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# NIA Project Registration and PEA Document

## Date of Submission

Jun 2024

## Project Reference Number

NGED_NIA_076

## Project Registration

### Project Title

V2G Dynamic Headroom Control

### Project Reference Number

NGED_NIA_076

### Project Licensee(s)

National Grid Electricity Distribution

### Project Start

July 2024

### Project Duration

1 year and 7 months

### Nominated Project Contact(s)

Liza Troshka - ltroshka@nationalgrid.co.uk

### Project Budget

£419,191.00

### Summary

This project will use smart meter data to provide improved visibility of the existing capacity headroom along the length of feeders, and to improve the targeting in location and time of active and reactive power management of V2G, (also known as Volt/Var or Volt/Watt control techniques), while improving the confidence that assets will remain within thermal and voltage limits.

### Third Party Collaborators

Loughborough University

### Problem Being Solved

Dynamic and local control of active and reactive powers of Vehicle-2-Grid (V2G) within LV networks can help facilitate accommodation of all Low Carbon Technologies (LCTs), benefiting local customers and providing increased flexibility services to system operators, while minimising reinforcement costs and optimising fairness between customers. There is however a concern that V2G connections can increase levels of power exports, potentially pushing voltages beyond statutory limits and/or exceeding thermal limits. These exports could have long time durations and could have low levels of diversity.

Simple active power export limiting has been trialled previously but risks limiting the very benefits V2G can provide. Methods responding to voltage variations could reduce this risk but pre-configured characteristics could still be far from optimum. Control of V2G reactive power consumption can address local voltage concerns but may not provide compliance with thermal limits. There is a further risk that customers at the ends of feeders will be unfairly affected by these methods.

V2G exports could cause excessive voltage rise, or thermal overloads, for example when multiple customers on the same LV feeder have an aggregated response to provide power for grid support services. The timing of these exports could coincide with daytime periods when exports from domestic solar PV are already high. The rated powers of EV chargers will mostly be greater than those of the solar PV systems, and durations of export could be lengthy where batteries are fully charged, possibly creating high levels of phase unbalance. The timing of V2G exports may also be less diversified than the corresponding imports for EV charging if multiple customers on an LV feeder are responding to the same high-value price signals from an aggregator. V2G exports could therefore have a significant impact on voltage ranges and on thermal loading.

The previous NGED's Electric Nation project addressed these concerned by setting fixed limits to the V2G active power exports. However, in many instances, exports will occur at the same time as other demands, or when other customers cannot participate as their EVs are elsewhere, and so the fixed limit unnecessarily obstructs a potentially useful grid service. The customer may also lose revenue that would have supported their investment in providing the V2G capability.

It seems likely that exports from an EV charger may often operate in a vehicle-to-home (V2H) mode, using charge stored at off-peak times or from periods when solar PV generation exceeded demand, to reduce the need for power imports when electricity prices are higher. This V2H function reduces the customer impact on grid capacity and could improve the financial viability of domestic solar PV systems. A key requirement is therefore to ensure that V2H operation should not be constrained due to the technical possibility that the EV charger could also operate in V2G mode, even if this is not the mode of operation adopted by the customer.

Future peak electricity demand could be much higher, and a recent Royal Society report considering future energy storage requirements estimated that this could rise to 98 GW. This maximum demand will be driven by the electrification of heat, where very much higher ramp rates and peaks are required than at present. Generation from renewable sources will also be intermittent and will likely be scaled to provide the mean annual demand, plus some degree of over-capacity, but will not be sufficient to meet these short term daily peaks. In addition to long-term storage covering seasonal variations in generation, a short-term storage mechanism will be needed to cover intra-day demand variations. Electric vehicles and V2G are expected to be a key resource to provide this short-term storage. If connections for V2G are not enabled by DNOs then there will be significant costs to the consumer for this short-term storage capability to be provided elsewhere, for example by using large-scale battery parks storage.

## Method(s)

This project will use smart meter data to provide improved visibility of the existing capacity headroom along the length of feeders, and to improve the targeting in location and time of active and reactive power management of V2G, (also known as Volt/Var or Volt/Watt control techniques), while improving the confidence that assets will remain within thermal and voltage limits.

Existing pre-configured autonomous active and reactive power control methods first need to be assessed in the context of UK LV feeder designs to quantify the probability that V2G devices will cause thermal and voltage limits to be exceeded, and to identify which customers would be most affected by constraints. The project will then develop more granular methods, where the autonomous power control characteristics are adjusted locally and at specific time periods, to avoid applying unnecessary constraints. This allows the available capacity to be shared more equitably between customers. The simulation and modelling work will set the technical directions for a future trial of active and reactive power response for consumer devices.

Anticipating that there will be feeders where these techniques still result in unacceptable constraints, such that the full benefit of customer flexibility cannot be realised, the project will also explore how the control methods could be combined with changes to the network, defining a strategy for future reinforcements.

Work Package 1: Initial modelling using profile data

The modelling will use a real LV feeder network data but the demand data will be entirely simulated, so that the voltage and current can be fully categorised without any complications due to the limited coverage of smart meters. The effectiveness of the control techniques of the V2G operation so that it remain within network operational limits will be defined and documented. The control options will be considered with varying dynamic behaviours for the defined thresholds and limits.

Work Package 2: Modelling with smart meter data

Follow-up modelling with real smart meter readings. WP2 will develop the most promising control methods from WP1 and apply these techniques in simulation models using real voltage and current data derived from smart meter readings.

Work Package 3: Implementation feasibility

This work package will develop a higher resolution analysis to model specific scenarios where the control techniques may be considered to risk undesirable modes of operation. While it is recognised that there are implementation risks that may only become apparent in a trial with real V2G devices, this work package is intended to identify those risks that could reasonably have been foreseen, providing design recommendations for the future trials hardware

Work Package 4: Dissemination and closedown report

WP4 covers dissemination of the project learning to internal and external stakeholders and the writing of a closedown report. This closedown report is intended to form part of a portfolio of evidence that would be required in the development of new compliance standards for V2G inverters.

## Scope

Control policies are implemented in V2G devices to effectively avoid excessive voltage rises and to ensure exports remain within thermal limits. Voltage-controlled techniques classified as volt/var or volt/watt characteristics have been trialled by South Australia Power Networks which are designed such that the control policy at the V2G inverters can be pre-configured with each device then operate autonomously thereafter. However, it remains uncertain whether these control policies will achieve the desired objectives with UK LV feeder topologies, or whether the control parameters may need to be modified, either to ensure voltage limits are maintained or to avoid excessive export power constraints. Further work is also needed to determine how the available export power will be constrained and how the impact of these constraints will be shared between the customers.

There is an opportunity to use measured voltage data from smart meters to better inform the control policies implemented in V2G devices. Voltage data can be captured, either on a near-real-time basis to determine whether limits are exceeded, or more likely as a less immediate method using data from previous days or months[1] to determine the available headroom for additional exports while maintaining a high confidence that voltages will remain within range. Aggregated demand data can also be examined to assess the headroom available for additional export power while remaining within thermal limits.

It is still envisaged that the near-term operation of active and reactive power control in V2G devices will be managed autonomously, but with control policies that can be customised for each LV feeder, using settings that are informed by analysis of the available headroom according to the smart meter data. Settings could be updated as a background process, as the number of LCTs with export capability increases, or possibly more frequently if the effects are seasonal or subject to daily variations. It may also be appropriate to define separate control policies for different periods/days of the week, or for specific periods within the day.

This method also allows for the impact of constraints to be shared more equally between the customers on a feeder. This might be via allocation of a fixed export quota, possibly in conjunction with a voltage-based method, or by setting a lower voltage rise threshold for customers that are nearer to the substation. It seems likely that these methods may have some penalty in terms of the total export power that might be achieved, but with the benefit of a fairer distribution of the constraints between customers sharing the same LV feeder.

A recent Royal Society report[2] considering future energy storage requirements estimated that this could rise to 98 GW. This maximum demand will be driven by the electrification of heat, where very much higher ramp rates and peaks are required than at present.

Generation from renewable sources will also be intermittent and will likely be scaled to provide the mean annual demand, plus some degree of over-capacity, but will not be sufficient to meet these short term daily peaks. In addition to long-term storage covering seasonal variations in generation, a short-term storage mechanism will be needed to cover intra-day demand variations.

Electric vehicles and V2G are expected to be a key resource to provide this short-term storage. If connections for V2G are not enabled by DNOs then there will be significant costs to the consumer for this short-term storage capability to be provided elsewhere, for example by using large-scale battery parks storage. It is difficult to determine the future cost saving enabled by using V2G, but an indication of the value of storage is provided by the Powerloop project, estimating that customers could earn up to £180/year from participation in the balancing mechanism via an aggregator. Scaling this for 28 million customers suggests a cost saving against the overall short-term storage requirement of £5 billion per year. Clearly this is at current pricing, and the returns may be diluted as more customers enter the market, but the requirements for short-term storage are also expected to increase significantly.

[1] For the purposes of this project it is intended to download voltage data from smart meters on a monthly basis.
[2] [2] Sir Chris Llewellyn Smith, Royal Society, 'Large-scale electricity storage', https://royalsociety.org/-/media/policy/projects/large-scale-electricity-storage/Large-scale-electricity-storage-report.pdf

## Objective(s)

Key objectives are:

· Evaluate V2G control techniques to understand their effectiveness in maintaining LV assets within operational ranges in a desk-top environment

· Assess the benefits of new techniques where smart meter data is used to customise V2G control methods, varying either with location, time of day, or as the uptake of LCT appliances progresses

· Quantify the impacts on losses of reactive power control techniques

· Assess the impact on customers, in terms of the likelihood and equity of power constraints

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

The solution is not aimed specifically at customers in vulnerable situation. It is expected that the benefits derived from this study will be applicable to all domestic customer with V2G capabilities.

## Success Criteria

The project will have been successful if the following outcomes are achieved:

- A clear understanding of the expected benefits of different V2G control strategies that are the focus of this study, and in particular of the additional value obtained if control parameters are updated locally and dynamically rather than being pre-set equally on all devices. This would lead to the specification of control algorithms that can be assessed in a future trial using real V2G devices on live LV feeders.
- A clear understanding of the optimum level of control interaction, where improvements in power exports and customer experience fairness are balanced against increased communication overhead.

## Project Partners and External Funding

- Carl Ketley-Lowe, a NGED DNO Policy Manager, will be a project sponsor.
- Electricity North West is a project partner and will contribute through technical input.

## Potential for New Learning

The learning from this project is intended to inform industry recommendations for future changes to V2G equipment standards, enabling an increased number of connections to be accepted to LV feeders, and with minimal export power constraints. This is enabled by co-operative control policies which will require to be mandated by standards in order to be effective.

This learning will be shared by dissemination and closedown events, and will support proactive engagement with equipment vendors, DNOs and the regulators to review the project outcomes.

## Scale of Project

The simulation analysis is expected to use network data for around 100 distribution substations, selected to have a varied range of local topologies, urban and rural, and with different ages of housing development.

## Technology Readiness at Start

TRL5 Pilot Scale

## Technology Readiness at End

TRL6 Large Scale

## Geographical Area

The selected substations will be chosen from four network data samples, one for each NGED license area. These samples are expected to be around 25 km square extracts from the Electric Office network database.

## Revenue Allowed for the RIIO Settlement

N/A. This project was not considered within the current RIIO settlement

## Indicative Total NIA Project Expenditure

NGED will contribute a value of £41,909.02 to this project, requiring NIA funding of £377,271.18

# 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:

The energy system transition will involve the uptake of LCTs which significantly increases the peak electricity demand. In addition to long-term storage covering seasonal variations in generation, a short-term storage mechanism will be needed to cover intra-day demand variables. Electric vehicles and V2G are expected to be a key resource to provide this short-term storage and this project aims to improve the targeting in location and time of active and reactive power management of V2G while improving the confidence that assets will remain within thermal and voltage limits.

### 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

In case of the V2G project the benefit is associated with postponing required investment associated with V2G export as stated in the PEA:

- Avoiding bringing the required investment forward by 4 years due to V2G (i.e. voltage rise investment of £9.5k per LV feeder) will saved £368 per LV feeder.

- Assuming that the proposed methods would be application in 10% of feeders, then there is a saving of £1.9m over the 54,064 NGED feeder that is included in the LV6 architype from SILVERSMITH project that was taken as representative for the purposes of this calculation

- Over the GB distribution system, this saving can approximately be scaled by the number of domestic households served, 28 million across GB compared to 8 million for NGED, suggesting a GB-wide saving of £6.6m.

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

The method developed in this project will be applicable to all Distribution Network Licensees across the UK.

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

Rollout across GB is not expected as an outcome from this project.

In case of the V2G project the benefit is associated with postponing required investment associated with V2G export as stated in the PEA:

- Avoiding bringing the required investment forward by 4 years due to V2G (i.e. voltage rise investment of £9.5k per LV feeder) will saved £368 per LV feeder.

- Assuming that the proposed methods would be application in 10% of feeders, then there is a saving of £1.9m over the 54,064 NGED feeder that is included in the LV6 architype from SILVERSMITH project that was taken as representative for the purposes of this calculation

- Over the GB distribution system, this saving can approximately be scaled by the number of domestic households served, 28 million across GB compared to 8 million for NGED, suggesting a GB-wide saving of £6.6m.

## 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 learning from this project is intended to inform industry recommendations for future changes to V2G equipment standards, enabling an increased number of connections to be accepted to LV feeders, and with minimal export power constraints. This is enabled by co-operative control policies which will require to be mandated by standards in order to be effective.

This learning will be shared by dissemination and closedown events, and will support proactive engagement with equipment vendors, DNOs and the regulators to review the project outcomes.

The project aligns with the priorities in the 2023 NGED Innovation Strategy:

Transport

Development of improved control methods for V2G will allow more EV chargers with export capability to connect to networks, and will allow those connected to export without unnecessary constraint. Facilitating these connections opens up an additional revenue stream for customers that can encourage adoption of electric vehicles.

Data

The proposed methods build on the uses of smart meter data developed in the NIA SMITN project. This project aims to gain further value from this data, going beyond just characterising the network, developing methods to directly manage the connected devices. This makes best use of operational data available from customer smart meters and provides visibility of the network capacity that complements the data that could already be available from substation monitoring.

### 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 learning from previous innovation projects such as 'SMITN' (NGED) and 'Electric Nation' (NGED) and it uses a novel demand modelling approach using smart meter voltage data to characterise the impact of existing demands and superposition of voltage drops due to anticipated future demands.

### If applicable, justify why you are undertaking a Project similar to those being carried out by any other Network Licensees.

not applicable - not duplicating other projects

## Additional Governance And Document Upload

### Please identify why the project is innovative and has not been tried before

Previous innovation projects have explored the use of smart meter data to provide visibility of the LV network, but the use of smart meter data in a closed-loop approach to manage the network has not been demonstrated in the UK. Techniques developed here will enable an increased number of connections of V2G devices, actively managing any constraints using smart meter data as a feedback mechanism.

The project will also provide new understanding of volt/watt and volt/var control techniques. Although these have been introduced elsewhere, there is so far limited data to indicate whether these methods will perform successfully with the LV feeder topologies and demand profiles found in the UK. The established volt/watt and volt/var control techniques will be enhanced with new dynamic profile settings, derived using voltage and power data from customer smart meters.

The project will also develop an innovative approach to power-flow analysis, aiming to avoid the need for disaggregated load data from each customer, and instead using measured smart meter voltages. This allows the analysis to concentrate on the scope for additional LCT demand or generation, modelled in superposition to the voltage impacts of the existing demands.

### Relevant Foreground IPR

Background IPR (Loughborough University):

- Smart meter analysis - Loughborough University project

- Algorithm selection - which algorithms are expected to be most useful and why

- New method using correlation between aggregated demand and smart meter voltage data for both phase and feeder identification

- Validation methods for phase identification algorithm

- Validation methods for feeder identification algorithm

- Validation methods for LCT detection algorithm

- Phase and identification method using spatial correlation of voltage data

- LV simulation software

Shared Background IPR (NGED/Loughborough University 50% each):

- Losses Investigation data handling routines / processes

The following IPR is expected to be generated during delivery of this project:

- Volt/watt and volt/var V2G control parameters optimised for UK feeders

- Temporal and feeder-based V2G parameters for volt/var and volt/watt control

- Methods to define capacity headroom based on smart meter data

- V2G modelling simulation tools comprising a power-flow analysis with added customisation to model LCT demand and V2G operation

- Novel demand modelling approach using smart meter voltage data to characterise impact of existing demands and superposition of voltage drops due to anticipated future demands

- Applicability of V2G control methods to UK networks

## Data Access Details

Anonymised data will be available to share in accordance with NGED's data sharing policy.

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

The methodology to evaluate V2G control techniques is not proven and too high risk for BAU. It also requires specialist knowledge and is not currently within NGED remit

## 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 low TRL of the technologies being developed and the unproven methodology means that this project is unsuitable for BaU activity.

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

☑ Yes