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NIA Project Registration and PEA Document

Date of Submission

Jun 2022

Project Reference

NIA2_NGET0017

Project Registration

Project Title

System value from V2G peak reduction in future scenarios based on strategic transport and energy demand modelling

Project Reference

NIA2_NGET0017

Project Licensee(s)

National Grid Electricity Transmission

Project Start

July 2022

Project Duration

1 year and 0 months

Nominated Project Contact(s)

Atia Adrees (box.NG.ETInnovation@nationalgrid.com)

Project Budget

£881,503.00

Summary

This project aims to develop a strategic transport and energy demand (STED) model using transport demand modelling techniques and a whole-energy simulator to investigate the impacts of V2G on the electricity peak demand across the entire GB system under different credible decarbonisation scenarios. The STED model will develop profiles for electricity demand from domestic vehicles to 2035 and 2050, considering behavioural preferences, infrastructure constraints, battery degradation and price profiles. The project will also quantify the option value of flexibility from V2G and smart charging concepts using the F methodology and develop a framework to identify cost-effective expansion strategies for the GB transmission network in the presence of multi-dimensional uncertainties. The project will also investigate challenges and opportunities associated with a nationwide rollout of fast EV charging stations. This work will also assess and analyse the cyber security issues associated with V2G

Nominated Contact Email Address(es)

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Problem Being Solved

The transition to EVs will need increased network capacity to provide power for this new and significant source of electricity demand. Studies suggest that electric vehicles could see peak demand rise by more than ~20GW (which is 35% of current peak demand). The analysis also shows that the peak demand due to domestic cars' electrification can become negative after 2035 with the vehicle to grid (V2G) technology. But, V2G's success depends on many factors, e.g., consumer behaviour, availability of charging infrastructure,

and available tariffs. Therefore, there is a need to develop the capability to assess the effectiveness of V2G in reducing the peak demand of the GB to make the right decisions about network reinforcement to facilitate secure and cost-effective decarbonization of road transport. Network capacity will be needed, but it is challenging to identify exactly where and when EV uptake is likely to arise. Underinvestment or overinvestment in transmission networks could be costly and have negative environmental implications. Therefore, it is crucial to consider several key uncertainty sources and characteristics to mitigate the risk of future regrets in planning the network reinforcement.

The fast-charging stations' nationwide rollout will also present many challenges and opportunities. These stations, typically positioned alongside main traffic corridors and connected to the distribution grid at high voltage levels, will be required to provide high power output levels to serve fast charging customers on their forecourts. This may require network reinforcement of both distribution and transmission networks.

Method(s)

This project will develop a strategic transport and energy demand model (STED) using transport demand modelling techniques (taking into account consumer behaviour, infrastructure constraints, and battery degradation) and a whole-energy simulator to investigate the impacts of V2G on the electricity peak demand across the entire GB system under different credible decarbonisation scenarios.

This project will apply an advanced modelling framework based on stochastic optimisation to quantify the ‘option value’ of flexibility from smart charging and V2G concepts to identify cost-effective expansion strategies for the GB transmission network in the presence of multi-dimensional uncertainties. In addition, the F-factor methodology applied in the fundamental review of network security standards will be extended to enable quantification of the security of supply contribution delivered by smart charging and V2G, taking into account uncertainties in the availability of these services.

The impact of the fast-charging stations will be assessed on the future system operation and investment by taking into consideration that most of these stations are expected to be equipped with battery energy storage that would support high charging power requirements while being able to charge from the grid at a slower rate during the night or other times of lower demand on the system, which would avoid overloading of the local grid and to reduce the size and the cost of the grid connection.

Data Quality Statement (DQS):

The project will be delivered under the NIA framework in line with OFGEM, ENA and NGET internal policy. Data produced as part of this project will be subject to quality assurance to ensure that the information produced with each deliverable is accurate to the best of our knowledge and sources of information are appropriately documented. All deliverables and project outputs will be stored on our internal SharePoint platform ensuring backup and version management. Relevant project documentation and reports will also be made available on the ENA Smarter Networks Portal and dissemination material will be shared with the relevant stakeholders.

Measurement Quality Statement (MQS):

The methodology used in this project will be subject to supplier’s own quality assurance regime and the source of data, measurement process and equipment as well as data processing will be clearly documented and verifiable. The measurements, designs and economic assessments will also be clearly documented in the relevant deliverables and final project report and made available for review.

Risk Assessment and Audit

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

TRL Steps = 1 (2 TRL step)

Cost =2 (£881,503)

Suppliers =2(3)

Data Assumption = 1 (Data will be gathered using available network model)

Scope

The project will consist of three work packages (WP).

WP 1: V2G and peak electricity demand

Stage 1: Scenarios

The first stage of the project will define the exogenous scenarios that we will use throughout the project. These scenarios seek to describe potential EV uptake and usage out to 2050, and how these may vary by broad archetypal regions.

Stage 1 includes the following tasks

- Scenarios for EV uptake
- Scenarios for Travel pattern
- Definitions of regions
- Workshop to agree key scenarios parameters

Deliverable 1.1: A short report setting out two exogenous scenarios for EV uptake and use for 2035 and 2050, varying by three broad regional archetypes.

Stage 2: Understanding customer characteristics and behaviours

The purpose of this part of the analysis is to develop an initial set of customer archetypes to use in the first stage of the modelling. These archetypes will be based on varying factors that may drive differences in the propensity to engage with V2G.

The key tasks in stage 2 are listed below

- Initial literature review
- Qualitative research
- Initial archetypes: challenges and review workshop

Deliverable 1.2: Short report setting out initial qualitative customer archetypes that combine sets of consumer characteristics, the rationale for their choice, and a set of gaps to be filled by further behavioural research

Stage 3: Initial model development

In this stage an agent-based model will be developed which simulates the charging patterns (including V2G usage) of individual representative vehicles. This will be done in two stages:

 In stage 3, described here, a basic model, using placeholder inputs. This will allow us to carry out sensitivity tests to understand which parameters of consumer behaviour it will be most important to quantify in our survey.

 In stage 5, the model will be refined based on the data from the behavioural research, allowing us to produce V2G profiles.

The key tasks in stage 3 are as follows

- Design the model
- Build the first version of the model
- Run sensitivity analysis to determine which factor may matter most

Deliverable 1.3: Placeholder model outputs which National Grid's academic supplier can use to prepare its model.

A short note or slide pack documenting sensitivity analysis highlighting key drivers that will be investigated in Stage 4.

Stage 4: Quantitative behavioural research

The aim of Stage 4 of the research is to develop robust and statistically significant estimates of key input variables for the modelling.

- Prioritisation of factors to investigate in the primary research
- Design and implement survey

Deliverable 1.4: Statistically valid analysis of drivers of customer behaviour, documented in a short report. Revised assumptions for model inputs.

Stage 5: Revised modelling based on behavioural research

Deliverable 5: A final set of charging/discharging profiles.

Stage 6: Revised modelling based on behavioural research

Deliverable 6: Final report and model

WP 2: Grid impact of flexible charging paradigms for electric vehicles

Task 1: System impact of smart charging and vehicle to Grid

Whole Electricity System Integration Model, to assess the overall system impact of various EV charging paradigms, including a) unmanaged charging, b) smart charging, and c) V2G operation. We will identify key drivers for whole-system cost across these charging scenarios for private and light commercial vehicles and break down any cost savings from smart charging and V2G against the counterfactual into components associated with investment cost into generation and network assets as well as system operation cost.

Deliverable 2.1: A short report summarizing the methodology and findings

Task 2: Projection of future energy and ancillary services prices via ancillary services constrained energy scheduling model

The prices for energy and ancillary services will be generated for future scenarios of the GB electricity system. Several relevant sensitivities will be considered within ACES, including different levels of RES penetration, flexibility of electric vehicles in charging and providing frequency regulation services amount of energy storage etc., to quantify the impact on prices for both energy and ancillary services, and corresponding cost of EV charging, and revenues related to V2G services.

Deliverable 2.2: A short report

Task 3: Impact of fast EV charging stations on the future system operation and investment [Duration: 5 months]

The task will investigate challenges and opportunities associated with a nationwide rollout of fast EV charging stations.

Deliverable 2.3: A short report

Task 4: Quantification of smart charging and V2G contributions in delaying/displacing transmission network reinforcement.

The F-Factor methodology, applied in the fundamental review of network security standards, will be extended to enable quantification of the security of supply contribution delivered by smart charging and V2G, taking into account uncertainties in availability of these services.

Deliverable 2.4: A short report

Task 5: Planning the GB transmission network under long-term uncertainties

Advanced modelling framework based on stochastic optimisation, will be applied to quantify the ‘option value’ of flexibility from smart charging and V2G concepts to identify cost-effective expansion strategies for the GB transmission network in the presence of multi-dimensional uncertainties (e.g. considering different FES pathways).

Deliverable 2.5: A short report

WP 3: Cyber security issues associated with V2G

Task 3.1: Risk identification

Identify risk-related events and cyber observables contributing to risk events in V2G.

Deliverable 3.1: A short report

Task 3.2: Risk impact assessment

Provide the probabilities and consequences of the risk events and cyber observables contributing to V2G services. These could include but are not limited to capability and functionality impacts

Deliverable 3.2: A short report

Task 3.3: Risk prioritisation

Provide a set of rules that UK NG can utilise to rank identified risks based on their level of criticality and sensitivity. This task will also include a taxonomy of these risks for netter tracking and tracing

Deliverable 3.3: A short report

WP 4: Providing data and degradation curves using battery degradation model

Task 4.1: Construction of degradation curves

Deliverable 4.1: A report detailing the EV battery degradation model, the methodology used to obtain the degradation curves, the degradation curves and their associated simulated data.

Objective(s)

The key objectives for this project are as follows

- Develop a strategic transport and energy demand model (STED) using transport demand modelling techniques (taking into account consumer behaviour, infrastructure constraints, battery degradation) and a whole-energy simulator to investigate the impacts of V2G on the electricity peak demand across the entire GB system under different credible decarbonisation scenarios.
- Quantify the smart charging and V2G contributions in delaying/displacing transmission network reinforcements and identify cost-effective expansion strategies for the GB transmission network in the presence of multi-dimensional uncertainties.
- Determine the impact of large EV charging stations on the future system operation and investment
- Identify risk - related events and cyber observables contributing to risk events in V2G and provide risk impact assessment.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

An assessment of distributional impacts (technical, financial and wellbeing related) for this project has been carried out using a bespoke assessment tool, which assesses the project as having a positive, negative or neutral effect on consumers in vulnerable situations. To help inform the assessment, this tool considers the categories of consumers identified in the Priority Services Register.

This project has been assessed as having an overall positive impact on consumers in vulnerable situations. The assessment has identified that this project will look to reduce the costs for households. Other considerations including the projects impact on supply, immediate health and safety in the home have been made in carrying out this assessment.

Success Criteria

The project will be considered successful if it delivers against the objectives defined in the proposal.

The following key criteria need to be met for the project to be considered successful:

- Study objectives are met
- Clear understanding of the V2G role in reducing peak demand
- Stakeholder engagement and alignment

Project Partners and External Funding

National Grid Electricity Transmission: £866,503

National Grid ESO: £15,000

Potential for New Learning

This is the first project developing a strategic transport and energy demand model including consumer behaviour, battery degradation and infrastructure constraints to better understand the peak demand due to electric cars to make network investments at the right time.

This project is the first project developing methods to quantify smart charging and V2G contributions in delaying/displacing transmission network reinforcements and identify cost-effective expansion strategies for the GB transmission network in the presence of multi-dimensional uncertainties. In addition, for the first time, this project will explore the impact of large EV charging stations on future system operation and investment.

The learning from this project will be disseminated via the ENA portal and through the stakeholder engagement within the project itself.

Scale of Project

This project is desk-based research, and the analysis will cover the whole Great Britain. This is a large project delivered by three suppliers. This type of project is needed to address the challenges due to the electrification of domestic cars. For the first time, this project will develop a strategic transport and energy demand model that will include consumer behaviour, battery degradation model and infrastructure constraints. This model is required to assess the impact of V2G on the network peak demand. The developed STED model can be used in Future Energy Scenarios and Distribution Future Energy Scenarios to estimate the effect of electrification of domestic cars on the network peak demand, so informed decisions can be made in infrastructure investment.

Underinvestment or overinvestment in transmission systems could be costly and will have implications. Therefore, it is essential to consider key uncertainty sources and characteristics to mitigate the risk of future regrets. This project will develop a methodology to identify cost-effective expansion strategies for the GB transmission network in the presence of multi-dimensional uncertainties.

Technology Readiness at Start

TRL2 Invention and Research

Technology Readiness at End

TRL4 Bench Scale Research

Geographical Area

It will be desk-based research and will perform analysis on Great Britain.

Revenue Allowed for the RIIO Settlement

Not Applicable

Indicative Total NIA Project Expenditure

NGET NIA funding: £779,853

NGESO NIA funding: £13,500

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 results of this project will create knowledge to understand better the potential of V2G in reducing the peak demand in the network. The project will develop tools that will identify the impact of different parameters on the success of V2G and facilitate network planning, taking into consideration multi-dimensional uncertainties. As a result, it will enable more efficient and cost-effective electrification of cars.

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

Not applicable

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)

Not applicable

Please provide a calculation of the expected benefits the Solution

As this is a low TRL project no cost benefit analysis has been carried out. The project results and tools will enable us to make more robust and informed decisions for network investments. The developed STED model can be used in future energy scenarios

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

The developed tools can be used by all TOs and ESO.

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

At this time costs for rolling out the method are hard to calculate.

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

n/a

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

Not applicable

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.

There are many projects assessing the challenges and opportunities offered by EVs and V2G. However, this is the first project developing a strategic transport energy demand model and a framework for network planning under multi-dimensional uncertainties. In addition, this is the first project exploring the implications of the fast-charging stations on network reinforcements.

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

Not applicable

Additional Governance And Document Upload

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

Many projects are exploring the V2G topic. However, this is the first project developing a model to assess the contribution of V2G in reducing the peak demand by considering multiple factors. This is also the first project developing a framework to plan a network under long term uncertainties.

Relevant Foreground IPR

The project will develop models which can be used by all licences and does not require background IP.

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 Grid 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.nationalgrid.com/uk/electricity-transmission/innovation
- Via our managed mailbox box.NG.ETInnovation@nationalgrid.com

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

The nature of this research means it carries a risk that the research may be unsuccessful or identify unforeseen barriers to implementation and NGET is unable to consider research of this scale as business-as-usual

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 modelling and analysis approach used in this work is relatively new to fully understand the risks associated with the corresponding solutions. In addition, the method being explored in the project is unique and have not been used anywhere commercially. Therefore, considering the risk associated with the success of the project, NGET believes NIA funding is the best route for the project

This project has been approved by a senior member of staff

☑ Yes