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 10 months

Nominated Project Contact(s)

Wayne Saggers

Project Budget

£389,444.00

Summary

Forecasting unmetered solar energy with AI aims to improve visibility and forecasting of unmetered solar generation. This will allow UK Power Networks to better anticipate network power flows. This should deliver lower flexibility procurement costs, reduced renewable curtailment and better-informed long-term network planning, resulting in lower costs for end users. The project will develop a machine learning (ML) algorithm to infer the capacity of unmetered solar generation installed behind substations. Capacity estimates feed into a solar forecast algorithm to produce forecasts of unmetered solar generation at primary substations. This forms an important input to the forecasting team's system modelling. This capacity is currently hidden from UK Power Networks' forecasting capabilities, and having improved estimates will allow better understanding of rooftop solar capacity growth to help calibrate strategic reinforcement planning.

Nominated Contact Email Address(es)

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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)

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.

The project aims to estimate behind-the-meter solar capacity generation 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 (timeseries data from commercial customers, under NDA) and open data in machine learning (ML) algorithms to implement a historical and live forecast service usable by UK Power Networks.

Estimate the behind the meter/unmonitored PV generation capacity

The project will develop models to infer the behind-the-meter solar generation capacity on UK Power Networks' network. The innovation will compare metered data at substation level with the theoretical solar generation predicted by an ML algorithm using historical weather and satellite data. Across a long history, this should enable the estimation of the renewable capacity in each region. Disaggregation techniques have been used by Open Climate Fix in domestic settings and we believe they can be applied effectively at the network level. The estimates of generation will be undertaken across our entire network.

Secondly, the project will develop and implement several methods to validate the behind the meter capacity estimates. Since the "ground truth" figures do not exist, more than one method will be used, from advanced simulation techniques using synthetic profile data to manual observation of the panels installed. The final capacity estimates will be accompanied by a level of confidence. The capacity estimates will allow UK Power Networks to understand historical capacity and estimate future PV capacity.

Forecast for behind-the-meter PV generation at primary substation level

The project will develop forecast algorithms for behind the meter PV solar generation on UK Power Networks' network. Once the behind the meter capacity is estimated, prototype forecasting algorithms will be created to predict solar generation and tested using historical data through back testing.

A live data pipeline will be built to process real-time inputs, enabling operational forecasting. A pilot service, including an API and user interface, will provide live forecasts while user feedback and performance analyses refine the model.

Scope

Prior to the commencement of work on this project, UK Power Networks' existing weather provider enhanced their offering, giving us major access to a one-hour updating ultra fine-tuned prediction model that incorporates satellite imagery. This meant that much of what was planned for work package 1 was no longer required and, therefore, continuing with the original scope no longer represent value for customers' money. As a result, the project has been rescoped to focus on behind the meter solar generation. The elements that have been descoped are:

- Realtime forecasting of metered solar and wind generation
- Half-hourly estimation of "behind the meter" wind generation

The project is therefore able to be delivered more efficiently, with a reduced budget. We are aware that the objectives and success criteria cannot be changed once registered, however the project in its revised scope still provides targeted and justifiable benefits. The reasons for any benefits or success criteria not being met as a result of the rescope will be documented in the final report.

The AI for Visibility and Forecasting of Renewable Generation project aims to enhance UK Power Networks' ability to forecast unmetered solar energy generation. By developing a machine learning algorithm, the project will infer the capacity of unmetered solar generation installed. This capacity estimate will feed into a solar forecast algorithm, producing forecasts of unmetered solar generation at primary substations.

The improved visibility and forecasting capabilities will enable UK Power Networks to better anticipate network power flows, reduce flexibility procurement costs, minimise renewable curtailment, and inform long-term network planning. Ultimately, this project seeks to deliver lower costs for end users and support the transition to a more sustainable energy system.

The scope of the project is segmented into the following work packages:

Work Package 1 – Data Readiness and Research

This work package will identify and collate all the relevant data sources required for the development of the service. It will then undertake appropriate data cleansing to ensure that it is of suitable quality and in the correct formats ready for use.

Work Package 2 – Algorithm Development and Prototype Testing

This work package will build the first iteration of the forecasting service. It will create the AI components needed to deliver the service and will be tested to verify that the capacity estimates it produces are valid.

Work Package 3 – Quality Forecast Service for Sites

This work package will seek to improve the accuracy of the service that was produced in Work Package 2. This will be achieved by refining the AI model based on the results of the testing carried out. A report analysing the accuracy of the machine learning model will be produced to support this work.

Work Package 4 – Project Management

Work Package 4 will undertake the supporting tasks required to ensure the successful delivery of the project. These include an initial kick-off meeting, regular weekly and monthly progress meetings, and governance activities to manage risks and capture any lessons learned. It will also track milestones and costs to manage project scope and progress.

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

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.

The partners will not be providing funding.

Potential for New Learning

The potential for new learning is in developing new algorithms 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 £389,444, of which £350,500 (90%) will be recovered from NIA.

Project Eligibility Assessment Part 1

Requirement 1

Facilitate the energy system transition and/or benefit consumers in vulnerable situations

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

N/A – this is a RIIO-ED2 project.

Please provide a calculation and/or description of the expected benefits of the solution

The total forecasted benefits including social return on investment for UK Power Networks are £901k over RIIO-ED2 and £2,024k over 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

The financial benefits for this project are forecasted to be £370k across RIIO-ED2, and £823k through ED3. The details and assumptions of these calculations is below.

Reduction in flexibility procurement

The UK Power Networks DSO's forecasting team uses forecasts of renewable generation across the UK Power Networks regions to procure flexibility services. Through having access to more accurate forecasts, the DSO will be able to estimate 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.

Open Climate Fix's solar forecast work with NESO reduced the demand error by 7%. Given that this project expands on this work by also improving the capacity estimation, this would likely be a conservative estimate. Based on this, UK Power Networks should be able to purchase flexibility more precisely by this amount. However, solar is not always the driver of flexibility requirements, and there is already good solar forecasting for metered capacity. We have therefore estimated that 15% of the improvement in error is likely to

be attributed to the new solution, providing 1.05%

UK Power Networks' Flexibility Dispatches Dataset shows that 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 1.05% on flexibility procurement, this delivers the cumulative savings outlined above.

Quantified Societal Benefits

Social benefits for this project are forecasted to total £531k across RIIO-ED2, and £1,201k through ED3 This corresponds to a social return that is 12.37 times the original investment. The details and assumptions for these calculations are below.

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 by taking the total reduction in curtailment due to dynamic outage management, and then applying a 1.05% scaling factor to account for the proportion of this reduction that will likely be attributable to the new service. This is then multiplied by the carbon benefit and energy price (£85/MWh).

Carbon savings are worth £70K and £261k in RIIO-ED2 and ED3 respectively.

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. The 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.

NESO – 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 NESO's grid awareness, allowing better estimates of renewable generation, better forecasts and ultimately better decisions on grid connections.

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

Projects 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

Involve Research, Development or Demonstration - Please select all that apply

☐ 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.

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. Networks must explicitly mention similar projects that they have considered and how these differ.

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 a part 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