NIA Project Annual Progress Report Document

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Date of Submission

Jul 2023

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)

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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 System value from V2G peak reduction in future scenarios based on strategic transport and energy demand modelling NIA2_NGET0017 ("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).

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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 F methodology quantifies F-factors which are applied in the fundamental review of network security standards, F-factors as the ratio of the maximum reduction in peak electricity demand (kW), over the power capability of the smart charging and V2G technology (kW). 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

- 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 2022/2023:

- 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.

Next Steps

Year 2023/2024

- Complete deliverables 5 to 15.

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

Year 2022/2023:

There have been no significant changes to the project.

Lessons Learnt for Future Projects

Year 2022/2023:

- Data and assumptions are crucial to ensure model robustness. One of the developed models is assumption-driven, current results indicate very high-level insights based on different assumptions. These assumptions will be refined in the next iteration of the model.
- 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.

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

Year 2022/2023:

- The project has demonstrated there are significant system benefits for the low-carbon GB system from deploying smart EV charging and V2G solutions. Implementation of Smart charging and V2G is highly compatible with fast expansion of variable renewable generation, as it can avoid investment into peaking generation or energy storage capacity, while also mitigating distribution network reinforcement cost.
- A comprehensive analysis of the V2G security risks and vulnerabilities has been conducted. The analysis showed that threats exist in all three layers of the V2G architecture, i.e., physical, network and application layers. The risks including human error, hardware/software compromise, network attacks and information tampering.

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 will include a developed whole system model integrated with a set of charging and discharging profiles for V2G impact studies, and any publications of journal or conference papers related to the developed method for analysing the long-term uncertainties in network planning. The default IPR position has been applied to this project.