nationalgridESO

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

Feb 2019

Project Reference

NIA_NGSO0020

Project Registration

Project Title

Short-term System Inertia Forecast

Project Reference

NIA_NGSO0020

Project Licensee(s)

National Grid Electricity System Operator

Project Start

March 2019

Project Duration

1 year and 7 months

Nominated Project Contact(s)

Zhibo Ma

Project Budget

£300,000.00

Summary

This innovation project involves, for the first time, investigation of the feasibility of a data-driven approach to provide multi-time resolution inertia forecasts with high accuracy.

Nominated Contact Email Address(es)

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Problem Being Solved

System inertia is continuing to fall and become more unpredictable due to the integration of non-synchronous connections on the GB electricity system.

This declining amount and reduced predictability of inertia, driven by the integration of non-synchronous connections, significantly increases the challenge in maintaining system stability and efficient operation.

National Grid as the Electricity System Operator (ESO) has investigated methods to measure the inertia of the electricity system in real time. However, accurate day-ahead and intraday forecasts of system inertia will be required in the future to support the real-time system operation in the control room and frequency response procurement in the market.

Method(s)

This innovation project involves, for the first time, investigation of the feasibility of a data-driven approach to provide multi-time resolution inertia forecasts with high accuracy.

Scope

The project will involve the following activities and methodological approach:

1. Collect historical data for system conditions and estimate inertia levels. The most critical data is the historic or real time total system inertia measurements. Subject to availability, other data may be used to improve the forecasting accuracy of the system inertia, which includes weather data (such as temperature, wind), system condition data (such as National Grid ESO's Integrated Energy Management System (IEMS), PMU, BMU and so on) and forecasting data (such as demand forecast and renewable energy forecasts).
2. Apply data-driven approach (e.g LASSO) to identify the most relevant features (temperature, hour of the day etc.) related to the frequency (PMU data) and inertia (ROCOF data), contributions from synchronous generation (BMU data), demand side and distributed generation.
3. Develop Machine Learning-based predictive models (e.g., generalized linear models, deep learning, etc.) for multi-resolution point and probabilistic inertia forecasts in a rolling basis.
4. Apply advanced risk-constrained system scheduling model and frequency response market-clearing models to quantify the impacts and benefits for accurate inertia forecasts.

Due to the complicated dependency structure and lack of detailed measurements in the demand side, there is very limited understanding on the inertia contribution from demand side and embedded units.

Traditional physical modelling based approach is hence not applicable in this case. Therefore, in the context of this project, the proposed activities and methodology will develop advanced Machine Learning-based predictive models (e.g., random forest, deep learning, etc.) for multi-temporal inertia forecasts in a rolling-basis. Based on available data, this will also try to identify the most relevant features (temperature, hour of the day, demand forecast etc.) related to the inertia contribution from demand side by applying automatic feature selection methods.

Objective(s)

This project aims to provide a proof of concept tool for an accurate day-ahead and intra-day inertia forecast with multi-time resolution, that can be potentially used to support the day-ahead frequency response procurement and the real-time system operation.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

n/a

Success Criteria

The project will be successful if it can help the Electricity System Operator in the following ways:

1. To develop a reliable and accurate inertia forecast which will enhance system security, reduce cost of frequency response procurement and increase renewable penetration.
2. Demonstrate if machine Learning-based techniques can be applied to improve inertia forecasting
3. Utilise renewable forecasts (wind, solar) in the inertia forecast
4. Improving demand-side inertia assumptions (level of system demand and mix of demand) to improve overall inertia forecast
5. Overall, demonstrate if an accurate inertia forecast model can reduce inertia forecasting error by 1% RMS, and can be potentially used in control room, with innovative features of quantifying inertial impacts from renewable energy, distributed generation, mix of demand, renewable forecast error and probabilistic forecasts.

Project Partners and External Funding

The project will involve collaboration with Imperial College London. There is no external funding involved in this project.

Potential for New Learning

This innovation project is expected to deliver new learning by:

1. Investigating the feasibility of a data-driven approach to provide multi-time resolution inertia forecasts with high accuracy.
2. Developing Machine Learning-based predictive models (e.g., generalized linear models, deep learning, etc.) for multi-resolution point and probabilistic inertia forecasts in a rolling basis.
3. Apply advanced risk-constrained system scheduling model and frequency response market-clearing models to quantify the impacts and benefits for accurate inertia forecasts.
4. Develop a proof of concept for an accurate day-ahead and intra-day inertia forecast with multi-time resolution, that can be potentially used to support the day-ahead frequency response procurement and real-time system operation.

Scale of Project

The project will predominantly involve desk-based research, data analysis, software development and prototype testing activities at National Grid and Imperial College London.

Technology Readiness at Start

TRL3 Proof of Concept

Technology Readiness at End

TRL6 Large Scale

Geographical Area

This work will take place on a national scale and will benefit the accuracy of GB inertia forecasts.

Revenue Allowed for the RIIO Settlement

None

Indicative Total NIA Project Expenditure

The total indicative NIA expenditure for this project is £300,000.

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:

n/a

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)

Through developing an enhanced short-term inertia forecast and reducing inertia forecast error, the ESO is likely to achieve a considerable financial savings, with potential applications in the ESO Control Room and Commercial Operations. It is also likely that an advanced inertia forecast will help achieve a frequency response cost saving of £3m in 2020 and £15m in 2030 and help facilitate and develop a future Day-Ahead frequency response market. Also, the Machine Learning techniques to be developed in the project are likely to be transferrable to other critical areas of the business.

The potential savings which can be achieved in terms of a reduction in forecast error versus balancing costs will be evaluated and quantified as part of the implementation of this innovation project.

Please provide a calculation of the expected benefits the Solution

The expected benefits of the project will be assessed as part of the implementation of the project. This will involve measuring and comparing the inertia forecast errors with the current BAU processes.

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

The project will benefit all GB network licensees and the outcomes of the project will be made available such that licensees and other industry users can access the learnings from the project to better understand inertia forecasting and how it influence real-time system operation.

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

The project will develop a proof-of-concept inertia forecasting tool for the ESO.

It is expected that the methodologies used during the project to investigate inertia forecasting and learnings can be shared with other network licensees and the energy industry to enable novel approaches in understanding their implications in operating the GB electricity network and future changes to it.

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

n/a

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

From the National Grid System Operator Innovation Strategy document published in February 2018. This project will directly address the following strategic innovation areas:

- Improving short-term forecasting
- Managing volatility in a low-inertia system
- Leveraging analytics in a data-enabled future
- Enabling more non-synchronous connections

It will also have indirect benefits in the following other strategic areas:

- Creating markets for the future
- Harnessing a digitised grid
- Unlocking flexibility.

☑ Has the Potential to Develop Learning That Can be Applied by all Relevant Network Licensees

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.

No unnecessary duplication will occur as a result of this project. There are no other known innovation projects investigating inertia forecasting tools and how these can be optimised for real-time operational decision making.

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

Until present, inertia forecasts have not been required by System Operators as power systems around the world have had sufficient and predictable levels of system inertia. However, in GB system inertia is decreasing and becoming more unpredictable. This is due to the increasing amounts of non-synchronous and weather-dependent generation, and decreasing amounts of conventional synchronised machines. It is imperative that National Grid Electricity System Operator (ESO) has access to accurate inertia forecasts to inform the required levels of frequency response to safely and efficiently operate the GB electricity system. A data-driven Machine Learning (ML) inertia forecast is highly innovative and will be the first of its kind in the world. The project will leverage innovative methodologies to analyse historic data and assess the inertia contribution from Balancing Mechanism Units (BMUs) and embedded units. The project will: • develop an ML based predictive model for multi-temporal inertia forecasts on a rolling-basis. • develop, test and validate the proof-of-concept ML model to deliver accurate short-term inertia forecasts. • apply advanced simulation models to quantify the benefits of enhanced inertia forecasts.

Relevant Foreground IPR

n/a

Data Access Details

n/a

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

The applied research activities and methodologies proposed in this project have not been carried out before and cannot be carried out directly on the operational systems at National Grid Electricity System Operator (ESO). The project results will need to be tested and validated in a simulated environment before they can be used in the ESO's operational systems as part of business as usual activities, and disseminated for use by the wider energy market. The activities involved in this project are dependent on the specialist skills and knowledge of the chosen innovation partner, Imperial College London.

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

NIA funding is the chosen funding route for this innovation project for the following reasons: 1. It will facilitate collaboration with the chosen innovation partner to access their specialist skills and expertise in a cost-effective and timely manner, given the key operational challenges which this project is aiming to address. 2. It will allow the ESO to easily disseminate the key learnings from the project to the energy sector and GB network licensees. The insights from this project are expected to benefit the ESO and the energy sector to better understand and forecast short-term system inertia. 3. This project will test a number of approaches and methodologies that could not be applied to the ESO's operational systems as they are too risky. They must be tested in an agile way offline, before the most effective approach is validated, before implementing as BAU. The ESO Innovation approach, complemented by the NIA funding framework, is the most cost-effective way to do this.

This project has been approved by a senior member of staff

☑ Yes