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

Jul 2025

Project Reference Number

NIA2_NESO116

Project Registration

Project Title

Reactive Power Projections

Project Reference Number

NIA2_NESO116

Project Licensee(s)

National Energy System Operator

Project Start

June 2025

Project Duration

0 years and 10 months

Nominated Project Contact(s)

innovation@neso.energy

Project Budget

£250,000.00

Summary

The project aims to develop a robust methodology for projecting reactive power demand, investigate the reasons behind variations in reactive power on the transmission network, and create a projection tool to predict reactive power demand for up to 15 years at GSP (Grid Supply Point) level.

The aim of the project is that the primary outcome should be a robust methodology and a tool for predicting reactive power demand at Grid Supply Points (GSPs) within the GB network. This could enable NESO to better control voltages on the transmission network, reducing operational complexity and costs.

By understanding the reasons behind the variation in reactive power demand and projecting future trends, NESO aims to make informed operational and investment decisions, ensuring the resilience and efficiency of the network as it evolves to accommodate increasing renewable generation and changing demand patterns.

Preceding Projects

PRJ_1689 - Reactive Power Demand Trends

Nominated Contact Email Address(es)

box.so.innovation@nationalgrid.com

Problem Being Solved

NESO has a statutory obligation to maintain NETS voltages within safe limits as defined by the Security and Quality of Supply Standards (SQSS). Since 2005, there has been a consistent decline in reactive power demand from distribution networks. This decline has increased the need to manage high voltages on the transmission network, leading to higher costs for consumers. Every year, long-term studies are conducted to determine future requirements for reactive compensation. These studies are significantly influenced by long-term demand projections. While active power future values are currently based on DC load flow and is widely accepted, NESO currently lacks a consistent methodology for projecting reactive power looking into the future, up to 15 years ahead.

Method(s)

The project aims to develop a robust methodology for projecting reactive power demand, investigate the reasons behind the variations of reactive power to the transmission network, and create a projecting tool to predict reactive power demand for up to 15 years at GSP level. The method involves reviewing and evaluating options for the projection methodology, considering past projects and relevant literature, and documenting the methodology in a guide. The model development will follow a hybrid approach, combining data-driven machine learning techniques with archetypal power flow models to represent various configurations of the GB network. The projection stage will use the developed model to generate reactive power demand up to 15 years ahead for every GSP, producing outputs that can be directly used for simulation studies.

Work Package 1 - Review
Report on the reasons behind the decline in reactive power demand from distribution networks since 2005: An analysis of historical reactive power demand trends, identifying key influencing factors and insights.
Revisit the reporting from REACT and ATLAS to assess the relevance and potential changes in findings and conclusions.
Search for and review any other relevant literature.
Gather input from subject matter experts across TOs, DNOs, and NESO on the causes and impacts of changing reactive power demands.
Conduct high-level analysis of relevant datasets to identify initial trends in reactive power demand changes.
Examine correlations between reactive power demand variations and factors like local wind speeds, solar radiation, heat pump usage, and electric vehicle charging patterns.

Work Package 2 – Methodology
Methodology for projecting reactive power demand: A report detailing the chosen methodology, including inputs and outputs, a mathematical specification where appropriate, and justification for methodology choices.
Identify technical factors the methodology should account for.
Identify and gather datasets required for this work: historic values, dispatch scenarios, weather, DNO topology, among others.

Work Package 3: Model development
Finalise the methodology and develop a modular Python-based model.

Work Package 4: Projection
Use the model to generate projections of reactive power demand to 2040, considering changes in distribution networks.
Produce outputs for at least two Future Energy Scenarios. Define potential changes and dependencies in reactive power demand.
Integrate analysis results with insights from Work Package 1. Apply statistical techniques and machine learning to assess influencing factors and uncover key patterns.
Explore sensitivity of outputs to key assumptions, prioritizing factors for sensitivity testing based on the assumptions log and available resources.

Work Package 5: Tool deployment
Develop tool from work package 4 based on technical requirements.

Work Package 6: Training and tool documentation
Detailed documentation for input and output interfaces to aid future development.
ENIP Risk Rating:
Technology Readiness Level (TRL) change = [2]
Cost = 1
Suppliers = 1
Data assumptions = 2
Total =6 (Low)

Scope

Development of a reactive power demand projection tool: This includes creating a methodology and toolset for projecting reactive

power demand at Grid Supply Points (GSPs) within the GB network.
Assessment of declining reactive power demand: Analysing historical trends and identifying key drivers behind the decline in reactive power demand from distribution networks.
Analysis of future reactive power drivers: Evaluating potential future changes in the distribution network and their impacts on reactive power demand.
Out of Scope:
Implementation of reactive power solutions: The project does not include the actual implementation of reactive power management solutions or infrastructure changes
Market design and regulation: The project does not cover the design of new market mechanisms or regulatory frameworks for reactive power
Short-term projections: The project focuses on long-term projection and does not include short-term or real-time reactive power demand determination.

Objective(s)

The objective of this project is to:

- Investigate the causes behind the decline in reactive power demand from distribution networks since 2005.
- Develop a projection tool and methodology capable of predicting reactive power demand up to 15 years ahead under different scenarios
- Analyse future changes in the distribution network and their potential impacts on reactive power demand.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

No specific impact on consumers in vulnerable situations

Success Criteria

The success criteria will be determined by the approval of the deliverables, which may include reports, documents, or software development:

- Agreed methodology for projecting reactive power demand
- Report on the reasons behind the decline in reactive power demand from distribution networks since 2005
- Proof of concept projection tool for predictive reactive power demand (up to 15 years ahead) delivered
- Evaluation of the accuracy and reliability of the tool
- Analysis of future changes and impacts on reactive power demand

Project Partners and External Funding

TNEI will carry out the project in collaboration with NESO. No external funding is needed.

Potential for New Learning

The project will have the potential to inform best practice for using a hybrid approach that combines data-driven learning techniques and archetypal power flow models. It will also provide learnings as result of in-depth investigation into the variables influencing reactive power injection from Distribution Network Operators (DNOs) for the entire network. These learning will be disseminated through project reports shared on the smarter networks portal.

Scale of Project

This project will be delivered in 6 work packages, following an agile approach over 10 months.

Technology Readiness at Start

TRL1 Basic Principles

Technology Readiness at End

TRL4 Bench Scale Research

Geographical Area

This project is being delivered by UK based suppliers and funding by NESO, it therefore has a geographical scope of Great Britain.

Revenue Allowed for the RIIO Settlement

None

Indicative Total NIA Project Expenditure

250000

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:

This project will play a crucial role in facilitating the energy system transition by addressing several key aspects:
Enhanced Grid Management: By improving NESO's ability to manage voltage levels across the NETS, the project ensures a stable and reliable grid, which is essential for integrating renewable energy sources and accommodating increased electrification.
Proactive Decision-Making: The deeper understanding of reactive power demand trends enables NESO to make proactive, data-driven decisions, ensuring the grid can adapt to changing energy scenarios and demand patterns.
Future-Proofing: Addressing uncertainties in reactive power demand trends and preparing for potential increases by 2030 ensures NESO is ready for evolving energy scenarios, including increased electrification and renewable integration.
Cost Savings and Efficiency: Optimising investments in reactive power management infrastructure helps avoid unnecessary expenditure on transmission system reinforcements, making the transition more cost-effective.
Advanced Projection Capabilities: Developing a tool capable of predicting reactive power demand up to 15 years ahead allows NESO to plan strategically for the long-term, ensuring the grid can handle future energy demands.
Compliance and Innovation: Supporting continued compliance with voltage requirements defined within Grid Code and NETS SQSS, and building on insights from previous projects like REACT (UKRI10058535) and ATLAS (NIA_ENWL008), improves NESO's ability to anticipate and address long-term grid challenges associated with the energy transition.

How the Project has potential to benefit consumer in vulnerable situations:

No specific impact on vulnerable consumers

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)

N/A

Please provide a calculation of the expected benefits the Solution

The cost-saving benefits of this project could be significant although difficult to quantify. By optimising investments in reactive power management infrastructure, NESO can better manage reactive power to minimise the risk of unnecessary expenditure on transmission system reinforcements. This proactive approach ensures that funds are allocated efficiently, reducing overall costs. Additionally, the advanced projection capabilities of the tool allow for strategic planning, helping NESO anticipate future reactive power demand and make informed decisions that prevent costly last-minute adjustments. Overall, the project enhances operational efficiency and supports long-term financial savings by enabling NESO to manage reactive power demand more effectively and avoid overspending on infrastructure.

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

Solution can be used by NESO to project reactive power across full GB Transmission system.

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

Not applicable as solution to be developed will be applicable across GB.

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

Enhanced Grid Management Techniques: The improved methods for managing voltage levels and understanding reactive power demand trends can be adopted by other network licensees to enhance their own grid management practices. This will help them maintain stability and efficiency in their networks.
Proactive Decision-Making: The data-driven decision-making approach developed through this project can be shared with other licensees, enabling them to make more informed and proactive decisions regarding reactive power management and grid operations.
Future-Proofing Strategies: The insights gained from addressing uncertainties in reactive power demand trends and preparing for evolving energy scenarios can help other licensees anticipate and adapt to similar challenges in their networks.
Cost Savings and Operational Efficiency: The strategies for optimising investments in reactive power management infrastructure and avoiding unnecessary expenditure can be valuable for other licensees looking to improve their operational efficiency and reduce costs.
Advanced Projection Capabilities: The projection-based tool developed in this project can be utilised by other licensees to predict reactive power demand in their networks, allowing for better long-term planning and strategic decision-making.
Compliance and Innovation: The methods for ensuring compliance with regulatory and policy requirements, as well as the innovative approaches to grid management, can be shared with other licensees to help them meet their own regulatory obligations and drive innovation in their networks

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

N/A

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.

This project builds on insights from previous projects like REACT (UKRI10058535) and ATLAS (NIA_ENWL008). While REACT and ATLAS were primarily focused on specific aspects of reactive power management and grid stability, this project has a broader scope. It aims to enhance NESO's ability to manage voltage levels across the NETS, develop advanced projection capabilities, and prepare for future energy scenarios, including increased electrification and renewable integration.

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 project aims to use a hybrid approach that combines data-driven learning techniques and archetypal power flow models which have not been used before in this application. The project proposes an in-depth investigation into the variables influencing reactive power injection from Distribution Network Operators (DNOs) for the entire network based on previous studies, and historic values. Improving the current approach which uses historic values to create a linear trend of the relationship between reactive and active power and applies the forecasted active power to calculate the future reactive power.

Relevant Foreground IPR

Agreed methodology for projecting reactive power demand
Report on the reasons behind the decline in reactive power demand from distribution networks since 2005
Proof of concept projection tool for predictive reactive power demand (up to 15 years ahead) delivered
All relevant documents related to the tool
Evaluation of the accuracy and reliability of the tool
Analysis of future changes and impacts on reactive power demand

Data Access Details

Data for this project and all other projects funded under the Network Innovation Allowance (NIA), Network Innovation Competition (NIC) or the new Strategic Innovation Fund (SIF) can be found or requested in a number of ways:
A request for information via the Smarter Networks Portal at https://smarter.energynetworks.org, to contact select a project and click 'Contact Lead Network'. National Energy System Operator already publishes much of the data arising from our innovation projects here so you may wish to check this website before making an application.
Via our Innovation website at https://www.neso.energy/about/innovation
Via our managed mailbox innovation@nationalenergyso.com
Details on the terms on which such data will be made available by National Energy System Operator can be found on our website: Data Sharing Approach | National Energy System Operator.

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

High Initial Uncertainty: The initial costs associated with developing, releasing, and maintaining a new reactive demand forecast model, along with the uncertainty of its success, make it impractical to fund through regular business activities.
Need for Rigorous Quality Assurance: The extensive quality assurance, calibration, and functionality assessments required to ensure the models' accuracy and reliability involve significant resources and expertise that go beyond typical business 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

Commercial Risk:
The initial costs associated with developing, releasing, a new model, along with the uncertainty of its success, make it impractical to fund through regular business activities.
Technological Risks:

Model Accuracy and Reliability: Ensuring that the model is accurate requires extensive calibration and ongoing updates.
Data Integration: Sourcing and integrating appropriate can be complex and resource-intensive.
Operational Risks:
User Training and Misinterpretation: Developing comprehensive documentation and conducting training workshops/webinars to prevent the wrong usage or misinterpretation of the models is essential to their successful adoption.
Unproven Approach: There is a chance that this novel approach may encounter unforeseen challenges, making it less effective or more complex than anticipated.

This project has been approved by a senior member of staff

☑ Yes