

NIA Project Registration and PEA Document

Date of Submission

Nov 2023

Project Reference Number

NIA2_NGESO061

Project Registration

Project Title

VoltaVisor

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Project Licensee(s)

National Energy System Operator

Project Start

October 2023

Project Duration

0 years and 6 months

Nominated Project Contact(s)

Marian Kantor (ESO)

Project Budget

£450,000.00

Summary

Low demand on the network has the potential to push network voltages beyond safe operating levels. Network voltages are maintained within these safe operating levels by controlling which voltage support equipment: generators, circuits and reactive equipment are in use in each UK network region. Currently, determining which voltage support equipment should be in use is done using complex simulations, which can be time-consuming and take up to one week to plan which combination should be switched in or out for any one week.

As part of this project, the relationship between national demand forecasts, outage patterns and voltage advice given in the Integrated Energy Management System (IEMS) data will be analysed and the most common pattern of assets switched in/out will be extracted. This will result in the development of predictive techniques that allow high confidence assignment of one of the common switching combinations or a suggestion to return to simulation in unusual circumstances, achieving huge reductions in time spent on simulation.

Third Party Collaborators

Faculty Science Ltd

Nominated Contact Email Address(es)

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Problem Being Solved

Low demand on the network has the potential to push network voltages beyond safe operating levels. Network voltages are maintained within these safe operating levels by controlling which voltage support equipment: generators, circuits and reactive equipment are in use in each UK network region. Currently, determining which voltage support equipment should be in use is done using complex simulations, which can be time-consuming and take up to one week to plan which combination should be switched in or out for any one week. As a result, the system cannot adapt to short term changes, such as a circuit fault. Decisions on which assets are switched in or out are made based upon national demand forecasts and patterns of outages in the IEMS data. Furthermore, actions taken in the past to resolve historic situations are predictive of solutions to similar circumstances today. Therefore, it would be possible to rapidly assess the combination of assets required from a group of most frequently used combinations using algorithms trained on historical data.

As part of this project, the relationship between national demand forecasts, outage patterns and voltage advice given in the IEMS data will be analysed and the most common pattern of assets switched in/out will be extracted. This will result in the development of predictive techniques that allow high confidence assignment of one of the common switching combinations or a suggestion to return to simulation in unusual circumstances, achieving huge reductions in time spent on simulation.

Method(s)

The Project will be delivered through 3 work packages (WPs):

Work Package 1: User research and design - Engage with ESO users to define the project problem statement and scope of the AI software solution, in particular, how the outcome of this project can support in providing voltage advice.

Work Package 2: Data Science – ingestion and analysis of relevant datasets (for example, regarding outages, prior voltage advice and system outcomes) to determine an appropriate solution design to be tested with ESO. The project will continue to build a proof-of-concept (PoC) solution, which represents the core output of this phase.

Work Package 3: Backend engineering – actively identify and test potential deployment pipelines, such that models described above can be successfully integrated into ESO infrastructure within subsequent phases.

Using a combination of National demand forecasts at day to week ahead, historical outages, network voltage data, generator availability and previous voltage advice, Faculty will develop a PoC model that identifies the amount of voltage support (in MVars) required in each region (for the time corresponding to minimum demand, overnight on weekends), and possible combinations of plants and reactive equipment (e.g. Static VAR compensator, Voltage Controllers, Voltage Control Centres, Static Reactors) to deliver it, based on relationships identified from historical data.

Due to the nature of the data utilised in the project it will restrict how the data can be handled and shared; we have put mitigations in place with our security teams to ensure that the data used for the project follows a strict governance process with our supplier, and information that is deemed confidential will be redacted from the final reports and outputs to ensure we comply with our obligations.

At the end of this project, we expect to have the following:

- A PoC solution for delivering fast voltage advice that can adapt to last minute changes and unscheduled outages, benchmarked against key metrics
- An agreed plan for how the tool will be deployed for regular use by end users, developed in close collaboration with ESO's IT team. While we expect the format of the advice to not change from current practice, deployment will require ongoing access to the data needed by the model.
- Established infrastructure for tool deployment as tested with a skeleton solution.

However, we would not expect tools to be fully deployed and this would need to follow in a next iteration phase.

In the next phase, we would anticipate the following activities to be undertaken, with estimated cost/effort to be developed towards the end of the project:

- Building of the full solution architecture and deployment of models within ESO infrastructure
- If required, further refinement of the POC models based on findings from earlier phase to improve performance.
- Development of monitoring systems to ensure alerting in the case of unexpected issues. Monitoring for model performance and data drift will also be developed.
- Further user testing during live deployment to adjust usability or utility of tool.

The project will deliver a solution that provides voltage advice in the same format as currently used by the Network Access Planning (NAP) team but to an agreed acceptable standard on far shorter timescales. Upon completion we will test out the tool further within

NAP and the wider business and if successful we will aim to embed the tool into the NAP process with the help of the ESO IT teams

In line with the ENA's ENIP document, the risk rating is scored Low.

TRL Steps = 1 (2 TRL steps)

Cost = 1 (£450k)

Suppliers = 1 (1 supplier)

Data Assumptions = 2

Total = 5 (Low)

Scope

Currently, voltage advice for the week ahead is generated using simulations from PowerFactory software (a power systems model of the electricity transmission network), a process that takes approximately a week for Voltage Engineers to produce. In particular, Voltage Engineers spend considerable time manually inputting and adjusting different scenarios and contingencies, a process which is inflexible in adapting for last minute changes (e.g. plant outages).

By examining the relationship between voltage, forecasted national demand, planned outages, and commonly seen patterns of advised voltage support, this project aims to deliver rapid voltage advice under most circumstances utilising AI techniques. The end solution will be used by voltage engineers to rapidly understand the total amount of support required and assess potential combinations of plants and other reactive equipment to mitigate high overnight voltages.

This solution has scope to deliver significant time savings for voltage engineers, providing initial recommendations within minutes, as opposed to hours and days using existing methods. In turn, this can enable the ESO to test a wider set of scenarios than would have been possible before. This not only has benefits for time saved but also acts as an extension of existing capability, further improving system resilience and the quality of advice provided.

Objective(s)

This project aims to deliver a PoC AI solution to provide rapid voltage advice, namely, a solution that has been trained and tested on historical data but is not yet deployed on ESO infrastructure. The specific objectives of the project are to develop:

- A PoC model that identifies the amount of voltage support (in MVars) required in each region (for the time corresponding to minimum demand, overnight on weekends), and possible combinations of plants and reactive equipment (e.g. SVCs, VCCs, SRs) to deliver it, based on relationships identified from historical data. This will include initial designs of a front-end user interface to represent how the bespoke software would be integrated into decision-making
- A plan for full deployment during a prospective phase based on engineering discovery activities combined with user research (deployment out of scope of this phase).

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

The ESO does not have a direct connection to consumers, and therefore is unable to differentiate the impact on consumers and those in vulnerable situations. Benefits to all consumers are detailed below.

Success Criteria

The project will be deemed successful if the following criteria are met:

- Voltage advice provided by a PoC solution, validated through acceptance testing with Voltage Engineers and a wider ESO Steering Group.
- Statistical benchmarking of advice provided by the tool relative to prior voltage advice and/or voltage control reports documenting observed actions undertaken by ESO.
- An approved front-end interface facilitating buy-in from end users.
- Clear plan for deployment if successful

Project Partners and External Funding

Faculty.ai will be carrying out the work. No external funding required.

Potential for New Learning

There are multiple channels for new learning through this project, including:

- Potential to improve the quality of advice provided, by enabling rapid understanding of prior advice and historical relationships.
- Ability of voltage engineers to run a wider range of scenarios through this rapid voltage advice solution, building new capability over

and above the time-consuming, inflexible approaches currently in place.

- Learnings regarding the adoption of AI solutions across the business, both for application within these projects but also more widely as to opportunities for AI adoption across the organisation.
- Data quality – this project will provide learnings for ESO how best to share, process and maintain data for analysis in a consistent, secure and efficient manner, providing learnings for use not only by this project but future AI use cases.

Learning will be shared internally through regular briefings, user research, solution documentation and presentation of key findings. Externally, the team will identify opportunities to present at ENA / Ofgem / DESNZ events to highlight outcomes of this project, and also publish documentation on the ENA Smarter Networks Portal (and other relevant forums).

Scale of Project

The project spans six months with one project partner. The project consists of desk-based research, tool development and workshops with the relevant ESO teams (including network and wider teams).

Technology Readiness at Start

TRL3 Proof of Concept

Technology Readiness at End

TRL6 Large Scale

Geographical Area

Based in the GB ESO area of operations.

Revenue Allowed for the RIIO Settlement

None

Indicative Total NIA Project Expenditure

£450,000

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:

Provision of rapid advice enables voltage engineers to run and plan for a wider range of scenarios (e.g. different wind capacity utilisations), optimising the set of plants and reactive equipment (and avoiding unnecessary use of fossil fuel generators to provide voltage support, where possible). This can be extended from minimum demand on weekend periods (as is planned currently on a week-ahead basis) also to weekday analyses, extending this impact. This will support the ESO in accommodating the impact of intermittent renewable generation.

Ultimately, solutions delivered through this project support coordination of the system to navigate voltage constraints and ensure security of supply, helping the ESO to accommodate greater renewable generation and reduce the carbon intensity of the grid.

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)

N/A

Please provide a calculation of the expected benefits the Solution

The primary benefits are:

- The enablement of wider scenario planning capability.
- Better quality voltage advice, not just at the weekend demand low point, but extending capability to voltage advice planning throughout the week.

Better quality voltage advice, and the extension of such capability throughout the week, would be reflected through downward pressure in the cost of procuring such support.

For example, in order to access reactive power support, on occasions, a generator is required to be synchronised to the network, and energy supplied by that generator (accessed through the balancing market) – this solution, and better quality advice, seeks to minimise the occasions on which this is required. While many of these instances may be unavoidable or outside the control of the ESO, the scale of such costs implies scope for considerable efficiencies even if marginal improvements can be delivered.

Baseline Cost: Voltage system costs have grown considerably (and consistently) in recent years, from £100m in 2014-15 to £488m in 2023 – this is in part driven by input prices (predominantly natural gas).

Method Cost: The scale of voltage costs introduces the possibility for considerable financial savings should better quality advice be delivered. For example, taking the 2020-21 Outturn Voltage costs for conservatism (£75.5m synchronisation cost and £66m utilisation cost, for a total of £141m – this is the last full year before considerable increases in gas prices were observed), even a 2% efficiency

delivered (or rather, 1 in 50 days in which advice led to the material avoidance of a costly unit being brought online to provide support), would deliver efficiency savings of £2.8m per year (nominal). Taking the most recent full year figures for outturn voltage costs (2022-23), this figure would be £9.75m per year.

Should such efficiencies be delivered, the cost of rolling out the VoltaVisor solution would be recovered within the first year of implementation.

Source:

<https://data.nationalgrideso.com/constraint-management/outturn-voltage-costs?from=0#resources>

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

The method will be applied across all regions in which the ESO coordinates voltage support; as such the full GB operating area is in scope of the voltage advice tool.

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

Following conclusion of this phase, a further phase would be required to finalise model development (from PoC to deployable product) and integrate the solution into ESO systems. It is estimated that the cost of this next phase would cost between £0.5-1m – these costs will be developed further within the scope of this 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

This project will deliver an initial PoC for direct use and testing with ESO end-users (voltage engineers). User feedback will be incorporated into future deployment. The ESO will own and operate the solution developed within this project, so will directly benefit from the learnings of the project within day-to-day operations, but other Network licensees will also benefit through more responsive outage planning services to (TOs and DNOs) leading to improved customer experiences and satisfaction.

Additionally, it enables the early identification of issues, facilitating efficient contracts with generators and ultimately reducing consumer expenses. Solutions delivered through this project support coordination of the system to navigate voltage constraints and ensure security of supply, helping the ESO to accommodate greater renewable generation and reduce the carbon intensity of the grid.

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 is the first attempt to provide rapid voltage advice using AI techniques, as opposed to physics-based network models that consider network topology, constraint boundaries and geographic dispersion of assets (through PowerFactory). While the application of AI solutions, given the benefits they can deliver, is being pursued both by the ESO and other stakeholders within the energy system, this is a specific use case for which there is no publicly available precedent.

By assessing only the relationships observed between the combination of plants and reactive equipment advised, high-level characteristics of demand, generation (e.g. outages) and outcomes, the AI methodology is an entirely separate approach to such power systems representations, and aims to provide additional capability to the ESO, as opposed to duplicating existing methods. For example, provision of rapid voltage advice would enable the ESO to develop new capability to rapidly consider scenarios and deliver advice during weekday periods (as opposed to weekend low points), and potentially well in advance of the week-ahead timescales that voltage engineers currently work within.

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 will investigate a new approach to providing voltage support using AI solutions that has not been tried before – existing models seek to use physics-based models of the power system. As such, there is a risk that using AI, which finds associations between past advice and network characteristics, may not provide usable advice that sufficiently takes into account the nuances of coordinating the network. Use of these techniques has only become feasible in recent years due to advancements in the field and improvements in computing power.

As this approach is untested, there is a risk that a solution of the required accuracy might not be found. Hence, innovation funding is better suited to trial the solution before implementing it into BAU. Additionally, there are specific risks around data access and model deployment given the sensitive nature of the data needed and the current technical set-up at the ESO.

Relevant Foreground IPR

The following foreground IP is expected to be generated in the course of the project:

- a PoC solution to provide voltage advice, validated through acceptance testing with Voltage Engineers and a wider ESO Steering Group.

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:

1. 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 Grid ESO already publishes much of the data arising from our innovation projects here so you may wish to check this website before making an application.
2. Via our Innovation website at <https://www.nationalgrideso.com/future-energy/innovation>

3. Via our managed mailbox innovation@nationalgrideso.com

Details on the terms on which such data will be made available by National Grid ESO can be found in our publicly available “Data sharing policy relating to NIC/NIA projects” at <https://www.nationalgrideso.com/document/168191/download>.

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

Due to the inherently risky nature of the project, given that it is trialling new approaches to providing voltage support using new, innovative AI techniques, it does not fall into current business as usual (BAU).

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

- The project attempts to use AI to provide rapid voltage advice, a complex area of the business, and the overall TRL is low. Innovation funding is therefore more suitable for exploring the project's potential and increasing TRL before transferring into BAU if proof of value can be delivered. This is a project that otherwise would not be pursued without the assistance of innovation funding.
- This is a novel application of AI methods both for this use case and across ESO – this brings an inherent risk that workable advice cannot be provided, a risk that is not suited for BAU funding.
- Standard ESO processes and procedures relating to data capture, storage, processing and sharing may need to be adapted to fully integrate the solution into ESO architecture and run the solution at the frequency required (daily, hourly).

This project has been approved by a senior member of staff

Yes