurements

Project Partners and External Funding

National Physical Laboratory (NPL) will be delivering the work.

SP Energy Networks (SPEN)

External funding: £670,000 from National Measurement System (NMS)

Potential for New Learning

This project will help National Grid ESO understand the following:

- Accuracy of different innovative inertia monitoring tools considering different use casE
- Overall system inertia and improved situational awareness for decision making
- Impact of different generation and demand scenarios on network inertia
- Representation of regional inertia generation across GB
- Standardisation of inertia measurement methods and instrumentation

Documentation developed that provides technical specifications for reference instrumentation, and that proposes a reference framework for inertia measurement will be made publicly available and submitted to the International Electrotechnical Commission (IEC) standards committee for any further standards development and for use across the wider industry.

Scale of Project

Work will be carried out within NPL over a 2 year period using NGESO through a combination of comparison of measurement and operational data, model simulation and specific site measurements made by NPL devices installed at key locations across the network

Technology Readiness at Start

TRL2 Invention and Research

Technology Readiness at End

TRL5 Pilot Scale

Geographical Area

Will be based upon the GB ESO area of operations.

Revenue Allowed for the RIIO Settlement

None

Indicative Total NIA Project Expenditure

£371,000

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 ESO.

The ability to measure real-time inertia will 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.

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 pathfinder assessments, helping to define the required volume, where it should be purchased and potentially enable the future despatch of inertia services.

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

This project will assess new commercial tools for inertia measurement and provide a standardised methodology for measurement. The methodology established can be disseminated across the industry to support Network Licenses with inertia measurements, both within the UK and around the world.

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.

Inertia monitoring products arose from previous projects:

- Reactive Technologies – SAMUEL & Project SIM NIA projects (NIA_NGET0119 & NIA_NGET0192)
- GE – MIGRATE European project WP2

Both NIA innovation projects resulted in a limited amount of live system data. Following a tender, both Reactive and GE solutions have recently been developed in partnership with the suppliers under a NGESO IT project, with data being collected to validate against NGESO existing inertia "estimation" method.

A previous project has also been undertaken by Imperial College (NIA_NGSO0020, Short-term System Inertia Forecast) to produce a more accurate Inertia Forecasting capability. This system requires more accurate inertia monitoring data, such as that produced by the GE and Reactive tools, to complete the analysis of its methodology.

With decreasing inertia and the resulting increase in costs to manage RoCoF a number of solutions have already been implemented; stability pathfinder phase 1 & 2, Accelerated Loss of Mains Protection (AcLoMP) and revised levels of risks following the Frequency Risk and Control Report (FRCR), however alongside these it is critical to understand the actual inertia on the system at any point in time. This includes the ability to forecast inertia ahead of time to enable appropriate actions to be taken. It is therefore important that the ESO has an accurate method to do this that is standardised and recognised as an approved method.

As both measurement systems are first-of-their-kind operational installations, we have the opportunity to 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 the method for either measuring or forecasting inertia. This project will be an industry first, looking at the measurement tools and assessing how they respond under different operating scenarios and using this data to establish standards for inertia measurement methods and devices.

Current methods of estimating inertia are based around assessing large loss events, this new data will provide significantly more data to compare across a complete range of operational scenarios. In addition to this, regional inertia values will enable regional inertia representation to be understood.

This project will develop a better understanding of the regional and scenario difference in inertia values which will feed into future market provision such as stability pathfinder. Without this funding, we are likely to continue to rely on national values.

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.
- Proposed reference framework for inertia measurement including test cases and methods.
- Technical specifications for reference instrument. Exploitation plan for reference methods and instrument developed in WP3 and WP4, respectively.
- Final report on the results of WP5.
- Test protocol for on-site verification of inertia measurement systems.

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 using new tools to develop a measurement standard for inertia, this does not fall into current business as usual (BAU) 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 overall framework 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