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

Jun 2023

Project Reference Number

NIA_NGT0212

Project Registration

Project Title

Probabilistic Projections

Project Reference Number

NIA_NGT0212

Project Licensee(s)

National Gas Transmission PLC

Project Start

June 2023

Project Duration

1 year and 7 months

Nominated Project Contact(s)

Sabia Sadiya, box.GT.innovation@nationalgrid.com

Project Budget

£162,666.00

Summary

The energy system is changing rapidly, with many of these changes making patterns of demand harder to predict and more dependent on the weather, and the relationship between the gas and electricity networks more complex. As a result, probabilistic forecasts that consider the uncertainty in variables are becoming more important to inform planning and operational decisions and include risk quantification and management. This project will develop tailored forecasting models to allow predictions of variables relevant to NGT's decision processes from operational lead-times to the modelling of future scenarios that inform decades-ahead planning and investment decisions. Use-cases of these forecasts will be presented to demonstrate their benefit to NGT.

Third Party Collaborators

Newcastle University

Nominated Contact Email Address(es)

Box.GT.Innovation@nationalgrid.com

Problem Being Solved

High quality forecasts are critical for the safe, secure, and efficient planning and operation of Great Britain's gas system, informing decisions on multiple time scales. For investment planning, the gas industry (including National Gas Transmission, its customers, and other stakeholders) need a view of what sort of gas supply and demand capacities might be required for many decades into the future. This requires a robust macro-level view of how the energy system might change – typically this is informed by the curation of a set of scenarios. However, it is necessary to predict how different elements of the system might behave if this scenario unfolds – for example, the volume of wind energy electrolysed into hydrogen requires scenarios for wind and electrolysis capacity, but also consideration for how the wind output and electricity demand varies half-hour by half-hour and knock-on impacts for system design and operation.

For season-ahead planning, the gas system operator will want reassurance that, for example, there is sufficient stored gas to ensure supplies throughout the winter, with possible risks arising due to cold winter driving high demand, and low wind speeds increasing the demand from gas power stations. Weeks-ahead and days-ahead, forecasts are important for managing constraints and congestion in the system. Historically, the day-to-day operation of the gas system is relatively predictable, and the market has been able to manage this well with conventional forecast approaches. As a result, constraint costs in the gas system are several orders of magnitude lower than equivalent costs in the electricity system.

However, the evolution of the energy system in the coming years could lead to conventional forecast systems becoming unsuitable for efficient and secure operations and planning of the gas network, particularly as patterns of supply and demand become harder to predict and more dependent on the weather, and as the links between the electricity and gas system become more dynamic and more complicated.

For example, a future system may involve widespread hydrogen electrolysis of curtailed wind power generation. The extent of this will depend on the potential electricity production of the wind output (which depends on wind speeds), the demand for electricity (which will be sensitive to temperature), and the broader dynamics of the electricity market. However, the potential for this hydrogen electrolysis will also be important for determining the supply of hydrogen to the gas system. All of these elements could be very uncertain individually, and, in combination, a significant source of operational risk. The gas system operator therefore needs methods that can quantify this risk to support secure and efficient operation.

This also introduces challenges for investment planning, where these same sources of uncertainty might influence decisions about the optimal levels of electrolysis and storage capacity, or where to invest in the gas network.

Within existing practices, National Gas Transmission do consider some of the sources of uncertainty that might influence gas demand in the long-term predictions, but there are considerable opportunities to modernise these approaches: for example, current shorter-term forecasts do not provide any quantification of uncertainty and risk.

Method(s)

Mathematical modelling methods will be used in this project to construct high-quality probabilistic models of energy system variables covering electricity and gas supply and demand. This will include the underlying elements of electricity and gas demand for heating, appliances, and lighting, as well as the supply of weather-based renewable energy. These models will be used as inputs to existing NGT system simulation models, In conjunction with other scenario information (such as uptake pathways for different low-carbon technologies).

For example, the models will be used to produce probabilistic traces for electricity demand and renewable energy supply. These can be provided to a power-station scheduling model to provide a probabilistic projection of the required hydrogen electrolysis and storage capacity under a given scenario. Where existing system simulation models are found to require further development, this will be flagged as part of the findings of the work. The diagram below illustrates how historic data will be used to build the probabilistic models. Combining these with defined scenario pathways will lead to probabilistic projections of inputs (like renewable energy production time-series). Running these through existing system models will allow for the creation of projections of outputs (like required hydrogen storage capacity). The green colour shows which parts of this process are within the scope of this project.

Figure 1: Building blocks for making long-term projections, with green blocks showing the elements in scope for this NIA

These models will be trained on historic data about the relevant variables, gathered from public domain sources wherever possible. This will include high spatial and temporal resolution historical weather observation data, and weather reanalysis data, which will provide very long time series of how weather variables have varied over several decades, capable of being used for simulating scenario outcomes. The models will be developed using Python and the statistical programming language R, and the workbooks – containing code, results, figures, and commentary – describing this development will be delivered as an output of the project. This will aid NGT's further development and implementation of these methods.

Measurement Quality Statement

The measurement approach used to meet Data Quality objectives will be through the identification of high calibre project partners who are experts in their given field. The methodology used in this project will be subject to our supplier's own ISO 9001 certified quality assurance regime and the source of data, measurement process and equipment as well as data processing will be clearly documented and verifiable. The measurements, designs and economic assessments will also be clearly documented in the relevant deliverables and final project report and made available for review. The project will, wherever possible, use high quality data access from public sources, supplemented with data from NGT where strictly necessary. However, the quality of the outputs will depend on turn in the quality of this data.

Data Quality Statement (DQS)

The project will be delivered under the NIA framework in line with the agreed Energy Networks Innovation Process document NGGT / NGET internal policies. Data produced as part of this project will be subject to quality assurance to ensure that the information produced with each deliverable is accurate to the best of our knowledge and sources of information are appropriately documented. All deliverables and project outputs will be stored on our internal SharePoint platform ensuring backup and version management. Relevant project documentation and reports will also be made available on the ENA Smarter Networks Portal and dissemination material will be shared with the relevant stakeholders.

Scope

The work will be completed in three work packages:

· WP1: The first work package will involve engagement with subject matter experts across National Gas Transmission to: (i) elicit the decision-making problems where projections are used; (ii) document the processes, methods, and data used to make projections in existing business-as-usual practises, and (iii) identify any implementation barriers for new methods. This will also give the project team an opportunity to confirm exactly which energy system variables will be considered.

· WP2: The second work package will involve the creation of data-driven probabilistic simulation models, using best-in-class mathematical (and, where appropriate machine learning) methods. The exact quantities to be forecast will be determined during WP1, but we expect this to include several supply and demand variables for both electricity and gas. Candidate variables include wind generation, solar generation, electricity demand and LDZ gas demand. Options for spatial resolution will also be considered in the context of the identified use-cases – for example, the demand for individual LDZ could be predicted separately, or we could predict the total demand across all LDZs. All projections will be comprehensively evaluated to demonstrate that they can be relied upon for use.

· WP3: The third work package will involve demonstration of how projections could be applied to inform the decision-making problems identified in WP1. For example, this might involve running simulated outputs from the models through existing NGT system models, like a power station scheduling model or perhaps calculation of simpler quantities like annual imbalance between renewable energy supply and electricity and gas demand.

Objective(s)

There are three objectives for this project:

· To document the possible use-cases for probabilistic forecasts and projections in the operation and planning of the GB gas system, while capturing how this might change as the energy system transitions (including an adoption of hydrogen within the gas network).

· To demonstrate whether high quality (reliable and skilful) probabilistic forecast and projection models can be produced for energy system variables relevant for these use-cases.

· To explore whether these probabilistic models could be used for forecasting and simulation in a way that is beneficial for decision-making use cases.

Depending on the outcome of these first three objectives, an optional fourth objective will be to deploy some form of probabilistic forecasting system for a subset of these forecast models, either on NGT IT systems or to publish it publicly for dissemination.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

An assessment of distributional impacts (technical, financial and wellbeing related) for this project has been carried out using a bespoke assessment tool, which assesses the project as having a positive, negative or neutral effect on consumers in vulnerable situations. To help inform the assessment, this tool considers the categories of consumers identified in the Priority Services Register. This project has been assessed as having a neutral impact on customers in vulnerable situations. This is because it is a transmission project.

Success Criteria

This project will be considered a success if:

· The project is delivered within time, cost, quality

· A set of use-cases can be developed in collaboration with subject matter experts within NGT.

· The project partners can identify whether it is possible to produce probabilistic forecasts and projections for the timescales and energy system variables that influence these use-cases.

· The project partners can demonstrate whether these forecasts can be used to inform these use-cases.

· The project establishes solid partnership with the sister BAU project.

Project Partners and External Funding

None

Potential for New Learning

The initial stage of the project, in consultation with subject matter experts at NGT, is expected to determine the variables and lead-times of importance for decision-making and where there is potential benefit from the use of probabilistic forecasts. The project will then investigate the skill in forecasts for these applications and the determine the size of the expected benefit through example use cases. Further details are provided in Section 3.5.1. The main output will be in the form of developed models in code, which will be disseminated through annotated workbooks. Where possible (e.g., subject to any data confidentiality issues) these will be openly published with the underlying data required to reproduce the outputs.

Scale of Project

There are many quantities which affect gas demand, which means NGT must produce forecasts of a complex set of inter-related quantities. Some of the key unique learning we expect to generate from this project will come from the breadth of variables considered (including sources of both supply and demand on both the electricity and gas systems). Without all these individual components, the learning generated within the project is expected to be much less valuable.

In addition, all of the lead-times considered within the scope are of significance and, given there will be some similarities in the methods used for different lead-times, it is prudent to consider all of these within the same project.

Technology Readiness at Start

TRL2 Invention and Research

Technology Readiness at End

TRL4 Bench Scale Research

Geographical Area

The activity in this project is largely desk-based, with work taking place at National Grid Gas's offices in Leamington Spa, and the offices of project partners in Glasgow and Newcastle.

The probabilistic models will consider the entirety of the Great Britain gas and electricity systems, at an appropriate level of spatial granularity. Some consideration will be given to wider European gas and electricity systems through the modelling of electricity and gas interconnector flows.

Revenue Allowed for the RIIO Settlement

Not applicable for this project.

Indicative Total NIA Project Expenditure

This project will be delivered by TNEI, with National Gas Transmission as the lead network

External Cost: £122,000

Internal Cost: £40,666.67

Total Cost: £162,666.67

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:

National Gas Transmission are committed to supporting the delivery of the Net Zero Transition by 2050, through the transition of the transmission network to delivering net zero gases to consumers. Whilst gases such as hydrogen, synthetic gas and biomethane provide solutions for net zero energy carriers, some production methods for these fuels can produce unwanted emissions. Alongside this in the transitional period it is possible that users will still utilise natural gas and therefore continue to emit harmful emissions. A key element of the transition is in the capture, use and storage of these emissions to prevent them escaping to atmosphere.

So far much of the energy system transition has taken place within the electricity system, but as we move closer to net zero the way the gas system is used and its links to other energy vectors will change. The forecasts developed in this project will facilitate the planning of the future gas system and support operational decisions as dependencies between gas and other energy vectors become more complex. For example, it is likely that curtailed wind power will be used to generate hydrogen, leading to injections into the gas grid at times of high wind and low electricity demand – and that the volume of this will grow with increased wind capacity in the future. This would add complexity to the relationship between wind, demand and gas and could lead to variation in the energy density of gas in the network as the proportion of hydrogen varies. Operational decisions would benefit from foresight of this scenario to allow planning and actioning of any response actions needed. Similarly, information on likely future scenarios for wind and hydrogen generation would allow long-term planning decisions based on realistic projections, ensuring the gas network maintains flexibility and security of supply as the energy system decarbonises.

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)

RIIO-1 Question N/A

Please provide a calculation of the expected benefits the Solution

This project is a research study: the objectives are to investigate whether it is possible to produce the gas supply and demand forecasts required by NGT and also whether these can be used. Therefore, no calculation of the expected benefits has been undertaken at this stage.

The benefit of the project will be the evidence provided, which will support further decisions within NGT as to whether such forecasts should be productionised and incorporated into decision-making process. In the long-run, this could enable significant benefits to be achieved in, for example, reducing the frequency of congestion in the gas system, and reducing the risk of supply shortfalls.

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

The probabilistic forecasting techniques explored in this project will have applicability for all gas transmission and distribution networks and assets across GB, with some possible learning for electricity networks and participants in the electricity market. They will only depend on the availability of data for any area of interest.

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

This would be the cost of implementing the developed forecasting models into NGT's IT infrastructure, beyond whatever implementation is deemed possible. Use of live forecast data in an operational forecasting system would also carry a cost, and development and adaptation of current decision-making processes would be needed to incorporate probabilistic information: while possible use cases will be demonstrated within the project, further work would be needed to operationalise this and apply to all relevant decisions.

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 probabilistic forecasting techniques explored in this project have wide applicability for both transmission and distribution networks across GB, particularly for the operational and planning decision making across the gas network.

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

RIIO-1 Question 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 activities in this project will build on the learning from academia, and also from the NIA Control REACT project by NGESO. Similar approaches can be taken for this project, but there are unique challenges and use cases for NGT that require careful consideration, including the need to explicitly consider supply and demand of gas, a change in emphasis with operational timescales (e.g., days-ahead and season-ahead will be more important), as well as the inclusion of very long-term scenario projections.

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

Transitioning to net zero though the deployment of weather-dependent renewables (wind, solar, hydro), and demand-side flexibility increases the complexity and uncertainty of operating and planning energy systems. Short-term forecasts are subject to growing and varying levels of uncertainty that depend on weather and market conditions, and planning studies must go beyond supply adequacy to consider the weather-dependent nature of renewable energy and impact on whole energy system operability. In response, the energy sector has begun to develop and adopt tools for uncertainty quantification but is at the beginning of this journey. This project will innovate to provide new capabilities in uncertainty quantification on operational time scales (probabilistic forecasting from hours to weeks ahead) as well as probabilistic modelling of supply and demand for use in planning studies.

Today, point forecasts are the primary tool for gas demand forecasting, and these are driven by predictions of the residual demand for heating and electricity after production from weather-dependent renewables. However, point forecasts cannot capture the fact that some situations are more predictable (less uncertain) than others, and vice versa, with knock-on impacts for risk quantification and management. This project will produce new forecasting tools that are innovative in that they quantify forecast uncertainty and relate this directly to operational decisions by producing predictions of key variables, such as residual demand.

Similarly, scenario-based energy system planning, under pinned by the Future Energy Scenarios for example, provides a view of system-level futures, but not the detail required to examine the risk of impacts on system operation and how this may in turn impact infrastructure investment decisions. This work will develop a modelling framework capable of producing the detailed demand and generation data required (e.g., multi-decade hourly time series of wind and solar power production, electricity consumption, gas demand) to understand the impact of different energy scenarios on whole energy system operations under different scenarios.

A further innovative element of this project is the mechanism by which NGT will internalise these innovations. By working in collaboration with, and using data from, NGT, and defining code/software and documentation as deliverables, this project will produce tools that require only minimal further development to incorporate into business as usual.

Relevant Foreground IPR

This project and the resultant outcomes/deliverables will conform to the default treatment of IPR as set out under the agreed NIA Governance (where the default requirements address two types of IPR: Background IPR and Foreground IPR).

Expected Foreground IPR constitutes know-how related to the implementation of statistical and machine learning methods for energy forecasting and modelling, implementations of methods in code, and numerical analysis of forecast/model performance. These will be included as project deliverables and shared as widely as possible. Where contributions to extend the capabilities of open-source software (e.g. the ProbCast R package) are required these will be contributed to said software under existing open-source licence conditions.

This project will build upon Background IPR published in academic journals, industry reports, and implementations in open-source software packages. There are no restrictions beyond appropriate acknowledgement on the use of the background IPR for the project.

Data Access Details

Data for this project, and all other projects funded under the Network Innovation Allowance (NIA) funding scheme, can be found or requested in a number of ways:

A request for information (RFI) via the Smarter Networks Portal at https://smarter.energynetworks.org. National Grid Gas Transmission regularly publishes much of the data arising from our innovation projects on the ENA portal, before submitting a RFI check this website.

Via our managed mailbox box.GT.Innovation@nationalgrid.com. Further data can be shared upon request through the innovation mailbox. Each request will be assessed by the NGT Innovation Team for its merits and viability.

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

The forecasting and modelling capability required by NGT includes skills and effort not available as part of business as usual. The present forecasting and modelling functions of NGT do not have capacity to develop innovative tools on this scale. In addition, NGT is not currently incentivised to produce short-term probabilistic forecasts, and this means NGT cannot justify spending resources on developing this. The benefits of the improvements to the longer-term projections will require approaches that are (to the best of our knowledge) not currently business as usual in the UK energy sector, and therefore not certain to be successful. In addition, any cost benefits associated with implementing these methods may not be realised for many years, and may in fact be strategically beneficial to a far broader group of stakeholders than just NGT.

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 need addressed by this project is specific to NGT and requires skills and experience not available within the company. Risks are minimal, in that the forecasting and modelling capabilities required have been proven in an academic context, and similar technologies developed for other applications, however, no commercial solution exists, therefore necessitating this innovation project. No regulatory risks have been identified.

This project has been approved by a senior member of staff

☑ Yes