

## NIA Project Registration and PEA Document

### Date of Submission

Mar 2020

### Project Reference

NIA\_NGSO0023

## Project Registration

### Project Title

Mapping the Impacts and Visualization of Risks of extreme weather on system operation (MIVOR)

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NIA\_NGSO0023

### Project Licensee(s)

National Grid Electricity System Operator

### Project Start

March 2020

### Project Duration

1 year and 4 months

### Nominated Project Contact(s)

Jonathan Barcroft

### Project Budget

£245,000.00

## Summary

The evidence of climate change is becoming apparent in the UK, particularly in the increasing frequency of “extreme” weather events. These events differ significantly from normal patterns, are associated with severe impacts and are historically infrequent. A number of extreme weather events experienced in the last decade in the UK have been attributed to climate change including include floods, heatwaves and droughts.

The effect of these events on electricity system operation is currently unclear. The magnitude of the impact of these events may be exacerbated by factors including aging infrastructure and an increasing reliance on weather-dependent renewable energy sources as we move to a net zero energy system. This may lead to higher operational costs and complexities for system operation.

### Nominated Contact Email Address(es)

box.so.innovation@nationalgrid.com

## Problem Being Solved

The evidence of climate change is becoming apparent in the UK, particularly in the increasing frequency of “extreme” weather events. These events differ significantly from normal patterns, are associated with severe impacts and are historically infrequent. A number of extreme weather events experienced in the last decade in the UK have been attributed to climate change including include floods, heatwaves and droughts.

The effect of these events on electricity system operation is currently unclear. The magnitude of the impact of these events may be

exacerbated by factors including aging infrastructure and an increasing reliance on weather-dependent renewable energy sources as we move to a net zero energy system. This may lead to higher operational costs and complexities for system operation.

## Method(s)

This project will evaluate the long-term impacts of extreme weather up to 2050 in GB. The key outputs will be a dataset and map that highlight:

- total risk to assets and SO operations through prevalence of extreme weather events
- both singly and in combination through wind, precipitation and heat
- damage and performance functions for transmission assets (and distribution and generation assets)

This will be delivered through several work packages:

WP1: Using data from a range of sources including National Grid Electricity Transmission and the Met Office, create the definition of each extreme event within temperature, wind and precipitation, taking into account damage limits per event type and infrastructure type.

WP2: Model the key power system assets' performance and behaviors under various extreme weather including wind and solar power output and heating and cooling demand growth patterns.

WP3: Identify the correlation of various extreme weather events to understand the potential of coincident extreme events to exaggerate the consequences on system operation.

WP4: Analyse GB in a 25km by 25km grid to identify the risks of extreme events including the probability of damage thresholds being reached and variations in renewable generation and demand.

WP5: Develop a map to visualise the risks, probabilities, and consequences in each grid square.

## Scope

The evidence of climate change is becoming more evident in the UK, for example, the UK Climate Projections 2018 (UKCP18) project found that:

- average sea level has already risen by around 16cm in the last 100 years and could increase by 8 to 115cm by the end of the 21st century (compared to the 1981-2000 average) depending on location and future greenhouse gas emissions
- average temperatures in England over the last decade (2008-2017) were around 0.8°C higher than they were in the 1970s and 1°C higher than pre-industrial times (1850-1900)
- the number of extremely wet days are increasing

As we transition to a highly renewable electricity generation mix, incorporating growing wind and solar power capacities, it is becoming increasingly important to understand the potential implications of extreme weather events on energy demand and generation in the UK. While renewable generation is highly dependent on meteorological conditions, it is also recognised that energy demand will change significantly. Climate change studies indicate, with high confidence, that the UK climate will become increasingly warm. This may reduce heating demand, and hence the severity of winter-time peak residual demand events, but increase summer-time cooling demand, highlighting the importance of considering climate change in future energy system planning.

Our understanding of how an energy system based on a high level of renewables could perform during extreme weather events associated with a changing climate needs to expand rapidly. This project will evaluate the long-term impacts of extreme weather up to 2050 in GB, highlighting the risk to assets and system operation. The models developed in the course of the project will identify damage and performance functions for transmission, distribution and generation assets and forecast the cumulative effects of extreme wind, precipitation and heat events. A greater understanding of extreme weather impacts will facilitate system operation, reducing system balancing and constraint management costs, and enabling planning for resilience to potential climate risks.

## Objective(s)

This project will evaluate the impacts of extreme weather events on system operation up to 2050 and produce a map demonstrating the risks, probabilities, and consequences of such events at a 25km grid level of GB.

## Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

n/a

## Success Criteria

The project will be successful if:

- The risk correlation between the occurrence of extreme weather events and the consequences on the system is tested and evaluated.
- The damage and performance functions for transmission, distribution and generation assets is modelled.

- The fragility, performance and behaviours of key power system assets is modelled under relevant weather scenarios.
- The interaction and cumulative effects of extreme wind, precipitation and heat events is assessed for energy demand and generation.
- A map is developed that visualises the distribution of risks, probabilities and consequences across the GB network to a 25km grid level.

### **Project Partners and External Funding**

University of Bath will be delivering this work.  
There is no external funding.

### **Potential for New Learning**

This project will include one of the first application of scenarios from UK Climate Projections (UKPC18) climate analysis tool in the energy industry which will significantly enhance the accuracy of energy system impact modelling. It will also focus on the impacts of the whole supply chain, renewable generation, network assets, and demand, ensuring that the learnings produced are relevant to the whole energy system.

### **Scale of Project**

The project will involve desk-based research and data analysis that will be carried out at the University of Bath.

### **Technology Readiness at Start**

TRL3 Proof of Concept

### **Technology Readiness at End**

TRL5 Pilot Scale

### **Geographical Area**

The project will cover all of GB.

### **Revenue Allowed for the RIIO Settlement**

None

### **Indicative Total NIA Project Expenditure**

£245,000.00

## 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)

Improved understanding of extreme weather impacts to reduce system balancing and constraint management costs.

One example of the impact this project could have on system operation is on our ESTEX constraint boundary. Extreme temperatures cause summer pre-fault derating of 6-12%, reducing the ESTEX constraint boundary by 450 MVA. Managing the constraint could involve buying off a thermal generator or interconnector (within the constraint boundary) and buying on another generator outside (the boundary).

#### 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 outcomes of the project will be replicable to all DNOs and the wider energy industry as it will address the impacts of extreme weather events on the whole supply chain, renewable generation, network assets, and demand for the whole of GB.

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

It is expected that the dataset and map produced in the course of the project will be shared with other network licensees and the wider energy industry to inform planning and forecasting activities as the energy system works towards achieving Net Zero targets.

### 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 address the following strategic priorities from our Innovation Strategy published in April 2019:

- Digital Transformation
- Forecasting of supply and demand
- Constraint Management

- 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 have been a number of existing projects,

Resilient Electricity Networks for Great Britain (RESNET) – NIA\_NGET0053

- RESNET examined the impacts of extreme weather on transmission assets using the Met Office 2009 UK Climate Projections (UKCP09).
- The UKCP09 climate projections were mainly focussed on three emissions scenarios in the 2020s, 2050s and 2080s and have not been updated since 2009. The RESNET project modelled the risk of failure of components during extreme weather events using fragility functions.

Key differences between MIVOR and RESNET

- Significantly expanded power system network. RESNET used a significantly reduced power system network when examining infrastructure resilience, only modelling 29 nodes and between 40-50 lines. MIVOR will examine all HV substations (~360) and circuits, which would also capture large power stations and wind farms connected to the HV transmission system.
- New climate projections. RESNET used UKCP09 climate projections produced by the Met Office, which are now 9 years old so significantly out of date.
- Statistically useful outputs showing risk profile. The UKCP09 climate projections used an ensemble of 280 HadSM3 simulations. This is statistically very small compared to the >10000 ensembles that MIVOR will run for each climate scenario, allowing for an enhanced understanding of extreme 'tail' events. These rare extreme events will be of more interest to the ESO, rather than less

extreme 'average' projections produced by the MET Office.

#### Condition and Climatic Environment for Power Transformer (ConCEPT) - NIA\_NGET0213

- Objective is to examine the impacts of climate change on ETO transformers. Sensors will be installed on transformers and will be used to investigate the urban heat island effect and oil temperature and cooling issues.
- The project will make use of the UKCP09 and the UKCP18 climate projections..

#### Key differences between MIVOR and ConCEPT

- Risk evaluation. MIVOR will provide comprehensive risk mapping for assets across the UK using latest climate modelling and thousands of ensembles (probability distribution functions).
- More assets. MIVOR will include far wider range of assets types compared with ConCEPT, which only explores transformers.
- Much better climate modelling. MIVOR outputs will be available in 2020 and will enable ESO teams to improve their modelling (SOF) and conduct novel analysis (e.g. FES air conditioning). ConCEPT will not finish until 2021 and its outputs will have very little value to the ESO.

#### **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**

Several aspects of the project demonstrate its innovativeness. The project will utilise scenarios from UK Climate Projections (UKPC18) climate analysis tool developed by the Met Office, a significant update from the previous version UKCP09, and will be one of the first applications within the Energy Industry. Other inputs to the model will include, but not be limited to, the Hadley Centre HadGEM35 model, the CMIP56 set of models. Rich historic data will be analysed using data mining techniques, helping to create fundamentally new models that generate insights that are not possible with traditional datasets. The project focuses on the impacts of the whole supply chain, renewable generation, network assets, and demand.

#### **Relevant Foreground IPR**

n/a

#### **Data Access Details**

n/a

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

The scope of work involved in this innovation project involves research and development activities and the models created will require validation before the outputs can be utilised to support system operations and planning. The proposed methodology has not been tried, many of the datasets haven't been utilised in the energy sector to date and the development of fundamentally new models requires the specialist skills and knowledge of the academic partner.

#### **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 is the chosen funding route for this innovation project for a number of reasons. Firstly, it will facilitate collaboration with network operators and stakeholders to access relevant datasets given the GB wide focus on asset behaviour, generation and demand. Secondly, it will enable the ESO to disseminate the key learnings from the project to the energy sector and GB network licensees. The insights from this project are expected to benefit the SO, all (transmission and distribution) network licensees, and the energy sector in general in better understanding the risks of climate change on the energy system. Finally, this project will develop fundamentally new models and combine a range of datasets and scenarios not applied within the energy industry to date. Therefore, it is more suitable to utilise NIA funding to perform detailed data analysis and development of the models to produce the report/ map demonstrating the risks, probabilities, and consequences of extreme events before going into BAU implementation.

#### **This project has been approved by a senior member of staff**

Yes