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NIA Project Registration and PEA Document

Date of Submission

Jul 2026

Project Reference Number

NIA_SPEN_0140

Project Registration

Project Title

GenVolt

Project Reference Number

NIA_SPEN_0140

Project Licensee(s)

SP Energy Networks Distribution

Project Start

July 2026

Project Duration

0 years and 8 months

Nominated Project Contact(s)

Parham Momeni

Project Budget

£250,000.00

Summary

This project trials the implementation of dynamic voltage control through the coordinated control of DER to improve voltage management to the benefit of customers. Constraint Management Zone (CMZ) control infrastructure delivers coordination actions for voltage control. This includes ensuring complimentary coordination between ANM (DER constraint management) and DVC actions. Other relevant voltage control and other network functions which will feed into the DVC overarching control include, but are not limited to, CLASS (Demand Reduction & Boost), ANM, T/D boundary management and reactive power management. DVC operation can include co-ordination with operational/emergency control functions, such as OC6. This project encompasses the different stages of designing and testing a prototype DVC application, providing foundations for a DVC that can be tested in a later-stage operational trial.

Third Party Collaborators

Smarter Grid Solutions

Nominated Contact Email Address(es)

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Problem Being Solved

Managing voltage across the network is critical to ensure that customers receive an appropriate system voltage while maintaining the numerous other objectives of the network such as minimising network losses, minimising customer bills, and enabling the cost-effective and timely connection of DER to the distribution network. Traditional voltage management techniques are limited in the degree of control available to deliver these goals and whilst delivering highly localised control, cannot coordinate across multiple objectives or wider network areas. This project investigates how the implementation of dynamic voltage control by including the coordinated control of DER can improve voltage management to the benefit of customers.

Method(s)

Voltage control can presently be achieved through control of the tap settings at Grid and Primary transformers and through harnessing P and Q control at DER sites. Much of the existing generation on SPEN networks is operated in voltage control mode, hence DER sites will automatically vary power factor (within bounds) to maintain voltage to a set-point at the point of connection (PoC). The voltage set-point of a DER can be utilised as part of DVC to achieve the desired resultant voltage profile on SPEN distribution systems.

The project will utilise the existing Constraint Management Zone (CMZ) enabling infrastructure to deliver control and coordinate actions for voltage control. This includes ensuring complimentary coordination between ANM (DER constraint management) and DVC actions. Other relevant voltage control and other network functions which will feed into the DVC overarching control include, but are not limited to, CLASS (Demand Reduction & Boost), ANM, T/D boundary management and reactive power management. Additionally, the DVC operation can include co-ordination with operational/emergency control functions, such as OC6. This project encompasses the different stages of designing and testing a prototype DVC application, which provide the foundations of development for a voltage control system that can be tested on the live network in an operational trial.

Scope

The scope of work is detailed in the following sections, covering Phase 1 (DVC Base Case), Phase 2 (Additional DVC Functionality) and Project Deliverables

Phase 1 – DVC Base Case

The DVC Base Case is defined and studied in the first instance in advance of additional DVC functionality being defined. The purpose of the Base Case is to prove the fundamental functionality of the DVC concept. In this case, this is the ability to control/optimise voltages on the LV network to provide customers with suitable voltages, which is dependent of the specific needs of LV customers. However, at a minimum, the control of voltage on the LV network must demonstrate the ability to keep all customers within statutory voltage limits.

The majority of SPEN's secondary transformers (11 kV / 415 V) do not have the capability to have their tap settings altered remotely. Therefore, the available levers to centrally and indirectly manage voltages on the LV network are as follows:

- Primary transformer tap settings,
- Grid transformer tap settings, and
- DER voltage set points.

The project will define and demonstrate the DVC Base Case through the following steps.

Task 1.1 – Base Case Control Principles, Modelling and Scenario Definition

Control principles required to achieve optimised network voltages. The control parameters will be the levers described in Section 2.1. Control observations on the LV network will be used within the control principles to check control has been applied correctly. The control will take voltage statutory limits into consideration to ensure these are always maintained.

A network model of the trial network area will be required to successfully test the DVC Base Case. One 132 kV / 33 kV Grid Supply Point (GSP) will be used as a trial network area for the Base Cases. Suitable PowerFactory models of the selected GSP will be required from SPEN, with some portions of the LV network modelled. This will allow for LV network voltages to be observed and controlled. Within the LV network, there will be some representation of "end of feeder" points, which are the nodes in the network most susceptible to low voltage issues. As the LV network is vast, only portions of it are required to be modelled for testing purposes.

A range of study scenarios will be defined to fully test the DVC Base Case functionality. These scenarios will be defined in collaboration with SPEN, with all relevant parameters, control variables and network configurations specified. Potential scenarios to be tested are as follows:

- LV Network Low Volts: Deliver safe low voltages to the LV network to achieve conservation of voltage reduction, resulting in lower customer bills.
- LV Network LCT Voltage Optimisation: Optimise voltages on the LV network to manage varying levels of LCT demand on the

network, avoiding statutory limit exceedance.

- Network Topology Changes: Test how the DVC Base Case control reacts to changes in network topology.

Task 1.2 – Base Case Test Environment Specification & Build and Data Set Collection

The Base Case test environment specification will build on the previously drafted test-bench architecture shown in Figure 1. The test environment will utilise the following software/applications:

- Strata Grid – application of DVC & ANM algorithms,
- PowerFactory – load flow engine to simulate network behaviour in the tests, and
- Python – for implementation of relevant test harnesses for DER and application of DVC.

Test instance of Strata Grid are used to demonstrate the DVC Base Case functionality – a "CMZ-in-the-loop" simulation approach. Alongside Strata Grid, a test harness will be developed to simulate DER responses to CMZ control set-points, which will reflect DER ramp-rates and voltage/reactive power deadbands. Additionally, other test harnesses will be implemented to represent OLTC and AVC settings and the delivery of the DVC voltage control. Additional test modules will deliver aspects of the DVC Base Case functionality and perform the necessary coordination of additional separate voltage functions in Phase 2, following successful testing of the Base Case. This test module approach is taken where functionality is not directly configurable in Strata Grid, hence implementation of the test module as part of this trial implementation.

This approach allows a more granular study of network control, observing the minute-by minute dynamics of voltage control and ANM functions. When compared to approaches such as time-series steady-state study, this higher resolution solution-in-the-loop approach provides greater insight into the coordination between the different control use cases. The test process includes a load-flow simulation in the testing loop, allowing calculation of network parameters for the given set of inputs. The inputs will either be fixed (such as for demand and firm generation) or variable (such as non-firm DER, and OLTC set-points as informed by Strata Grid via test harnesses.

Task 1.3 – Base Case Test Simulation and Result Analysis

The desired test scenarios will be implemented in the test environment, using the CMZ-in-the loop simulation approach. This will log the simulation outputs and provide a high-resolution view of CMZ and network behaviour under the delivery of Base Case DVC. A collection of metrics will be recorded for each test scenario. These metrics will include the following, many of which can be visualised as a time-series dataset:

- System power flows (P & Q);
- System voltages;
- Transformer tap settings;
- DER export/import levels; and
- DVC Base Case metrics.

Following the completion of the tests and the collection of results, the outputs will be analysed and compared against the Base Case aims to confirm if the objectives have been achieved. The findings from the Base Case tests will be published in a deliverable report, which will also include details on the test environment and methodology.

Phase 2 - Additional DVC Functionality

Following the successful completion of the DVC Base Case, SPEN may wish to commission Phase 2 of the project, which will test more DVC use cases and functions. If Phase 2 is commissioned, this section of the scope can be updated if learnings from Phase 1 indicate scope updates to be beneficial.

The Phase 2 scope has been split into 3 Stages, containing a total of 10 distinct activities:

- Use Case and Testing Definition: The setting out of how Dynamic Voltage Control will deliver outputs and the design of the test regime which shall validate the proposed approach and meet desired outputs.
- Simulation Testing Delivery: The build of the test environment, collection of necessary test data, and performance of the tests with subsequent analysis of results.
- Implementation Roadmap: Informed by simulation trial outputs, this stage sets out the requirements and deployment architecture for

implementation, forming a proposition for live network trial.

Task 2.1 Use Case & Testing Definition

Definition of Voltage Control Use Cases and Coordination Principles

The first step of full DVC design is to have a clear vision of the desired voltage control use cases that solve a conflict or enhance the system via coordination. A focused perspective to DVC Use Cases has been applied, aiming to consider those which are novel and offer the most value. The proposed Use Cases are as follows:

- Transmission / Distribution Boundary Management,
- Coordinating generator voltage control set-points,
- Contributing to CMZ actions,
- Reducing DER Curtailment,
- Provision of Non-Emergency Demand Control, and
- Enhanced Provision of OC6 Demand Control.

The final Use Cases for study will be agreed and these Use Cases developed further, building out a structure and detailed Use Case definition and to illustrate each process via a flow chart. This will define the potential conflict or coordination to be addressed, cases to be studied, and the network conditions under which they will arise. For each voltage control function, the impacts of ANM will be considered, including how best to avoid potential conflicts while these additional Use Cases are being delivered. The clear definition of detailed Use Cases will be crucial to the development of successful coordination principles, as this allows for quicker implementation of each control function and their interaction with other control functions when building the prototype DVC. Control functions used in the prototype DVC should be applied in a priority order, with the DVC having the functionality to allow for alteration of this priority. The flexibility of function deployment priorities will be built into the control principles from the offset.

Test Design for Validation of Use Cases

Following the definition of uses cases, a set of test cases will be designed to study each use case. The test cases will consider relevant parameters and control variables for each use case, with the aim being to demonstrate a potential control conflict and then showcase how conflicts can be resolved through the application of a coordinated DVC action, which may involve the implementation of multiple different control functions.

Test Environment Specification Update and Definition of Test Scenarios

The Test Environment Specification will be updated in preparation for testing additional Use Cases. Following on from the test design, the test scenarios will also be defined, with all relevant parameters, control variables and network configurations specified.

Task 2.2 Simulation Testing Delivery

Test Environment update

Building on the work completed in Phase 1, the test environment will be updated to allow the demonstration of the additional DVC Use Cases.

Test Dataset Collection

Additional required datasets for use in Phase 2 will be collected/created and configured for use in the Test Environment. Similarly to the Base Case, datasets which will likely be required include:

- Power system parameters, including transformer tap settings and constraint threshold details,
- PowerFactory network model of the study GSP, including sections of HV and LV network,
- Load import profiles & load ZIP values (to model the effect of voltages changes on demand),
- DER export profiles (wind, solar, synchronous etc), and
- DVC function settings. This list is non-exhaustive, other datasets may be identified during the specification of testing scenarios.
- Platform Testing

The desired test scenarios will be implemented in the test environment to analyse the additional Use Cases, using the CMZ-in-the-loop simulation approach. Similarly to the Base Case methodology, this will log the simulation outputs and provide a high-resolution view of CMZ and network behaviour under the coordinated voltage control methods. A collection of metrics will be recorded for each test scenario. These metrics will include the following, many of which can be visualised as a time-series dataset:

- System power flows (P & Q),
- System voltages,
- Transformer tap settings,
- DER export/import levels,
- DVC function metrics, and
- ANM operation/trigger metrics.

Post-Testing Analytics and Dissemination

Following the completion of the additional Use Case tests and the collection of results, the outputs will be analysed and compared against the use cases to confirm if the objective of each have been achieved. The findings from the test scenarios will be published in a deliverable report, which will also include details on the test environment and methodology.

Task 2.3 Implementation Roadmap

Voltage Orchestration Requirement Specification

Once the analysis of the test results has been completed, the functional requirements for the voltage orchestration which underpins the DVC will be written out in a specification. The requirements specification will outline the specific functions that must be delivered from different architecture components. This will be used post-project to assist in the configuration of a DVC application to be used on the live system. This Requirement Specification will give details of the level of visibility and control needed on the SPEN network to implement DVC.

Voltage Orchestration Deployment Architecture

Similarly to the Voltage Orchestration Requirements Specification, the Voltage Orchestration Deployment Architecture will be completed after the analysis of the simulation trial results. This will be included in the same report as the Voltage Orchestration Requirement Specification and will describe the different technology components required to deliver DVC functionality and their deployment architecture, including the interactions between different control functions.

Network Trial Design & Implementation Roadmap

An Implementation Roadmap will be delivered that showcases how the DVC application will be taken forward beyond test-bench testing, deployed to a live network trial and subsequent wider deployment. This will outline the process of implementation to the existing Strata Grid infrastructure at SPEN and the longer-term operations and support principles for the deployment.

Objective(s)

The objectives of this project are to design, validate, and de-risk the implementation of Distribution Voltage Control (DVC) within SPEN’s operational environment. Specifically, the project will:

- Establish clear rules and frameworks for the coordination of multiple voltage control use cases across the network.
- Develop a practical design for the implementation of voltage control and management capabilities within the Constraint Managed Zone (CMZ) infrastructure.
- Demonstrate the feasibility and performance of DVC methods through a controlled test-bench and simulation-based environment.
- Generate key learnings and evidence to inform the design, business case, and delivery approach for future full-scale deployment and network trials of the DVC concept.

These objectives collectively support more efficient network operation, enabling reductions in network losses, improved customer outcomes, and lower carbon emissions through optimised voltage management.

Consumer Vulnerability Impact Assessment

This project is expected to deliver a positive impact for consumers in vulnerable situations by improving the efficiency and stability of network operation through enhanced voltage control. From a technical perspective, more consistent voltage levels can reduce the risk of supply quality issues that may disproportionately affect vulnerable customers, particularly those relying on sensitive electrical equipment. From a financial perspective, optimised voltage management has the potential to reduce overall system losses, contributing to lower network costs over time and helping to minimise upward pressure on customer bills. From a wellbeing perspective, improved network resilience and reliability supports continuity of supply, which is critical for vulnerable consumers who may be more exposed to the impacts of outages or poor power quality.

At this stage, impacts are expected to be broadly positive and non-discriminatory, with no adverse distributional effects identified. Further assessment will be undertaken in later phases, particularly ahead of any live network deployment, to ensure that consumer vulnerability considerations are fully understood and appropriately addressed.

Success Criteria

1. Demonstration of a DVC base case in a lab setting to prove the fundamental functionality of the DVC concept. In this case, this is the ability to control/optimise voltages on the LV network to provide customers with suitable voltages, which is dependent of the specific needs of LV customers.

2. Demonstration of extended DVC use cases in a lab setting to explore the capabilities to DVC to maximise it's benefit to customers.

3. Delivery of an implementation roadmap which is informed by the above trial outputs and sets our the requirements and deployment architecture which would be allow DVC to be deployed on a live network trial.

Project Partners and External Funding

Smarter Grid Solutions Limited – delivery of trial design, implementation, execution and reporting.

Potential for New Learning

We expect to enhance understanding of the applicability of DVC to deliver benefits to customers and network operators. The extent to which these benefits can be realised will be determined through both phases 1 and 2. We expect to disseminate this learning to others through the publication of the deliverable reports produced in this project.

Scale of Project

Simulation of DVC is a key first step to test before the development of a control solution to be implemented on the live network. By proving the base case and additional DVC functionality in simulation, this will lead to the creation of an implementation roadmap which will be critical for developing a control solution for use on the live network. The project has been scoped so that a range of use cases and scenarios can be simulated in order to successfully test and demonstrate DVC functionality under a range of different network circumstances.

Technology Readiness at Start

TRL4 Bench Scale Research

Technology Readiness at End

TRL6 Large Scale

Geographical Area

The project activities will be delivered from SPEN and Smarter Grid Solutions office sites, reflecting the desktop and lab-based testing to be undertaken. The project will simulate network areas within the SPD licence area. Drumcross and Bathgate have been identified as potential test areas.

Revenue Allowed for the RIIO Settlement

0

Indicative Total NIA Project Expenditure

£250,000

Project Eligibility Assessment Part 1

Requirement 1

Facilitate the energy system transition and/or benefit consumers in vulnerable situations

Please answer **at least one** of the following:

How the Project has the potential to facilitate the energy system transition:

One of the objectives of the Dynamic Voltage Control concept demonstrated in the project is to improve the efficiency of the distribution system in line with the goals of the energy system transition. This efficiency improvements comes from at least two areas:

1. Reduce inefficiency due to losses. The project aims to reduce losses and improve the efficiency of the operation of the distribution system, contributing to the energy system transition.
2. By managing the voltage level at customers point of connection while maintaining statutory voltage levels, we expect to reduce disruptions of customer connected energy devices such as low carbon technologies (LCT), leading to efficiencies in how the distribution network is used.

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

Vulnerable customers may be sensitive to the cost of electricity usage. Reducing their consumption of electricity benefits them through lower bills. This project aims to reduce customer bills by lowering voltage while maintaining statutory voltage levels.

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

n/a

Please provide a calculation and/or description of the expected benefits of the solution

The expected benefits are based on a comparison between current network operation (baseline) and operation with an optimised Distribution Voltage Control (DVC) approach.

Cost efficiency: Reduced network losses and deferred reinforcement can lower overall system costs compared to the current method of operating fixed voltage profiles.
Customer benefit: Savings are expected to be passed through to electricity consumers through reduced network costs, helping to limit bill increases over time.
Environmental benefit: Reduced energy losses and improved efficiency will contribute to lower carbon emissions.
System resilience: Improved voltage control can enhance network stability and quality of supply, benefiting all customers, including vulnerable users.
The primary recipients of these benefits are electricity consumers connected to the SPEN network, with wider system and societal benefits arising through decarbonisation and more efficient use of existing infrastructure.

A quantified cost–benefit analysis will be developed in later phases, using trial and simulation data to compare the baseline cost of current operation against the projected cost and benefits of implementing the DVC solution.

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

If DVC was progressed beyond simulation to a live network control solution, it could be implemented in distribution network areas with existing Constraint Management Zones / Active Network Management control. Due to the nature of wider grid constraints including areas covered by NESO 'Technical Limits' control, there are increasingly large areas of the network under CMZ/ANM control and thus with infrastructure that can support this functionality. The Implementation Roadmap which will be generated as part of this project will detail requirements and system architecture for a live DVC control system. Further learnings from a subsequent live trial innovation project would also feed in to the replicability of the Method.

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

The roll-out of the Distribution Voltage Control (DVC) method across GB would involve a combination of system, infrastructure, and integration costs. Key cost components are expected to include upgrades to network monitoring and control systems, enhancement of communication infrastructure to enable real-time data exchange, and integration with existing Distribution Management Systems (DMS) and flexibility platforms such as Constraint Managed Zones (CMZs). Additional costs may arise from adapting protection settings, deploying local control devices where required, and ensuring interoperability across different network areas.

There will also be costs associated with system design, engineering, workforce training, and change management to support operational adoption. However, these upfront investments are expected to be offset over time through reduced network losses, deferred reinforcement, and more efficient use of existing assets.

At this stage, costs are indicative and will vary depending on network characteristics and the scale of deployment. A more detailed cost assessment will be developed in later phases of the project, based on learning from simulation and demonstration activities.

Requirement 3 / 1

Involve Research, Development or Demonstration

Projects 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

Involve Research, Development or Demonstration - Please select all that apply

☐ 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

Network Licenses can use the learning to understand how the studied approach to Dynamic Voltage Support can realise benefits for their customers. The CMZ capability demonstrated here is deployed by several DNOs and those DNOs could leverage this capability for Dynamic Voltage Control quickly and efficiently.

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. Networks must explicitly mention similar projects that they have considered and how these differ.

Please demonstrate below that no unnecessary duplication will occur as a result of the Project.

While some aspects of the project have similarities to innovation projects previously completed, the key difference which this project will investigate is the application of the voltage control via a DERMS platform which can dynamically control generators via set points, alongside the control of network transformer tap changers to provide a cohesive dynamic voltage control solution.

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 simulate voltage control techniques which will be applied via SPEN's Constraint Management Zone (CMZ) infrastructure. The CMZ infrastructure has the capability to send set points to generator, currently delivered for constraint management functions. This functionality allows a generator's active power and reactive power/voltage can be controlled. While network voltage control solutions have previously been studied and tested in other innovation projects, this project will test voltage control when applied via a CMZ/DERMS platform, meaning that generator set points can be controlled alongside transformer tap changers ensuring full coordination between different the network control use cases delivered via CMZ/DERMS.

Integration of DVC with a DERMS platform allows for contribution to SPEN's constraint management zones (CMZ) to be tested. DVC can contribute to CMZ in various ways which can reduce DER curtailment, enhancing value.

Relevant Foreground IPR

We do not expect to generate relevant foreground IPR as part of this project. The project will use existing background IPR from the project partner, Smarter Grid Solutions in a new use case setting. Development activities within the project are focussed on the dynamic modelling and simulation of existing network voltage control systems and the integration of these with the existing real-time grid management application of Smarter Grid Solutions as described above.

Data Access Details

The SP Energy Networks Data sharing policy can be found here.

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

Project seeks to develop innovative approach to Dynamic Voltage Control (DVC) which will utilise CMZ infrastructure, the project will demonstrate a proof of concept which will inform business as usual development in the RIIO-ED3 price control. Utilising innovation funding will enable SPEN to demonstrate and test the proof of concept outside of business as usual approaches derisking network and customers. The project will also provide learning for other network licensees which will support the industry in developing enhanced DVC capabilities ahead of RIIO-ED3.

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

Project seeks to develop innovative approach to Dynamic Voltage Control (DVC) which will utilise CMZ infrastructure, the project will demonstrate a proof of concept which will inform business as usual development in the RIIO-ED3 price control. Utilising innovation funding will enable SPEN to demonstrate and test the proof of concept outside of business as usual approaches derisking network and customers. As DER customers under CMZ constraints are on commercial contracts and there is increased interaction uncertainty with DVC and CMZ control, the NIA funded proof of concept enables an approach to be collaboratively developed which mitigates the technical and commercial risks of implementing a solution directly as BaU.

This project has been approved by a senior member of staff

☑ Yes