REPORT

Solar PV Nowcasting Using Deep Learning

Feasibility of Running ML-powered PV Nowcasts in Real Time.

OPEN CLIMATE FIX

Prepared by	Open Climate Fix Limited
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Acronyms

API	Application Programming Interface
AWS	Amazon Web Services
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
GB	Gigabyte
GSP	Grid Supply Point
ML	Machine Learning
NIA	Network Innovation Allowance
NG-ESO	National Grid Electricity System Operator
NWPs	Numerical Weather Predictions
OCF	Open Climate Fix
PV	Photovoltaic
PEF	Platform for Energy Forecasting
RSS	Rapid Scan Service
UI	User Interface
WP {1, 2, 3}	Work Package (for example, "WP1" stands for "Work Package 1")

Table 1. Table of common acronyms used in this document.

Executive Summary

One of the key goals for the NIA project is to put the cutting edge ML research into a service that is running in real time for users within NG-ESO, and specifically within the control room. The WP2 Progress Report describes the progress achieved through WP2.

We are confident that we are in a good position to deliver a production service by the end of the project. We are delivering the first alpha release in July this year, which will allow us to identify any outstanding issues. This document outlines our status and anything that is required to be done through WP3.

Data Access

As with any machine learning model, having access to the data for training and inference (forecast) time is essential. The following data types are used in the forecast.

Satellite Data

We are gathering satellite data from EUMETSAT's five-minutely Rapid Scan Service (RSS) that covers Europe and North Africa. While the scan happens every five minutes, the data is not available for between half an hour and one hour after collection, meaning the input satellite data to our models is not real time during inference.

Additionally, the service goes down for 48 hours every 26 days, as well as for a whole month each year. During those times, we can fallback to the 15-minutely full disk scan data and interpolate between each frame to get a close approximation of the RSS imagery. The full earth disk data is more compute intensive to process, which must be addressed in our data pipeline, but we are working to use the Data Tailor service to only download the data our models use.

Numerical Weather Predictions

We are collecting Numerical Weather Predictions (NWPs) data from Met Office Weather DataHub. These models are computationally expensive to run, so each model takes roughly one hour to run, and therefore live data is slightly delayed.

PV Actual Outturn Data

We are currently getting five-minutely PV data from PvOutput.org. This is for approximately 1,000 systems across the UK. Sheffield Solar are providing GSP-level solar generation data via PVLive. They are also providing us with five-minutely PV data

from approximately 750 systems across the UK. By using two data providers for PV data we are reducing the risk of not having any PV data for our ML models.

Integration of the Service Within NG-ESO

There are two routes to integrating the forecast service into the control room's decision making. The first is to make the service available via a UI on the public internet, and the second is to have an API integration with the NG-ESO automated systems.

Open Climate Fix will deliver both routes by the end of the project. The UI is under development and will be available in July 2022.

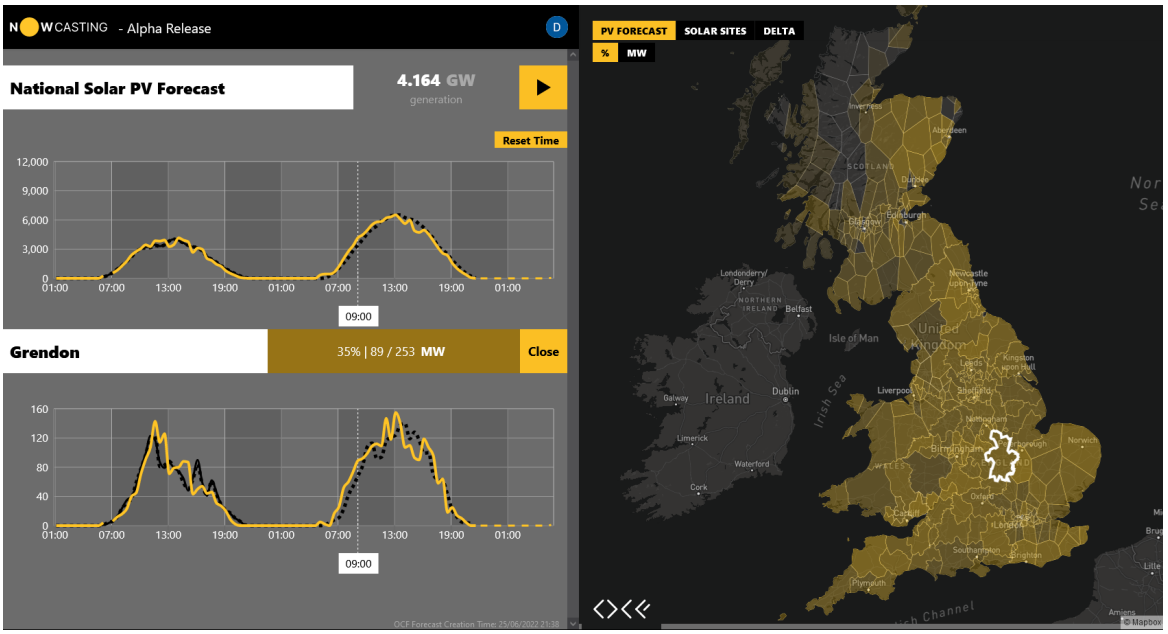

Figure 1. UI of the OCF Nowcasting service in its current stage of development.

The UI is still evolving, but it has the advantage that it will be available to NG-ESO staff with only a login required and no additional IT integration.

The API integration requires the NG-ESO systems to be ready to receive the information, which includes scoping how this information would be used and ensuring it is integrated in the right way. This is a business analysis task as well as an IT integration task. Open Climate Fix will be talking to Sumit Gumber from NG-ESO PEF through WP3 on if and how this might be feasible. We are not expecting this would be achieved in 2022, but by the end of the year we would ideally have a high-level understanding of what would be required to do so.

Costs of Running the Service

The following sections cover the costs for collecting data, and the cost of running the forecasting service on AWS. It does not include training costs, or staff costs. These will be estimated throughout WP3.

Data Costs

Some elements of the input data must be purchased commercially. These are outlined in the table below:

Data Feed	Cost (per month)
Satellite Imagery	£600
PV Data (PVoutput.org)	£67
Numerical Weather Predictions	£423
Total	**£1,090**

Table 2. Cost of data input elements.

The costs are considered to be relatively firm. It may be possible to work with NG-ESO to split the costs of the NWPs in the future which could reduce the total cost. However, since it's not possible at the moment, we did not account for that in our calculations.

Inference and Presentation Computing costs

Item	Cost (per month)
Cloud compute	£1,167
Storage	£1,056
Tools	£440
Total	**£2,663**

Table 3. Cost of computing costs input elements.

These costs are estimates made using our current understanding of the hardware requirements and using the AWS costs calculator. These may be subject to change as we learn more from the alpha service release coming in July this year. We assume three different environments are running: production, testing and development (note that testing and development are sized to be at 50% of production). Storage costs

include both file storage and database costs. It may be possible to reduce some costs by investigating some cost reductions through software efficiency measures.

People costs

There will be staff costs to support the service which includes:

- Ensuring the service is running for required hours;
- Providing client support, help & training;
- Fixing bugs or issues;
- Folding in enhancements or feature requests from the users and keeping the service up to date with the latest research.

The level of support required will depend significantly on the NG-ESO expectations around these - particularly if we will support through a Service Level Agreement.

These can be discussed through WP3.

Risks

While we are very positive that we can successfully implement this service into production before the end of the project, which is evidenced by the alpha release of the service being available in July, almost six months in advance, it is important to highlight any potential risks we envisage. The table below summarises key risks that we expect in the final phase of the project as well as mitigation measures that will help us to ensure a smooth delivery.

It should be noted that these risks for the service delivery are all small and medium in likelihood and severity, but the impact measurement is at risk.

Risk	Likeli-hood	Severity	Mitigation
Lack of access to real-time data from individual PV systems. Impact could be slightly less accurate forecasts than possible otherwise.	M	L	In addition to using PV data from PVOutput.org we have approached Sheffield Solar and gained access to their real-time data. By having access to two datasets we mitigate the risk of reduced forecast accuracy.
API integration with NG-ESO relies on other projects and resources at NG-ESO being available.	M	M	We will be working with Sumit Gumber through WP3 to identify how we can best progress this. In the short term, the UI still has use for the control room without API

			integration.
Getting engagement with control room users to determine future features or changes.	L	M	We have had very good engagement with Alex Carter to date and he is involving more of his team. An ongoing risk, but reduced to a low likelihood at the moment.
It is possible that measuring impact of the new forecast may not be possible during the project lifecycle.	H	M	OCF plans to engage with NG-ESO on this matter early in WP3 to come up with a joint mitigation plan as this task will require close engagement with the relevant NG-ESO team.

Opportunities

In order to ensure NG-ESO and the electricity system as a whole is maximising their benefits from the NIA project, we consider the opportunities to benefit from this work beyond the project completion.

Firstly, Open Climate Fix has been successful in being awarded funding from Innovate UK's Open Source Solutions for Net Zero. In this project, we will forecast PV production for individual systems. We are expecting the work from the NG-ESO NIA project will feed into this coming project and make it a success - including the machine learning, the infrastructure and the UI. This will benefit PV systems from solar+storage installations to PV farms to smart homes. This in turn may be of interest to NG-ESO in the future, if there's an interest in forecasting large individual systems.

Secondly, we are looking forward to discussing how the forecasts produced in this report may be of use to NG-ESO as an ongoing service after the end of the NIA project in December. We expect this will be the subject of discussions through WP3.

Next Steps

Throughout WP2 we focused on developing a functional prototype of the PV solar Nowcasting service. The main objectives of WP3 will be to integrate real-time solar PV Nowcasting service within the NG-ESO control room, assess its impact, and to continue to improve the performance of the forecast.

Pilot the prototype with the NG-ESO control room staff

In WP3, we will continue to gather feedback on the forecast service - both on the UI and forecast accuracy. We will give access to the service to all NG-ESO users and we will refine in response to feedback and implement our own ideas for improving the system.

Integrate a fully functional Nowcasting service

Beyond piloting, in order to integrate a fully functional Nowcasting service within NG-ESO, we will undertake the following steps:

1. We will start discussing options for running the PV nowcasting service "business as usual";
2. We will continue working on API security: In particular, we plan to add Auth0 to our API for secure access to API;
3. We will provide the necessary technical training to the control room staff and gather their feedback.

Impact assessment

We will work with NG-ESO to assess the impact of the service in terms of CO_2 reductions and cost reductions. This will be one of the main agenda points for the upcoming August Working Steering Committee meeting as this will require close cooperation with the relevant NG-ESO team.

Further improve the skill of the nowcast

While the skill of our nowcast is already at least three times better than the current national NG-ESO PV solar forecast (for a 2 hour forecast horizon), we are planning to further improve our machine learning model (for more details, please see the "Known limitations & planned solutions" section of the WP2 Progress Report).