nationalgridESO

Notes on Completion: Please refer to the appropriate NIA Governance Document to assist in the completion of this form. The full completed submission should not exceed 6 pages in total.

NIA Project Registration and PEA Document

Date of Submission

Sep 2021

Project Reference

NIA2_NGESO002

Project Registration

Project Title

Solar PV Nowcasting

Project Reference

NIA2_NGESO002

Project Licensee(s)

National Grid Electricity System Operator

Project Start

September 2021

Project Duration

1 year and 11 months

Nominated Project Contact(s)

Lyndon Ruff

Project Budget

£500,000.00

Summary

Using Deep Machine learning techniques, this project is exploring whether if we had more accurate predictions for solar electricity generation then we could reduce the amount of "spinning reserve" required. This would reduce carbon emissions and reduce costs to end-users, as well as increase the amount of solar generation the grid can handle

Nominated Contact Email Address(es)

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Problem Being Solved

Today, solar electricity generation causes problems for electricity grids: the power generated by solar generators changes rapidly as clouds move overhead and existing forecasts struggle to predict clouds, which means they struggle to predict solar generation.

Due to the lack of good solar electricity forecasts, electricity grid system operators have no choice but to "firm up" solar electricity generation with fossil-fuel-powered "spinning reserve" generators. This is carbon-intensive and expensive.

This project is exploring whether if we had more accurate predictions for solar electricity generation then we could reduce the amount of "spinning reserve" required. This would reduce carbon emissions and reduce costs to end-users, as well as increase the amount of solar generation the grid can handle.

Method(s)

The project proposes to create more accurate forecasts for solar electricity generation by applying machine learning (ML) to satellite imagery and numerical weather predictions. By undertaking the following work packages:

- Trial and prototype a functional solar forecasting system
- Test delivered forecasts to the UK National Grid Control Room. Working closely with users to ensure we meet operational needs.
- Development and measure the impact on the grid's carbon intensity and costs.

The project will look to develop a ‘Deep Learning’ machine learning model which takes a sequence of recent satellite images and numerical weather predictions. The model will output probabilistic solar electricity nowcasts for each PV system in the country, these will be calibrated in near-real-time using live solar electricity data.

‘Deep Learning’ models can handle huge amounts of data, so we will train the model across the entire geographical extent of the satellite imagery (not just the areas which happen to have solar electricity systems). As such, the model will be trained to predict the next few frames of satellite imagery as well as solar electricity generation.

Scope

The project is split into three different work packages:

WP1 - Design
Research & develop the use of machine learning & satellite images to nowcast PV power generation at GSP-level. Research will be conducted in close collaboration with academia & industry.

WP1 will include the following:

- Use historical data to train machine learning models.
- Evaluate forecast skill using historical data.
- Compare against ESO's current approach; and ESO's approach + gridded NWPs; and CM SAF.
- ML model output: Probabilistic predictions for total solar PV power generation for each GSP at 5-minute intervals.
- The system will also estimate PV outturn 'now' (situational awareness).
- Calibrate forecasts in near-real-time using live PV power data.
- Static designs for user-interface (UI)

WP2 – Prototype Development

Research & develop a prototype of real-time PV nowcasting system. Research how to present nowcasts to Control Room users via an interactive web user-interface. Build a prototype of API & web UI & nowcasting engine capable of running in real-time.

WP2 will include:

- Develop operational requirements with Control Room engineers
- Research ways to run the nowcasting ML models every 5 minutes for all of the 1 million PV systems in the UK.
- Develop a suite of PV nowcast performance validation metrics
- Build a functional prototype of nowcasting system & web user interface.
- Expose PV nowcasts via the API for PEF implemented in work package 1.
- The UI will give an overview of the country's UK PV fleet and also allow the user to drill into details.

WP3 – Prototype Demonstration
Evolve nowcasting system through multiple rounds of user feedback. Quantify impact on grid balancing.

WP3 will include:

- Feedback, evolve, develop with Control Room engineers to learn what they do and don't like about the prototype PV nowcasting system.
- Quantify the effect of PV nowcasting on balancing costs & CO2 emissions (building on the Control REACT NIA project).
- Explore using probabilistic PV nowcasts to dynamically set reserves (working with the Dynamic Reserve NIA project).
- Explore ways to measure users' interactions with the PV nowcasting system.
- Research ways to blend PV Live with PEF's half-hourly PV forecasts with OCF's 5-minutely PV nowcasts.

Objective(s)

The project proposed to complete the following objectives:

1. Research report comparing the performance of our 'Deep Learning' nowcasting system against other forecasting techniques (including ESO's current approach).
2. Cost estimates for running business-as-usual (BaU).
3. Prototype web UI & PV nowcasting service running in real-time. Including a suite of validation metrics.
4. Report on the feasibility of running ML-powered PV nowcasts in real-time.
5. Developed and socialized agile/CI/CD methodology.
6. Workshop on implementing satellite-powered nowcasts BaU.
7. Workshop on agile/CI/CD in critical energy applications.
8. Joint proposal with ESO for candidate adjacent project with planning on cadence and target level of agile/CI/CD.

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 as a whole and those in vulnerable situations. Benefits to all consumers are detailed below.

Success Criteria

Project success will be defined by:

1. Demonstration of improved PV nowcasting skill compared to ESO's existing PV forecasting approach.
2. Delivery of a prototype of PV nowcasting service.
3. Measured change in balancing costs & CO2 emissions. User satisfaction. Identified next steps to apply agile/CI/CD to a future NGESO project.

Project Partners and External Funding

Project partners: Open Climate Fix (OCF) will be undertaking the work.

External funding: NA

Potential for New Learning

The following hypotheses will be tested as part of this project:

1. Machine learning with satellite imagery gives better short-term PV forecasts than the current state of the art.
2. The ML model can be run in real-time, every 5 minutes.
3. This torrent of forecast data can be presented via an intuitive UI.
4. Agile software development with frequent user-feedback delivers quality software at relatively low development costs.
5. Better PV nowcasts will reduce balancing costs & CO2 emissions.

These learnings will be disseminated via:

- Research report comparing the performance of our 'Deep Learning' nowcasting system against other forecasting techniques.
- Final report (including impact assessment, detailed assessment of options for running BaU and lessons learned from agile/CI/CD approach).
- Workshop on implementing satellite-powered nowcasts BaU.
- Workshop on agile/CI/CD in critical energy applications.
- Joint proposal with NGESO for candidate adjacent project with planning on cadence and target level of agile/CI/CD.
- Open-source code & openly published research results.

Scale of Project

This project will span 18 months involving a total of three work packages.

Technology Readiness at Start

TRL3 Proof of Concept

Technology Readiness at End

TRL6 Large Scale

Geographical Area

The project will focus on the whole of the UK by combining satellite images with numerical weather predictions from the UK Met Office and other data sources.

Revenue Allowed for the RIIO Settlement

None

Indicative Total NIA Project Expenditure

£500,000

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 energy system is going through rapid and extensive change, with changes in supply and demand. This project will facilitate the ESOs role though the energy system transition with better visiblity of Solar PV.

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

Not required.

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)

There are two routes to measure the benefits of the PV Nowcasting project:

- More optimal use of Balancing Mechanism (BM) dispatch, Fast Reserve and SpinGen/Pump through providing improved information for Control Room decision making.

Benefits are in two stages:

1. A web UI for the Control Room to take improved close to real-time decisions. No outside dependencies.
2. Improved forecasts feeding from a Nowcasting API into Demand Predictor application in the Control Room

- The Dynamic Reserve NIA project will enhance the benefits, but benefits will still be realized independently of this project.
- Lower Regulating Reserve and PV Reserves due to better forecasts feeding into the system operating plan (SOP) for the Control Room.
- There is a direct dependency on the Dynamic Reserve project to realize this benefit

The NGESO and OCF teams estimated the reduction in costs to be in the range of £1M to £60M per year. The wide range reflects the multiple levels of uncertainty.

Please provide a calculation of the expected benefits the Solution

This project is starting as a research project. However, the above value is estimated based on a host of assumptions that will be tested and validated during the project.

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

The method is highly replicable and could be applied to any network area across GB.

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

This research will be done on a national level across GB already.

Requirement 3 / 1

Involve Research, Development or Demonstration

A RIIO-1 NIA Project must have the potential to have a Direct Impact on a Network Licensee's network or the operations of the System Operator and involve the Research, Development, or Demonstration of at least one of the following (please tick which applies):

☐ A specific piece of new (i.e. unproven in GB, or where a method has been trialled outside GB the Network Licensee must justify repeating it as part of a project) equipment (including control and communications system software).

☐ A specific novel arrangement or application of existing licensee equipment (including control and/or communications systems and/or software)

☐ A specific novel operational practice directly related to the operation of the Network Licensees system

☐ A specific novel commercial arrangement

RIIO-2 Projects

☐ A specific piece of new equipment (including monitoring, control and communications systems and software)

☑ A specific piece of new technology (including analysis and modelling systems or software), in relation to which the Method is unproven

☑ A new methodology (including the identification of specific new procedures or techniques used to identify, select, process, and analyse information)

☐ A specific novel arrangement or application of existing gas transportation, electricity transmission or electricity distribution equipment, technology or methodology

☐ A specific novel operational practice directly related to the operation of the GB Gas Transportation System, electricity transmission or electricity distribution

☐ A specific novel commercial arrangement

Specific Requirements 4 / 2a

Please explain how the learning that will be generated could be used by the relevant Network Licensees

n/a

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

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.

No other projects innovation projects (IFI, LCNF, NIA or NIC) have explored Solar PV Nowcasting.

NGESO is aware of an Innovate UK funded project but there are differences in approach, scalability and applicability to NG ESO processes and control systems.

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 project is novel for the GB energy system but internationally (significant specialisation is needed for the GB system).

Relevant Foreground IPR

The following is expected to be delivered from this project:

- Open source research code and results
- Research Report: PV Nowcasting using deep learning
- Research Report: Feasibility of running ML powered PV Nowcasts in real-time
- Final Report

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

Use of machine learning methods have not been used for PV forecasting for the GB system before.

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 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.

This project has been approved by a senior member of staff

☑ Yes