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

Feb 2014

Project Reference Number

NIA_NGET0128

Project Registration

Project Title

Clustering effects of major offshore wind developments

Project Reference Number

NIA_NGET0128

Project Licensee(s)

National Energy System Operator

Project Start

April 2014

Project Duration

2 years and 1 month

Nominated Project Contact(s)

David Lenaghan

Project Budget

£319,000.00

Summary

The project will focus on the cluster of wind farms planned at Dogger Bank in the North Sea. This is the largest of the round 3 offshore zones, with an area of 8660 km2, and could see as much as 9 GW of capacity installed in a number of separate wind farms.

This project will investigate the variability of the wind resource within this cluster taking into account the wake effects of the individual turbines and the shadow effect of neighbouring farms. This will be achieved through drawing on established models, with central assessment developed using the WRF system. Based on the results of this analysis, the power characteristics of the individual wind farms or the cluster of farms will be derived for a number of meteorological conditions, defined by parameters such as wind direction, wind speed, atmospheric stability and turbulence.

By considering how the cluster of wind farms will be connected to the GB power system, this approach could be applied to identify any possible network stress points. To achieve this, a full analysis will be performed to determine the power characteristics at each of the connection points for a number of extreme events, identified in the previous project TAO 22260, 'UK-wide wind power resource: Extremes and variability':

- Rapid changes in wind-speed affecting power output (ramping)
- Persistent low wind producing low power output (low wind conditions)
- Very-high wind events (exceeding wind-turbine safety cut-out)

For each of the extreme events, previously derived techniques (e.g. Sinclair (2009)) will be used to classify the boundary layer type,n based on parameters such as stability, wind speed, wind direction, turbulence and boundary layer height. Prior observations will then

be used to determine the relationship between the weather type associated with the extreme events and the characteristics of the corresponding boundary layer. For example, the winter peak demand is likely to occur in anti-cyclonic conditions with easterly flow; by considering the associated boundary layer type the impact of clustering large wind farms can be investigated using the WRF modelling. By considering different boundary layer types the potential will be explored to extend the analysis to determine whether one type is more easily forecast than others, however, at present there are significant scientific unknowns to overcome.

Third Party Collaborators

University of Reading

Nominated Contact Email Address(es)

box.so.innovation@nationalgrid.com

Problem Being Solved

The expansion in offshore wind generation coming with the round 3 projects is bringing particular uncertainty for strategic and operational planning. Wind farms of the scale now planned influence the lower atmosphere sufficiently to impact the performance of adjacent farms, therefore the power generation characteristics of a cluster of wind farms (such as that planned for Dogger Bank) are largely unknown. The current generation of wind power forecasting tools, whilst representing the best commercially available, continue to have many shortcomings with regards to accurately predicting unusual weather conditions. This will be compounded by the larger investment into construction of the larger wind farms.

The manner in which turbines interact with the air-flow translate into significant uncertainties and costs for the GB National Electricity System Operator with regards to reserve planning, balancing and constraint management costs.

Method(s)

Research

This project will apply a mesoscale numerical weather prediction model to explore the atmospheric influence of the planned offshore wind farms. It is proposed to use WRF (Weather Research Forecasting), a state of the art modelling tool. This project will be structured in three work packages, aligned to the objectives described below:

WP 1 – Wind farm parameterization: this work package will review the parameterization approaches currently applied within WRF, review state of the art alternatives, and collect data to enable offline investigation.

WP 2 – Characterisation of the offshore cluster extreme events: this work package will use the MERRA (Modern Era-Retrospective Analysis for Research and Applications) dataset to identify extreme events, apply the WRF model to the Dogger Bank region of the North Sea and determine the power characteristics of the planned cluster of wind farms.

WP 3 – Enhance the predictability of extreme events: this work package will apply statistical techniques to classify the boundary layer type (and thus near surface wind-speed characteristics) for each extreme event; determine the relationship between the boundary layer type and the synoptic conditions; and investigate the scope for improving the predictability of the extreme events.

Scope

The project will focus on the cluster of wind farms planned at Dogger Bank in the North Sea. This is the largest of the round 3 offshore zones, with an area of 8660 km2, and could see as much as 9 GW of capacity installed in a number of separate wind farms.

This project will investigate the variability of the wind resource within this cluster taking into account the wake effects of the individual turbines and the shadow effect of neighbouring farms. This will be achieved through drawing on established models, with central assessment developed using the WRF system. Based on the results of this analysis, the power characteristics of the individual wind farms or the cluster of farms will be derived for a number of meteorological conditions, defined by parameters such as wind direction, wind speed, atmospheric stability and turbulence.

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Objective(s)

The objectives of the project include the following;

- Reduce reserve planning, balancing and constraint management costs through the modelling and analysing how clusters of turbines interact in different boundary layer atmospheric conditions.
- Identifying stress point on the network by using the WRF alongside established models to assess the power characteristics of a range of extreme events.
- Generate knowledge from this study which can be combined with network models and climate weather data to provide added certainty of various modelling techniques when considering future investment schemes and operational running arrangements.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

n/a

Success Criteria

The success criteria of the project will be based on the following:

- A preliminary report to document the assessment of wind farm parameterisation in mesoscale models
- A secondary report to identify characteristics of offshore cluster extreme events.
- A final report which established the development of atmospheric indicator set to enhance the predictability of extreme events.

Project Partners and External Funding

University of Reading / Department of Meteorology (research partner)

No external funding.

Potential for New Learning

The project will develop knowledge and experience in building operational modelling and cost-benefit analysis of the effects on clustering off-shore wind farms in extreme events.

Scale of Project

The project will involve a set of lab-based desktop modelling exercises based one of the planned round 3 off-shore wind farm clusters. The objectives of the project cannot be met at by considering the problem a smaller scale.

Technology Readiness at Start

TRL2 Invention and Research

Technology Readiness at End

TRL3 Proof of Concept

Geographical Area

The project will be undertaken in Reading and will involve numerical models of wind-profiles and interactions with turbines within wind-farms and interactions between wind-farms under various extreme weather conditions focusing on the Dogger Bank area.

Revenue Allowed for the RIIO Settlement

Zero.

Indicative Total NIA Project Expenditure

The total NIA Project Expenditure is £319,000

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)

It is challenging to estimate precisely the cost saving if the research is successful because of the uncertainties involved with the rates of installation of wind farms and the uncertainties with numerical weather prediction. Current forecast errors with 6GW of metered capacity are approximately 5.5% average over a month which equates to 400MW of error. This error has to be managed in the Balancing Mechanism (BM) with a combination of committing reserves, and accepting Bid Offer Acceptance (BOA). With the increase in installed wind farm capacity expected in the North Sea expected to more than double this the magnitude of the errors is expected to increase in proportion if no further developments are made in forecasting. This work is expected to manage the rise of forecasting error and prevent the balancing costs that would result from it. 800MW of imbalance would cost the System Buy or Sell price at the time. This would be up to £14m per month of additional imbalance costs compared with the imbalance expenditure at the current time.

Please provide a calculation of the expected benefits the Solution

Not required for Research Projects.

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

The Dogger Bank site is being used for the project to model the power generation characteristics of a cluster of offshore wind. The project could be replicated during the future expansion of round 3 offshore wind generation.

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

It is estimated that the cost of incorporating the new research into the operational forecasting system EFS (Energy Forecasting System) will be approximately £250,000 – 300,000. The implementation plan will be clearly define during the concluding stages of the project.

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)

The project will meet the environmental and system operability from National Grid's Innovation Strategy. The reliability and system operability of the network will improve due to a greater understanding of the effects of clustering off-shore wind developments.

☑ 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.

There are currently no projects which cover this subject of research .

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

n/a

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

n/a

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

n/a

This project has been approved by a senior member of staff

☑ Yes