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

Nov 2019

Project Reference Number

NIA_NGSO0029

Project Registration

Project Title

Applications of convex optimisation to enhance National Grid's NOA process

Project Reference Number

NIA_NGSO0029

Project Licensee(s)

National Grid Electricity System Operator

Project Start

October 2019

Project Duration

1 year and 7 months

Nominated Project Contact(s)

Mostafa Nick

Project Budget

£300,000.00

Summary

The aim of this project is to develop new tools using new advancements in mathematical and computational techniques to enable us to assess more scenarios and backgrounds and check whether they comply with SQSS and other industry codes. We will develop and test convex optimisation models and machine learning algorithms that adequately represent voltage and reactive power in the system.

Nominated Contact Email Address(es)

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Problem Being Solved

National Grid Electricity System Operator's (NGESO) Network Options Assessment (NOA) recommends investment options to achieve a sustainable, economic and efficient future electricity grid. NOA's technical analysis is predominantly based on winter peak conditions. As the energy system rapidly evolves and the penetration of renewable resources increases, future uncertainty also increases. Thus, there is a need for year-round analysis of the bulk transmission networks. Some of the pathfinder projects we run, e.g. high volts, require intensive analysis, but currently we can only assess a limited number of snapshots. The current pathfinder project on probabilistic studies only considers thermal constraints. Through this project, we will test ways of moving towards year-round analysis for voltage and reactive requirements. This will lead to more informed investment and operational decisions to ensure a secure, economic and efficient electricity grid.

Method(s)

The aim of this project is to develop new tools using new advancements in mathematical and computational techniques to enable us to assess more scenarios and backgrounds and check whether they comply with SQSS and other industry codes. We will develop and test convex optimisation models and machine learning algorithms that adequately represent voltage and reactive power in the system. The key project outputs are provided as follows:

1. A convex optimisation model of the electricity transmission system to assess reactive power requirements
2. A clustering algorithm to group and classify expected future operational scenarios in the GB system
3. Pilot testing of the proposed model on a part of the GB network
4. Application of the clustering algorithm on the scenarios generated using Future Energy Scenarios and Electricity Ten Year

Statement data
5. Full scale test of the proposed model on representative network in a size of GB network
6. Recommendations for integrating the proposed model into the NOA process

This approach will help us better understand the future needs for reactive power to (1) decrease the operational costs to maintain voltage compliance, (2) help decarbonization by reducing the number of conventional units needed for voltage support, and (3) make better investment decisions for reactive power resources.

Scope

The NOA recommends investment options to achieve a sustainable, economic and efficient future electricity grid. Boundary Capabilities (BCs) are the basis for the NOA process. These BCs are focused on the bulk transfer of power across the network and therefore predominantly address thermal constraint issues. The energy supply industry is rapidly evolving and the level of uncertainty is increasing due to high renewable penetration. Due to these changes, we have witnessed increased costs for managing voltage and reactive power in our network. To understand the reactive power and voltage issues, detailed modelling of year-around operational conditions is required. Through this project, we are going to develop a capability that will allow us to perform year-round voltage assessment (reactive power requirements).

Objective(s)

The project aims to:

1. Create a standard pipeline of data flow between NG ESO data format and the prototype OPF
2. Where necessary, enhance the prototype OPF to include a reasonable representation of relevant steady-state components models in PowerFactory.
3. Create a prototype tool to quantify future reactive power requirements against a very large range of scenarios in planning time-scale that capture uncertainties going forwards.
4. To develop an appropriate convex optimization method for inclusion in an AC-OPF model of the GB electricity system that permits assessment of the transmission system's ability to meet voltage and reactive power requirements.
5. Test the model on a representative network in size of GB high-voltage electricity system and validate results using current tools and techniques.
6. Provide advice on updates for the NOA process.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

n/a

Success Criteria

- Provide insight into convexification for OPF and clustering methods for future operational scenarios
- Provide a standard pipeline of data flow between NG ESO data format and the prototype OPF.
- Delivery of a prototype tool able to do AC-OPF and AC-PF on GB network with all lines, BMUs and primary equipment.
- The prototype tool can analyse multiple scenarios and provide meaningful results for year-round conditions.
- The result of the AC-OPF are validated against PowerFactory power flow module (all nodal voltages are within 1% error).
- The methods encapsulated within the prototype tool are compatible with our current tools for year-round assessment of the network and can therefore be merged.

Project Partners and External Funding

University of Strathclyde is the lead supplier for this project.
There is no external funding on this project.

Potential for New Learning

Convex optimisation methods and machine learning techniques have not been investigated in reactive power management in GB. This is the first time that a project is going to investigate their potential use. So the potential new learnings are:

- Applications of convex optimisation techniques in planning and operation of power networks and their advantages over the current tools and techniques
- Applications of machine learning techniques in planning and operation of power networks
- Impacts of future uncertainties on reactive power requirements and develop a new tool capable of doing multi-scenario studies

Scale of Project

This project will be a desk based research activity.

Technology Readiness at Start

Technology Readiness at End

TRL3 Proof of Concept	TRL5 Pilot Scale

Geographical Area

The project will be undertaken using teams based within NGESO and Strathclyde University.

Revenue Allowed for the RIIO Settlement

Not applicable.

Indicative Total NIA Project Expenditure

Total Network Innovation Allowance is: £275k

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)

1. The current annual spent on services for voltage management is ~ 150M£. Through the current pathfinder project looking at high volt issues we are aiming to reduce the spend on reactive power resources by identifying efficient solutions. This project aims to improve the speed and accuracy of the identification of reactive power needs nationally on an annual basis and with more snapshots, and consequently contribute to the overall reduction in the cost of operability constraints.
2. Reduce requirements to constrain on conventional generation for voltage support and consequently reduce CO2 emission and help to achieve 2050 zero carbon target.

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 methods and prototype tool are intended to analyse the entire GB transmission network. The methods could be used by any GB transmission licensees. Moreover, they have the potential to be adapted for use by DNOs in assessing voltage control on their EHV and HV networks.

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

Integration into our current tools and processes: this project is going to look at solutions and to make the outcome BAU further IT investment are needed.

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

The research on convex optimisation and machine learning techniques and their implementation will advance our understanding of the potential of such models for other network operators. As the OPF is the core of optimisation problems in power networks, the convex OPF module developed in this project provides an option for all network operators to improve their tools and techniques to operate and plan networks more optimally.

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

From our Innovation Strategy published in April 2019, the following strategic priority areas will be explored: Digital transformation and System Stability.

☑ 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.

As far as we are aware, no other projects are exploring convex optimisation methods in this application.

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

The application of convex optimisation methods is relatively a new concept in planning of power networks. To best of our knowledge, this methodology has not been tested on GB network. This project will investigate this new approach for real large-scale networks like GB.

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

Due to the state of the art nature of the proposed solution, and the complex and demanding requirements of the NOA process, the associated financial and technical deliverability risk is deemed to be too high to fund this project through business as usual activities. For our RIIO2 proposals we have indicated that to implement this within our business as usual activities, it is reliant on the success of this project. If this proof of academic concept is successful we will then be able to take steps through our RIIO2 funding to embedding the model within our process.

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

We need a step change in our tools and techniques to be able to analyse more scenarios and solutions-to keep pace with the rate of change of GB energy landscape. The expected growth of distributed generations and renewable resources are going to pose challenges on both transmission and distribution networks and therefore, collaboration and knowledge share though this project will aid in addressing these challenges.

This project has been approved by a senior member of staff

☑ Yes