NIA Project Close Down Report Document

Notes on Completion: Please refer to the appropriate NIA Governance Document to assist in the completion of this form. The full completed submission should not exceed 6 pages in total.

Network Licensees must publish the required Project Progress information on the Smarter Networks Portal by 31st July 2014 and each year thereafter. The Network Licensee(s) must publish Project Progress information for each NIA Project that has developed new learning in the preceding relevant year.

Date of Submission

Jul 2024

Project Reference Number

NIA2_NGET0017

Project Progress

Project Title

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

Project Reference Number

NIA2_NGET0017

Funding Licensee(s)

NGET - National Grid Electricity Transmission

Project Start Date

July 2022

Project Duration

1 year and 7 months

Nominated Project Contact(s)

Wangwei Kong (box.NG.ETInnovation@nationalgrid.com)

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.

Objectives

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.

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

Performance Compared to the Original Project Aims, Objectives and Success Criteria

NGET ("NG") has endeavoured to prepare the published report ("Report") in respect of NIA2_NGET0017 System value from V2G peak reduction in future scenarios based on strategic transport and energy demand modelling ("Project") in a manner which is, as far as possible, objective, using information collected and compiled by NG and its Project partners ("Publishers"). Any intellectual property rights developed in the course of the Project and used in the Report shall be owned by the Publishers (as agreed between NG and the Project partners).

The Report provided is for information only and viewers of the Report should not place any reliance on any of the contents of this Report including (without limitation) any data, recommendations or conclusions and should take all appropriate steps to verify this information before acting upon it and rely on their own information. None of the Publishers nor its affiliated companies make any representations nor give any warranties or undertakings in relation to the content of the Report in relation to the quality, accuracy, completeness or fitness for purpose of such content. To the fullest extent permitted by law, the Publishers shall not be liable howsoever arising (including negligence) in respect of or in relation to any reliance on information contained in the Report.

Project Overview

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.

Project Plan

The plan is comprised of the following deliverables:

- Deliverable 1: A short report setting out two exogenous scenarios for EV uptake and use for 2035 and 2050, varying by three broad regional archetypes (Month 2)
- Deliverable 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. (Month 4)
- Deliverable 3: A short report on risk identification. (Month 5)
- Deliverable 4: A short report summarizing the methodology and findings of system impact of smart charging and vehicle to grid. (Month 6)
- Deliverable 5: Placeholder model outputs which National Grid's academic supplier can use to prepare its model. (Month 7)
- Deliverable 6: A short report on projection of future energy and ancillary services prices via ancillary services constrained energy scheduling model. (Month 8)
- Deliverable 7: A short report on risk impact assessment (Month 9)
- Deliverable 8: Statistically valid analysis of customer behaviour drivers, documented in a short report. Revised assumptions for model inputs (Month 10)
- Deliverable 9: A report detailing the EV battery degradation model, the methodology used to obtain the degradation curves, the degradation curves, and their associated simulated data. (Month 10)
- Deliverable 10: A short report on the impact of fast EV charging stations on the future system operation and investment. (Month 10)
- Deliverable 11: A short report on risk prioritization. (Month 10)
- Deliverable 12: A final set of charging/discharging profiles. (Month 11)

- Deliverable 13: A short report on quantification of smart charging and V2G contributions in delaying/displacing transmission network reinforcement. (Month 11)
- Deliverable 14: A short report on planning the GB transmission network under long-term uncertainties. (Month 12)
- Deliverable 15: Final report and model. (Month 12)

Project Progress
Year: 2022/23

- Deliverable 1: After a few months of delay caused by contract negotiations, the project was started with a kick-off meeting in Oct 2022. A short report setting out two exogenous scenarios for EV uptake and use for 2035 and 2050 was delivered on time.
- Deliverable 2: The 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 was delivered on time.
- Deliverable 3: The short report on risk identification was delivered on time.
- Deliverable 4: The short report summarizing the methodology and findings of system impact of smart charging and vehicle to grid was delivered on time.

Year: 2023/24

The remainder of the project was delivered. Key outputs of this financial year are summarised below:

- Performed a quantitative survey of current electric vehicle drivers to understand their driving and charging behaviour, and to explore some hypothetical questions about future behaviour.
- Used the evidence from this research to develop inputs for the agent-based model.
- Used the agent-based model to illustrate the impact of V2G on local and system peak demand under a range of different behavioural scenarios.
- Drew conclusions on the extent to which consumers participate in V2G and the implications for National Grid.

Required Modifications to the Planned Approach During the Course of the Project

There were no significant changes to the scope, cost or duration of the project.

Lessons Learnt for Future Projects

The following lessons were learnt:

- Data and assumptions are crucial to ensure model robustness.
- Energy market is important while analysing the system benefits for V2G, new market designs will be needed to encourage more participants into V2G to scale ups the benefits.
- The security design of V2G systems should consider potential issues arising from the use of different devices and communication protocols by various stakeholders in a V2G ecosystem. Given the complexity of cyber-physical systems interconnections in V2G environments, further research is needed to better characterize threat sources and understand their origins and motivations.

Dissemination
Internal workshop to hand over the model and identify key model results with National Grid and the National Energy System Operator on 17 January 2024. Furthermore, an innovation article was published within National Grid to share learnings.

Note: The following sections are only required for those projects which have been completed since 1st April 2013, or since the previous Project Progress information was reported.

The Outcomes of the Project

The project has delivered against its objectives as detailed below.

Developing a strategic transport and energy demand model

- An innovative agent-based model has been developed that illustrates the impact of competition for public chargers on V2G uptake.
- The model and associated report provides a deeper understanding of the electric vehicle driver behaviours that might influence V2G uptake and how they vary across current EV drivers.

Quantifying the smart charging and V2G contributions to delaying/displacing transmission network reinforcement

- Model outputs include various scenarios and sensitivities that illustrate how different future behaviours may affect V2G uptake.
- The results show that smart charging can reduce the impact of vehicle charging on peak demand, but if consumers are willing to provide energy back to the grid via V2G, then substantial more reductions in peak demand are possible. There are some differences

in the size of this reduction in peak demand depending on the price signals received by consumers and the number of electric vehicles that can provide these services.

- We identified the main barriers to providing significant reductions in peak demand are a combination of ensuring battery degradation is minimal for consumers, allowing consumers to access V2G-enabled chargers and reducing the hassle associated with plugging in frequently.

Determining the impact of large EV charging stations on future system operation and investment

- The modelling shows how EVs have the potential to provide significant power for ancillary services.

Overall, key learnings included:

- There is significant variation in EV driver's behaviour, journeys made and access to infrastructure. These differences will ultimately drive the differences in V2G outcomes for each individual driver. The survey provided evidence on the extent to which specific behaviours could affect the uptake of V2G.
- The consumer behaviour research and the modelling results, demonstrated that the following may be required for V2G to have a significant impact on peak demand:
  - Cost reductions in V2G-enabled chargers will be required since the current costs are significantly higher than non-V2G-enabled chargers and lifetime returns are uncertain.
  - EV drivers will need to be confident that intensive discharging and recharging will not degrade their batteries.
  - Reducing the hassle associated with plugging in vehicles frequently will be required. We find that some drivers may respond to a small incentive to plug in every night. There may also be behavioural pushes or technological solutions that can increase the frequency of plugging in.
  - Vehicles may provide significant availability for system services, but technical uncertainties over response times remain.
  - The impact of non-domestic charging points is likely to be lower than domestic charging, particularly at peak hours.

Recommendations for further work

- Focus on non-domestic and fleets: commercial vehicles may have more predictable driving behaviours and may be more likely to optimise their charging strategy.
- Implications of business models for autonomous vehicles: in one future scenario in 2050, we find a large uptake of autonomous vehicles. Depending on the business models, these vehicles could provide significant V2G.
- Business models for V2G: more research could be done to help understand how to offer V2G to consumers in the most effective way (e.g. incentives that will cover the cost of the up-front charger).
- Integrating further differences in V2G into future energy scenarios: it might be useful to reflect differences in consumer behaviours across these scenarios.

Data Access

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

Foreground IPR

- The foreground IPR includes an agent-based model and results dashboard that can analyse the impact of driver behaviour on V2G. This includes a guidance document for how to operate the model and a report outlining the methodology, analysis and results.
- Any and all results created or acquired or otherwise developed during the project will be jointly owned by National Grid and the supplier.

Planned Implementation

Internal dissemination activities have received a positive response from relevant stakeholders within the business. The model has been shared with teams who are interested in the impact of EVs and V2G, particularly in the context of future network planning.

Other Comments

The Project outcomes and results contain confidential information and intellectual property rights that cannot be disclosed in this Report due to their proprietary nature. Should the viewer of this Report ("Viewer") require further details this may be provided on a

case by case basis following consultation of all Publishers. In the event such further information is provided each and any Publisher that owns such confidential information or intellectual property rights shall be entitled to request the Viewer enter into terms that govern the sharing of such confidential information and/ or intellectual property rights including where appropriate formal licence terms or confidentiality provisions. Dependent upon the nature of such request the Publishers may be entitled to request a fee from the Viewer in respect of such confidential information or intellectual property rights.

Standards Documents

Not Applicable.