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 2021

Project Reference Number

NIA2_NGESO003

Project Registration

Project Title

Probabilistic Machine Learning Solution for Dynamic Reserve Setting

Project Reference Number

NIA2_NGESO003

Project Licensee(s)

National Energy System Operator

Project Start

May 2021

Project Duration

1 year and 0 months

Nominated Project Contact(s)

Gabriel Griffin-Booth

Project Budget

£400,000.00

Summary

Currently, reserve levels are based on statistical analysis of historical generation and forecasting errors. Using artifical intelligence and machine learning this project will look to set reserve levels dynamically, day ahead.

When considering additional interconnectors and increasing weather driven effects on the uncertainty of visible demand (impacted by unmetered embedded generation) and metered generation, we would anticipate further increases in reserve holdings without innovative models and approaches to the challenges presented by a changing system. This innovation project attempts to prototype an advanced ML model as an ambitious methodology to capture the various sources of uncertainty, to be created in parallel with the BAU development of new models.

These algorithms would forecast reserve requirements by learning from historical behaviour and input drivers to find correlations with the uncertainty of system conditions.

Nominated Contact Email Address(es)

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Problem Being Solved

Currently, reserve levels are based on statistical analysis of historical generation and forecasting errors. They are set for each cardinal point and day type and updated twice a year at clock change, with additions within day for solar and wind forecast as well as low temperatures.

These values are stacked but errors can be caused by the same input drivers. While we do our best to optimise reserve holdings we believe there is much more we can do to with recent technological innovations in Artificial Intelligence (AI) and Machine Learning (ML) to improve these calculations.

The amount of renewable generation is increasing, seen as both generation and demand suppression in the ESO depending on the metering data availability. This creates increasing weather driven uncertainty in demand and generation curves and we must modify our reserve models to account for more input drivers and update reserve levels based on recent inputs due to weather forecasts. There are several approaches available, this project seeks to prototype an ambitious Probabilistic Machine Learning Solution for Dynamic Reserve Setting in parallel with BAU efforts.

Method(s)

This project will look to undertake the following scope of work:

- **Phase 1**: Phase 1 will assess the technical feasibility of end-to-end capability development and of the ML solution in terms of data availability and quality. Produce end to end proof of concept (PoC) Demo 1 on Smith Institute platform to identify and agree dependencies on data, systems, and expertise.

Breakpoint 1: Identify if data availability or quality issues are insurmountable.

- **Phase 2**: Phase 2 will establish a proof of concept ML model and compare its performance with the current reserve setting process. Develop PoC Demo 2 to implement, test, and document the data analysis and machine learning required in PoC Demo.

Breakpoint 2: A performance comparison between BAU and new approach.

The PoC solution outputs will be compared to the BAU approach to demonstrate superior performance in terms of matching reserve levels to NGESO's risk appetite and the expected cost or risk management benefits.

Parallel running of BAU approach and innovative approach for a period of time to build trust and understanding in the ENCC and allowing a "live" test of cost savings & risk identification and management.

- **Phase 3 (possibly for a future project)**: Explore options to integrate into control room systems and present a dashboard explaining reserve breakdown, for a period to get the most accurate estimate of cost-savings and build trust in solution.

Risk Assessment

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

TRL Steps = 2 (3 TRL steps)

Cost = 1 (£400k)

Suppliers = 1 (1 supplier)

Data Assumptions = 2 (data will be tested for ML applicability)

Scope

Dynamic Reserve Level Setting Approach

- The different types of reserve setting processes should be integrated to ensure that the total reserve held is representative of NGESO's risk appetite.
- In this project, we expect to apply the approach summarised below to both the basic reserve (possibly including interconnectors) and the reserve for renewable energy sources and we expect that our focus will be on 4–24-hour lead times.

Dynamic Reserve Setting Solution Design

This project will create a proof of concept for a DRS solution with the following features:

- Data pipeline which automates the extraction, cleaning, and preparation of raw data into storage.
- Probabilistic ML (machine learning) model which makes use of predictor variables in that data (e.g. temperature and wind forecast quantiles, and generation mix) to create more accurate predictions (and prediction intervals) of forecast errors and therefore set reserve levels, which better reflect NGESO's risk appetite.

- A database and dashboard for the display of the results of the ML model.
- Automated upload of the ML model results to control room systems.
- Retraining of the ML model to enable a cycle of continuous learning using new data about recent system conditions and forecast errors.

Objective(s)

- Probabilistic ML model which makes use of predictor variables in that data (e.g. temperature and wind forecast quantiles, and generation mix) to create more accurate predictions (and prediction intervals) of forecast errors and therefore set reserve levels, which better reflect NGESO's risk appetite.
- Retraining of the ML model to enable a cycle of continuous learning using new data about recent system conditions and forecast errors.

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. Benefits to all consumers areare detailed below.

Success Criteria

Optimising reserve levels and reducing balancing costs is a key challenge for the NGESO as we move towards our net zero targets and a more volatile system. Uncertainty is more difficult to predict in the short term and we are seeking to optimise reserve levels in the most efficient way.

The end result would be better optimised levels, avoiding 'overholding' and better value for end consumer, and avoiding 'underholding' in risky and uncertain periods.

Project Partners and External Funding

The Smith Institute will be carrying out the work. No external funding.

Potential for New Learning

These methods have not been used for reserve setting for the GB system before.

We know that the use of similar methods has been attempted on EU systems but their system is different to GB. Eila (Belgium) via N-Side which is part of the continental grid so has different system conditions, products, and procurement methods.

We expect to improve our ability to use a data driven approach to inform decision making in managing uncertainty. We have discussed, and will continue to discuss, progress on these changes at our Operability Transparency Forums. These are led by NGESO and are made public here https://data.nationalgrideso.com/plans-reports-analysis/covid-19-preparedness-materials

Scale of Project

The project spans 24 months with 1 project partner. It will be desk based research.

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

400,000

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 way we set reserves must fundamentally change because our demand and generation profiles are being increasingly driven by weather effects due to renewable energy source (RES). This project aims to deliver an ML model that will optimally recommend reserve sizes accounting for weather driven RES impacts on forecast error.

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

Not applicable.

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)

Not applicable.

Please provide a calculation of the expected benefits the Solution

This will be more widely explored as part of the project, but benefits will likely be seen via the following calculation:

[Reserve cost from BAU methodology] – [Simulated reserve cost from prototype ML methodology]

Recipients are anyone who pays an energy bill containing balancing costs

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

This will be the output of the project. Model designed for ESO with possible utility at DSO level.

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

- The PoC solution outputs will be compared to the BAU approach to demonstrate superior performance in terms of matching reserve levels to NGESO's risk appetite and the expected cost or risk management benefits.
- Once value has been demonstrated there will be an integration cost in the implementation into BAU NGESO systems (not part of this project)

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

Every network has to deal with uncertainty in demand and generation (supply). This model is designed to enable you to operate at your risk appetite level whilst accounting for weather driven factors which will have an increasing effect on our renewable energy sources during system transformation.

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

Not applicable.

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.

Whilst there are other projects exploring innovative approaches to reserve setting, they are not prototyping an ML model of this complexity and scope for the entire GB system.

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

- This is trying a novel approach requiring a specialist skill set and represent a significant shift in methodology and practice.
- These machine learning methods have not been used for reserve setting for the GB system before.
- We know that the use of similar methods has been attempted on EU systems but their system is different to GB.

Relevant Foreground IPR

The project outputs will be a proof of concept for a dynamic reserve setting model. There will also be a performance comparison report comparing the benefits.

Data Access Details

If it is deemed necessary to have access to background IPR to utilise the results, a request may be submitted to the ESO and project partners, if this is a reasonable request then any relevant data may be anonymised and redacted where necessary to protect any sensitive information. We don't foresee any requests for background IPR access being necessary.

The terms on which such data will be made available by National Grid can be found in our publicly available "Data sharing policy related to NIC/NIA projects" and https://www.nationalgrideso.com/future-energy/innovation/get-involved. National Grid already publishes much of the data arising from our NIC/NIA projects at www.smarternetworks.org. You may wish to check this website before making an application under this policy, in case the data which you are seeking has already been published.

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

The ML model design is ambitious. There is a chance that it will need to be simplified to meet data or process constraints. Therefore, we do not believe this proof of concept work would be funded through BAU activities, this de-risks a future BAU project.

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 learnings from the project can be shared more widely to the Network Licensees which couldn't be achieved if deemed as BAU activities. With the transition to DSOs the outputs of this project will be valuable learning to our DSOs who will also be facing similar challenges.

This project has been approved by a senior member of staff

☑ Yes