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NIA Project Registration and PEA Document

Date of Submission

May 2018

Project Reference

NIA_NGSO0008

Project Registration

Project Title

Solar PV Monitoring Phase 3

Project Reference

NIA_NGSO0008

Project Licensee(s)

National Grid Electricity System Operator

Project Start

May 2018

Project Duration

3 years and 1 month

Nominated Project Contact(s)

Kevin Tilley

Project Budget

£690,000.00

Summary

NULL

Nominated Contact Email Address(es)

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Problem Being Solved

The vast majority of PV generation is connected to the distribution network and currently cannot all be monitored directly by National Grid as the GB System Operator. In the last 7 years, approximately 12 GW of Solar PV systems have been integrated into the GB distribution network. The ability of the System Operator to forecast the generation from these systems is now a critical component of managing the network.

Lack of visibility of PV generation has a significant detrimental impact on our demand forecast error. For example, a 4.3 GW demand forecast error was observed in March 2017, approximately 2GW of which was due to Solar PV forecast error. Looking into the future, the situation will only get more complicated: the interaction of PV with battery storage on the distribution network means even less predictability. There is therefore an urgent need to get to grips with the monitoring, forecasting, measuring and managing the impacts of PV generation.

The completed PV Monitoring Phase 1 (NIA_NGET0139) innovation project focused on measurement of PV generation at a small number of sites. The PV Monitoring Phase 2 (NIA_NGET0183) innovation project utilised many more measurement stations and more

advanced data processing to develop a 30-minutely PV generation out turn at both national and GSP level. The as developed methods are currently deployed as a prototype API service at www.solar.sheffield.ac.uk/pvlive.

Following the 30-minutely GB and regional/GSP PV monitoring capability which has been built through the Solar PV Monitoring Phase 2 project, the Solar PV Monitoring Phase 3 project will address the following outstanding critical issues:

1. GB PV capacity is not static. Systems are continually coming online and going offline. The Government's registration schemes do not follow the "status" of the ~800,000 different PV connections, which means there is no record of PV generation going off the system due to breakdown, end of life, or other factors. There is therefore no adjustment to cater for capacity removed from the system and the accuracy of the Government PV capacity data will get worse in the future. We need to solve this issue by learning how to calculate capacity independently.
2. PV outputs change faster than 30 minutely and we need to have better knowledge of how these changes happen in order to support real-time operational decision making in the Electricity National Control Centre. The data sources for such calculations exist, but we do not know whether current tools will be able the cope with the increased throughput and nor do we know how the forecast accuracy will be affected. The ability to provide a more accurate forecast within a shorter time window (e.g. 5-minutely instead of 30-minutely) would be innovative and unprecedented for the GB transmission system.
3. At the moment we have quite a limited data feed in terms of different types of PV systems. For example, while over 50% of the GB capacity is solar farms, all our operational data comes from residential and relatively small commercial systems. At the moment we do not know what this means in terms of errors in the forecast. This will be investigated in the Phase 3 project.

Method(s)

Part of the challenges faced are due to the fact that the operational impacts of GB Solar PV generation can only be tackled by using probabilistic approaches that involve innovative sampling, interpolation and upscaling of different data sources – demand out turn, meteorological data and PV generation from many thousands of sites.

Instead of direct measurement (typical for centralised generation), statistical, sampled measurement approaches to monitoring PV generation are needed. Such innovative methods will involve algorithms for data sampling, handling, storage, measurement interpolation and aggregation. These techniques will be used during this Phase 3 project as part of the below outlined work packages and respective activities:

Work Package A – 5-minutely PV monitoring: In order to achieve a 5-minutely national PV out turn, the project will replicate the same method as used for the 30-minutely forecast and build on the learning from previous innovation projects. The project will aim to process all data available in less than 5 minutes. In order to achieve this, optimisations are anticipated to the systems and infrastructure (e.g. computation, databases and software algorithms) supporting the tools used in the project. In order to measure the accuracy of this new capability we will need to use learning from Work Package D (validation) and utilise one or more additional data sources identified in that work package. Working towards a regional or GSP 5-minutely forecast will require very good knowledge of the local spatial and temporal variations in solar radiation and we will need to build on learning from the Solar Forecasting Phase 2 innovation project (NIA_NGET0183) in order to achieve this. Developing the right approach to spatial (and temporal) interpolation is critical. Kriging and response surfaces are likely to be used further. Underpinning Work Package A is a geographically representative, high quality PV power data feed and accurate capacity data from Work Packages B and C.

Work Package B - Capacity estimate: It will be necessary to engage formally with external stakeholders (e.g. OFGEM, BEIS), internal teams at National Grid and private asset owners (through STA and others) to map the UK PV data sources and understand how these data sources are being used in our current capacity estimate methodology. We will also explore the additional sources of data that exist and discuss again with the stakeholders the barriers to accessing these other data sources. This work will result in a set of recommendations for the best approach to estimating capacity using existing system registration data. Furthermore, to improve existing approaches of capacity estimation, it is crucial to research methods for estimating capacity without using registration data i.e. to estimate capacity directly from a combination of PV_Live, demand outturns and meteorological observations. This is important because, although systems may be registered when they are installed, they may not be updated if the system changes, or they may not be de-registered when they are un-installed or stop working due to failure. With the potential removal of tariffs and incentives we expect to see an increase in systems being installed without any form of registration.

Work Package C – Sensitivity and resilience of Data Feeds: The monitoring and forecasting of PV power depends on the availability of PV data consisting of both a geographical distribution of installed systems across GB and the size of systems being monitored. The Solar PV Monitoring Phase 2 project strived to maximise this spread. However, it did not seek representation from different system sizes or from ground and roof-mounted systems. This project work package will involve engagement with solar farm asset owners such that we can secure a significant and geographically diverse data feed from solar farms to complement the current data from small roof mounted systems. This will then allow the possibility to fully measure the impact of system size, local mounting (roof or ground) and ownership by running our current (PV_Live) and future (PV_5-minutely) algorithms on different ensembles of data feeds. This information will enable the System Operator to make more informed decisions regarding future data supply contracts.

Work Package D – Validation of PV outturn: Currently there is no proven method to validate the nationally or regionally aggregated PV outturn. Validation must make use of additional data sources that are statistically linked to the PV power – in particular the net demand seen at each GSP location. This work package will first investigate the use of data sources that could be used to develop a method to independently evaluate the accuracy of both PV_Live and PV_5-minutely services. National Grid's demand data, the Distributor Network Operators' (DNOs) measurements of embedded generation (made available via Electralink) and meteorological measurement all have statistical relationships with the PV outturn and could theoretically be used in the work planned for this work package. We need to systematically investigate the correlations of these different data sources, develop a validation methodology and test this during the project.

Scope

This project will focus on addressing several key challenges identified in monitoring solar PV generation and its operational impacts on the GB electricity transmission system.

This project will build on methods and approaches for estimating PV generation and data provision to develop, test and validate the capabilities of a proof of concept system which would be suitable for integration and use within the System Operator's forecasting and control room operations.

Objective(s)

The Solar PV Monitoring Phase 3 innovation project aims to investigate novel methods for monitoring PV generation on the GB electricity system to support control room operations and decision-making.

The project will run over a period of three years with the following key objectives targeted through delivery of its four work packages:

1. Develop and validate a prototype 5-minutely national (GB scale) PV generation forecast
2. Develop and validate a prototype 5-minutely regional (GSP scale) PV generation forecast
3. Identify relevant and suitable national PV data sources/feeds to use in defining optimum approaches to extract PV capacity estimate directly from such PV feeds.
4. Investigate suitable methods to estimate PV capacity directly from a combination of PV_Live, demand outturns and meteorological observations instead of the current method which relies primarily on PV installation registration data. Further refine existing methods of capacity determination.
5. Evaluate the resilience of PV data feeds used and the sensitivity of the accuracy of the PV_30-minutely and PV_5-minutely monitoring prototypes to geographic distribution, mix of system sizes and mix of rooftop or ground-mount.
6. Devise and test suitable validation methodologies for validating the nationally and regional aggregated PV outturn.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

n/a

Success Criteria

The project will be successful if the System Operator is able to enhance its current Solar PV monitoring and forecasting capability through the following outcomes expected from the project:

1. Delivers validated prototypes for a 5-minutely national (GB scale) and a 5-minutely regional (GSP scale) PV generation forecasts which can enhance the capabilities of the Energy Forecasting and Control Room Operations within the GB System Operator.
2. Identifies and uses optimum PV data feeds to test novel research methods and algorithms for how regional solar PV capacity can be estimated. This would also include recommendations for such capacity data for the different types of PV installations in different regions.
3. Assessment of the accuracy and sensitivity of the developed prototypes national and regional PV monitoring systems to inform their readiness for integration into National Grid's Energy Forecasting team's operations and processes, as well as informing decision making in the Electricity National Control Centre.

Project Partners and External Funding

The project will involve collaboration between National Grid's Energy Forecasting team and the Sheffield Solar team at the University of Sheffield. There is no external funding involved in this project.

Potential for New Learning

The PV_Live (http://www.solar.sheffield.ac.uk/pvlive) outcome from the recently completed PV Monitoring Phase 2 (NIA_NGET0183) innovation project has been an important step forward in making PV generation visible to network operators.

In the future, as more embedded generation is installed within the network and as more battery storage and electric vehicles change the dynamics of electricity demand, it will be increasingly difficult to forecast national demand and operate the system. It is critical that the monitoring of solar PV be developed to a mature state over the next three years such that the system operator has confidence in the PV out turn data – at 30-minutely and 5-minutely and at GB and GSP level.

This learning in terms of methods, application and out turn data will allow the GB System Operator to move to the next level in terms of changes to the network confident that PV monitoring is mature and accurate.

DSOs will ultimately need to monitor and forecast demand and embedded generation in the same way as National Grid and the approaches developed under Phase 2 and Phase 3 will be an important starting point for their own development of more granular monitoring and forecasting requirements.

Furthermore, as a result of this work, energy forecasters (within the GB System Operator, in DSO's and in commercial energy trading) will continue to use and understand the relationships between PV out turn and demand in order to optimise cost effectiveness. PV live is currently used by 30-50 organisations for assisting in the management of electricity services. After the Phase 3 project, it is expected that the use of PV out turn will grow further and become a business as usual data source for 100's of organisations within the

electricity sector.

Scale of Project

The project will predominantly involve laboratory and desk-based research activities at National Grid and the University of Sheffield.

Technology Readiness at Start

TRL3 Proof of Concept

Technology Readiness at End

TRL7 Inactive Commissioning

Geographical Area

This work is of potential benefit to inform and manage PV generation and its impacts on the GB electricity transmission system.

Revenue Allowed for the RIIO Settlement

None

Indicative Total NIA Project Expenditure

The total indicative NIA expenditure for this project is £690,000

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:

n/a

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)

The total expected savings to industry and consumers from the Solar PV Monitoring Phase 3 project is estimated to be in the region of £8-£14 million per annum. This is based on current known (2018) solar PV generation within the GBSO and in addition to the saving realised from Solar PV Monitoring Phase 2 project.

Please provide a calculation of the expected benefits the Solution

This innovation project is expected to reduce the demand forecast error that results from embedded solar generation by 50 MW on average, in addition to what has already been achieved by the Solar PV Monitoring Phase 2 innovation project. Subsequently, this will reduce system balancing costs and lead to significant savings to industry, the end consumer and to National Grid.

The following benefits and savings are anticipated by 2021 from the work to be carried out during Solar PV Monitoring Phase 3 in reducing the demand forecast error by an average of 50MW:

- Reserve holding estimated at £8 - £10 million/annum
- Constraint management estimated at £2 - £4 million/annum.

Based on the above calculations, the total expected savings to industry and consumers from the Solar PV Monitoring Phase 3 project is estimated to be in the range of £8 - £14 million per annum.

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

The scope of the project and methods to be used are specific to the GB electricity transmission system. The project will benefit all GB network licensees and the outcomes of the project will be made available such that licensees and other industry users can access the outcomes of having more accurate real-time solar forecasts to manage their networks and plan operations.

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

No significant additional costs are expected for rolling out the method across GB. The project's activities and methods to be investigated will be focusing on enhancing the capability for monitoring PV on a GB scale and the learnings from the project will be disseminated in a similar fashion to the PV_live website to facilitate access to the outcomes.

Once the proof of concept methods are tested and validated, implementation costs are expected to integrate the outcomes from the project into National Grid's energy forecasting and control room systems.

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)

This project will directly address the strategic innovation area "Improving short-term forecasting of generation/supply and demand" in the National Grid System Operator Innovation Strategy document published in Feb 2018, and will have indirect benefits in the following other strategic areas - Managing volatility in a low-inertia system, Supporting Voltage and Reactive Power, Optimising constraint management and Harnessing a digitized grid.

☑ Has the Potential to Develop Learning That Can be Applied by all Relevant Network Licensees

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 known projects or activities can provide a 5 minutely PV estimate outturn at National as well as GSP level.

Initial innovation work on PV monitoring has initially focused (PV Monitoring Phase 1, NIA_NGET0139) on direct and indirect measures of PV generation at a small number of sites.

PV Monitoring Phase 2 (NIA_NGET0183) which has recently completed, utilised many more measurement stations and allowed the development of half hourly out turns at national level. Phase 2 has delivered a GB PV generation outturn with both real-time API and historical data: www.solar.sheffield.ac.uk/pvlive. By its conclusion the project will also have delivered regional GSP monitoring. These outputs have mitigated increases in demand uncertainty as the PV fleet has grown to ~11.7 GW.

In addition to these two PV monitoring NIA projects, Solar PV Forecasting Phase 1 (NIA_NGET0177) is attempting to improve

estimates in surface radiation by using Numerical Weather Prediction (NWP) models to correctly establish factors related to clouds, such as how much cloud cover there is, the thickness of the cloud and how these factors evolve over time. Solar PV Forecasting Phase 2 (NIA_NGET0183) will understand the variability of solar generation and seeks to improve solar PV generation forecasting in the medium and short term. PV forecasting phase 2 needs accurate and validated PV monitoring data to allow the development of statistical relationships between meteorological fields and PV power.

Other NIA funded DNO projects are largely related to smart grid development and focus on smaller geographical region. Examples from Western Power include: The LV Network Templates – G83 rooftop solar assessment; Carbon Tracing – a week ahead forecast based on historically measured output; Solar Storage – including an element of forecasting and real time measurement; Equilibrium – an Advanced Planning Tool that takes met office feeds to estimate solar and wind contributions to optimise voltage set points. While these DNO projects are building methods that are locally optimised for their needs, the unique challenges (large differences in climate and variable network and PV capacities) of GB wide monitoring remain for National Grid to address.

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

Renewable generation has been growing at historically high rates over the last decade on the GB electricity system. In the last few years approximately 12 GW of Solar PV generation have been integrated into the GB distribution network, and this is going to continue increasing. This change is unprecedented for National Grid as the GB System Operator. The ability to have visibility of the PV generation, measure it and predict the generation from these systems is now a critical component of managing the network and operational decisions which the control room has to make. According to the Future Energy Scenarios, this landscape is likely to change further: the interaction of Solar PV with e.g. battery storage on the distribution network means even less predictability. Such operational challenges are being faced for the first time on the GB system. So far, these have been tackled using probabilistic approaches that involve innovative sampling, interpolation and upscaling of different data sources such as demand out-turn, meteorological data and PV generation from many thousands of sites. These are however not sufficient to address the specific issues from solar PV and novel techniques are needed. This project is innovative as it will address these new challenges by investigating novel new methods, tools and proof of concept systems for data sampling, data handling and storage of different data feeds for solar PV generation on a GB scale. The project will look into how this data can be interpolated and aggregated. It will also evaluate the accuracy of the data, its resilience and how the methods to process it can be optimized to enhance the quality and timeliness of the PV forecast generated, on a national scale and a GSP regional scale. This has not been attempted before and if achieved, it will deliver a 5-minutely PV forecast for the first time.

Relevant Foreground IPR

n/a

Data Access Details

n/a

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

The proposed methodologies and activities to be undertaken in this innovation project have not been tried before. They are dependent on the specialist skills and knowledge of the chosen academic partner in using a number of new data feeds, tools and systems to deliver the project objectives. As these activities will be attempted for the first time, they will need to be tested and validated in a laboratory environment before they can be assessed for use in the System Operator’s real-time operational systems as part of business as usual activities.

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

NIA funding was used for the PV Monitoring Phase 1 and Phase 2 innovation projects. It is also the chosen funding route for this Phase 3 innovation project. This would facilitate collaboration with the chosen academic partner to access the required specialist skills and expertise in a cost-effective and timely manner, given the key operational challenges which this project is aiming to address. The proposed methods and work packages in this innovation project will be need to investigated and tested in a laboratory environment before they can be validated for use in the real-time operational systems to manage the GB system. It will be important that the algorithms which are investigated and tools developed are technology and platform agnostic. There is a risk that the algorithms to be used and developed may not scale to allow the highest spatial and temporal resolutions required for the project, and with an accuracy of value for operational use. There are also risks associated with the availability of different data feeds (sourced from different providers) which will be evaluated during the project. These will have to be analysed for their accuracy, reliability and resilience if they are to be used on an ongoing basis to support operational decisions. Through running the project under the NIA scheme, this will also allow the System Operator to disseminate the learnings from the project to the energy sector and GB network licensees. This is expected to contribute to enhancing the knowledge and capabilities for managing renewables on the GB electricity system as well as

delivering enhanced visibility of PV generation on the system. This will also benefit the distribution network operators (DNOs), industry users with an interest in Solar PV impact and renewables, and support the GB whole system operability strategy.

This project has been approved by a senior member of staff

☑ Yes