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

Oct 2024

Project Reference Number

NIA_UKPN0104

Project Registration

Project Title

AI for Visibility and Forecasting of Renewable Generation

Project Reference Number

NIA_UKPN0104

Project Licensee(s)

UK Power Networks

Project Start

October 2024

Project Duration

1 year and 5 months

Nominated Project Contact(s)

loukas.douvaras@ukpowernetworks.co.uk

Project Budget

£455,000.00

Summary

AI for Visibility and Forecasting of Renewable Generation aims to improve metered and behind the meter solar and wind generation forecasts to procure flexibility and reduce curtailment more efficiently, and better inform network investment. This will consist of the development of a machine learning algorithm that takes timeseries data from commercial customers and satellite imagery, weather forecasts and other open data to provide a live forecast service. This forecast will improve on the spatial and temporal granularity of existing forecasting, supporting the more efficient procurement of flexibility services and curtailment of generation, ultimately leading to financial savings for the DSO and customers, as well as CO2 savings.

Nominated Contact Email Address(es)

innovation@ukpowernetworks.co.uk

Problem Being Solved

The GB electricity grid is under pressure from the rising penetration of renewable energy sources necessary to meet net zero. The intermittency of this generation adds uncertainty to the power flows on the distribution network. Where physical assets are or could be overloaded, the distribution system operator (DSO) must act by curtailing renewable generation or purchasing flexibility services. This incurs a cost and is likely to rise as the distribution network connects more renewable capacity.

Adding to the challenge is significant behind the meter or unmonitored renewable generation where the connected capacity is not reliably reported, or recorded in the UK Power Networks' low carbon technology (LCT) register, and hence invisible to the DSO. Knowing the metadata (what is the asset, where is it connected, which way is it facing, etc) and generation profiles of this generation would reduce noise in the grid monitoring, further improving UK Power Networks' network visibility and short-term forecasting skill.

Improved forecasting of solar and wind generation assets connected to the distribution network will improve the visibility of power flows and enhance the DSO's overall forecasting precision. This will allow the DSO to:

- make better near-time decisions in the control room;

● optimise the procurement and dispatch of flexibility services; and
● manage grid constraints, which may enable greater connections of renewable generation.

Method(s)

Introduction to Open Climate Fix
This project will develop highly accurate forecasts for the renewable assets in the UK Power Networks licence areas and improving the estimate of behind the meter capacity on the UK Power Networks network.

Method
The project aims to improve our metered and behind the meter solar and wind generation forecasts to reduce our use of flexibility and associated costs and better inform our network investment. The proposed method for this project is technical research using UK Power Networks' data and open data in machine learning algorithms to implement a historical and live forecast service usable by UK Power Networks.

1. Metered generation: OCF will train AI algorithms on historical data and run a real-time forecast for the metered solar and wind generation on the UK Power Networks network. The AI algorithms consume data from weather forecasts, geostationary weather satellite imagery (rare in forecasting algorithms) and real-time weather-based generation readings to generate expected and probabilistic generation figures for the network. This builds on the experience OCF has in forecasting the national solar outturn, which will be extended to the solar and wind sites in UK Power Networks' region. The forecasts will be evaluated against UK Power Networks' existing forecasts of renewable generation to assess the improvement. The user focus will be on the forecasts being available in real-time to enable improved decision-making to reduce curtailment and help with real time network control.

2. Behind the meter/unmonitored generation: OCF will estimate the half-hourly behind the meter solar and wind generation on the UK Power Networks network. This innovation will compare metered data at substation level with the theoretical wind and solar generation predicted by a machine learning algorithm using historical weather observations. Across a long history, this should enable the estimation of the renewable capacity in each region. Disaggregation techniques have been used by OCF in domestic settings and their effectiveness will be tested at the network level. The estimates of generation will be undertaken across our entire network. Through work across OCF and UK Power Networks' Forecasting team, the project will provide a more nuanced and reflective estimate of the business value of improved forecasts to UK Power Networks.

Scope

This project scope aims to improve forecasts for all solar and wind generation within UK Power Networks' network, including both metered and behind the meter. Employing technical research and machine learning algorithms, OCF will analyse data from UK Power Networks and open sources.

OCF will train AI algorithms on historical data to deliver real-time forecasts, incorporating satellite imagery for heightened accuracy. Evaluations will compare AI-generated predictions with existing UK Power Networks' forecasts, enhancing decision-making in the control room.

A key innovation involves estimating behind the meter solar and wind generation capacity, utilising machine learning algorithms and comparing metered data at the substation level. The DSO will be able to reduce spend on procuring flexibility services through the use of more accurate generation profiles.

The forecast model will be made available to UK Power Networks via an API for use in the DSO's operations.

Objective(s)

The objective of the project is for the DSO to have improved forecasts across intra-day and day ahead horizons compared to the current model in use, to improve day ahead flexibility decisions and real time network control. This will be delivered through:
• Improved accuracy of generation forecasts for metered generation
• Improved understanding of capacity of unmonitored/behind the meter generation

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

The project looks to create cost savings related to reducing flexibility procurement. Savings are shared across all customers equally.

Success Criteria

The project aims to develop a forecasting model that provides a meaningful improvement in forecast accuracy for metered sites and provides an approach to unmonitored renewable capacity estimation. The data will be made available through an API which can be

used with our existing forecasting system. The success criteria are:

1. Forecasting accuracy improvement
Meaningful improvement in accuracy compared to forecasts using Global Forecast System (GFS) weather forecasts, demonstrating the effectiveness of the newly developed forecast algorithms. Probabilistic forecast accuracy will be assessed by measuring quantile exceedances and pinball loss. 10th and 90th percentiles will be assessed.

2. Unmonitored renewable capacity estimation
UK Power Networks to improve its energy accounting of behind the meter wind and solar generation capacity at the DNO level. Report (project milestone 3.3) will include an estimate and the uncertainty on the estimate.

3. Evidence of potential efficiencies
Initial assessment has suggested that this implementation has the capacity to reduce flexibility purchasing costs by ~1.5% after the system is operational leading to cost reductions as detailed in Section 3.2. The level of improvements seen in forecasting accuracy and capacity estimation, over the course of the project, should provide an indication that this forecasted cost reduction is attainable over the longer term.

Project Partners and External Funding

Open Climate Fix (OCF) will be the primary partner delivering the work. They are a non-profit lab focussed on delivering artificial intelligence (AI) solutions to help the electricity grid run on high renewables penetration. OCF will work closely with the UK Power Networks' DSO forecasting team, academics in the renewable forecasting field and contractors for specific user-interface design tasks.

Potential for New Learning

The potential for new learning is in developing new algorithms for more accurate generation forecasts of metered assets and for determining a way to forecast generation from unmetered assets. These algorithms will be open source, so other organisations will be able to benefit from the learnings.

Scale of Project

The forecasting model generated by this project will be used by the DSO to inform flexibility and curtailment decisions across the UK Power Networks network and the costs associated with researching and developing the underlying algorithms would not be reduced by reducing the geographic scale of the project. Therefore, it is essential that the project covers all of UK Power Networks' three licence areas.

Technology Readiness at Start

TRL4 Bench Scale Research

Technology Readiness at End

TRL9 Operations

Geographical Area

The project will cover all three licence areas of UK Power Networks

Revenue Allowed for the RIIO Settlement

No funding was provided within the current RIIO-ED2 settlement that will become surplus to requirements as a result of this project.

Indicative Total NIA Project Expenditure

We estimate UK Power Networks' total project budget will be £455,000, of which £409,500 (90%) will be recovered from NIA.

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 project is specifically focussed on renewable technologies, seeking to increase efficiency in flexibility procurement and result in a lowering of costs to support the distribution network where there is high renewable penetration, through improved forecasting of solar and wind. This in turn will allow the DSO to manage grid constraints, reduce renewable generation curtailment and has the potential to enable greater connections of renewable generation. In addition, it is envisaged that this approach will lead to an improved understanding of capacity of unmonitored/behind the meter renewable generation at the DNO level. More broadly, the data to be shared with the ESO may aid in their renewable map, allowing better estimates of renewable generation, better forecasts and ultimately better decisions on grid connections.

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

N/A – Cost savings related to reducing flexibility procurement costs are shared across all customers equally.

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 – this is a RIIO-ED2 project.

Please provide a calculation of the expected benefits the Solution

The total forecasted benefits including social return on investment for UK Power Networks are £2,378k over RIIO-ED2 and £5,459k over RIIO-ED3.
The quantifiable financial benefit arises from increased efficiency in flexibility markets and the resultant lowering of costs to support the distribution network where there is high renewable penetration. The quantifiable social return on investment arises from the reduction of curtailment of renewable generation.

Quantified Financial Benefit
Reduction in flexibility procurement
The base costs were calculated using published flexibility costs (ukpowernetworks.opendatasoft.com/explore/dataset/UK Power Networks-flexibility-dispatches/), 40% of costs for UK Power Networks in the four months through to October 2023 are paid out to reduce the oversupply of generation, usually weather dependent renewables, when demand is low. The base cost is £26,029k over RIIO-ED2 and £98,675k over RIIO-ED3.
The UK Power Networks DSO's forecasting team uses forecasts of renewable generation across the UK Power Networks regions to predict these events and to procure flexibility services. Through having access to more accurate forecasts, the DSO will be able to forecast likely constraints more accurately. This will allow the DSO to procure and dispatch flexibility services on fewer occasions, and at lower volumes while maintaining the same risk appetite. We estimate this would save in the order of 1.5% of costs due to such future events.
From the published figures, oversupply flexibility services cost over £500,000 over a four-month period (at time of writing), or around £5.4m per year. Flexibility is expected to grow as renewable generation increases on the existing infrastructure, so we have assumed an annual growth rate from 2025 to 2028. If we assume a modest efficiency gain of 1.5% on flexibility procurement, this delivers a

cumulative saving of £559k over four years to end of RIIO-ED2. Benefits will be £1.48m in RIIO-ED3.

Non quantified benefits:
Tailored forecasts
To enable whole system coordination, the service should be tailored to UK Power Networks. This requires regional aggregations of renewable generation at the primary and secondary level that are probabilistically coherent with each other and with demand forecasts. This means probability distributions must be aligned or correlated, not simply aggregated. Forecasts for individual weather ensemble members can be used to align with UK Power Networks' internal forecasts. The control room will have access to a user interface (UI) which can be deployed for granular real-time visibility.
Behind the meter renewable capacity
There is a significant amount of renewable generation behind the meter. A significant proportion of this embedded renewable capacity is unmetered or invisible to UK Power Networks. At the national level the uncertainty in the estimated total capacity of installed solar photovoltaic (PV) is the most significant source of error when estimating national or regional solar PV generation. To quote a recent paper from Sheffield Solar, "We find that the capacity error, at ±5%, dominates the yield calculation error, at < ±1% and leads to an overall error in GB solar PV output estimates of ±5.1%". [https://www.sciencedirect.com/science/article/pii/S1364032121012636]. This uncertainty nationally of up to 10% would tend to increase as you move to smaller aggregation levels as the averaging of noise across multiple regions is reduced. Therefore at grid supply point (GSP) or primary level, the error could be double that figure. OCF's project includes research and development to improve the energy accounting of renewables in the UK Power Networks regions. The research uses half-hourly substation load figures and the modelling of expected renewable generation given known weather conditions to infer the behind the meter renewable capacity in each primary and secondary substation area. This should have a significant impact on the accuracy of the end forecast as well as giving UK Power Networks a much-improved capacity map.
ESO – better grid connections & grid awareness
The outputs of this project (the capacity map) could be used as part of improving the overall energy accounting of renewable capacity in the UK Power Networks region. These forecasts and capacity estimates could aid the ESO's grid awareness, allowing better estimates of renewable generation, better forecasts and ultimately better decisions on grid connections.

Quantified Societal Benefits
Social benefits for this project are forecasted to total £1,819k across RIIO-ED2, and £3,979k through RIIO-ED3. This equates to a total SROI of 11.02
Reduced Curtailment
Improved forecasting will enable the DSO to more smartly manage distributed energy resources (DERs), including distributed energy resources management system (DERMS) settings and dynamic trim limits. These will enable the DSO to reduce the amount of curtailment that it enforces on generators providing a financial benefit to generators and a carbon reduction saving.
The benefits of reduced curtailment have been modelled using the same approach that UK Power Networks used in our RIIO-ED2 Business Plan. This takes the forecast uncurtailed annual energy generated by solar and onshore wind and assumes a 10% reduction each year. We have assumed that this innovation would contribute to 10% of that figure. Using an expected financial benefit for customers of £50/MWh, as well as the carbon intensity of the grid and carbon price each year, we arrive at the following social return on investment (SROI) benefits.
Customers are expected to save £1.7m in RIIO-ED2 and £4m across RIIO-ED3, and there are carbon savings worth £185K and £641k in RIIO-ED2 and RIIO-ED3 respectively.
Total NPV: (Base - Method + (Benefits (DNO/DSO) + (Societal Benefits)) = £7,598k

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

Whilst this project will focus on developing highly accurate forecasts for the renewable assets in the UK Power Networks licence areas, OCF develops the Intellectual Property in the open source using an MIT licence originating from the Massachusetts Institute of Technology). The algorithms are not specific to UK Power Networks' network and can therefore be scaled across GB by substituting data from UK Power Networks' area with that from other operators.

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

The solution will not require significant rework for uses in other licence areas. Therefore, the costs of roll out would be minimal. The ongoing cost required for upkeep of the solution is estimated to be around £35k annually.

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 potential for new learning is in developing algorithms for more accurate generation forecasts of metered assets and for determining a way to forecast generation from unmetered assets. These algorithms will be open source, so other organisations will be able to benefit from the learnings.

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 – RIIO-2 Project

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.

As far as we have been able to ascertain, this type of solution at the same level of sophistication is not being used in a production-level setting anywhere in GB. Separating PV and wind generation from historical substation meter data is also novel both in GB and globally. We therefore believe that this project will not entail any unnecessary duplication.

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

OCF has developed, trained and is running national solar PV generation forecasting for the ESO. For the ESO they have reduced solar forecasting error by 40-50%. However, the technology innovation proposed for this project extends that technique using site level forecasts of PV. This is not performed in the sophistication we are employing to our knowledge in a production service today.

OCF believe that the disaggregation of the PV and wind generation from historical substation meter data is new as a practical implementation.

Relevant Foreground IPR

The project expects to create several elements of foreground IPR. These consist of:
Forecast algorithms and machine learning models:
Newly developed algorithms for forecasting PV and wind site performance, and machine learning models integrated into the production pipeline.

Pilot and beta forecast services:
The operational pilot and beta services, including API.

Behind the meter renewable capacity mapping:
The mapping and analysis tools for behind the meter renewable capacity by region; techniques and methodologies for estimating and integrating unmonitored renewable capacity into forecast models.

There may be elements of Background IPR required to develop the Relevant Foreground IPR. Use of this is granted by the agreement for both the purposes of carrying out the Project and repeating or replicating the results of the Project

Data Access Details

To view the full Innovation Data Sharing Policy, please visit UK Power Networks' website here:
https://d1oyzg0jo3ox9g.cloudfront.net/app/uploads/2023/10/UKPN-InnovationDataSharingPolicy-Nov-23-v1.0.pdf
UK Power Networks recognises that Innovation projects may produce network and consumption data, and that this data may be useful to others. This data may be shared with interested parties, whenever it is practicable and legal to do so, and it is in the interest of GB electricity customers. In accordance with the Innovation Data Sharing Policy, UK Power Networks aim to make available all non-personal, non-confidential/non-sensitive data on request, so that interested parties can benefit from this data.

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

This project involves an approach unproven in its level of sophistication. This introduces risk that quality forecasts are not produced, meaning that the benefit to DSO flexibility procurement is not realised. There is also a risk around the possible quality and availability of certain data sources required for the project to be successful. These risk factors, combined with the need to collaborate with OCF to produce a new and innovative forecasting model using advanced techniques, mean that the project extends beyond the network licensee's usual scope.
Due to the risk and transformative nature of these goals, additional support is necessary to ensure they have a reasonable chance of realisation. The high risk, lower technology readiness, and overall uncertainty of the business case, given the factors outlined, prevent these activities from being carried out as part of UK Power Networks' regular operations

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

This project can only be undertaken with the support of NIA due to the operational risks and uncertainty of developing such a solution as outlined in Section 3.5.2. Whilst OCF have experience in solar PV forecasting, wind generation and the inference of embedded capacity is new. This means that the accuracy of the forecasting provided is unproven. There is a risk that substation level data is not available for the project, which would limit OCF's ability to produce accurate forecasts, and that that the behind the meter capacity estimation produces low quality results. As per the NIA guidance, certain projects are speculative in nature and yield uncertain commercial returns. This is the case with this project. If the solution does not provide the expected results, it would mean that the project does not benefit DSO flexibility procurement and weaken the benefits case.

This project has been approved by a senior member of staff

☑ Yes