Battery Storage and Grid Integration Program

An initiative of The Australian National University

REVS

Final Social Report

From the Realising Electric Vehicle-to-grid Services (REVS) trial

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Contents

Executive Summary

The social research stream of the Realising Electric Vehicle-to-grid Services (REVS) trial examines sociotechnical dynamics in the advancement of vehicle-to-grid (V2G), considering the views of technology developers and different user groups. This report centres on V2G in fleets, and can be read together with our Interim Social Report.

The report presents results from interviews conducted between May 2021 to April 2022 with the REVS consortium, REVS trial end-users, and future fleet end-users. In particular, it focuses on the socio-technical development of V2G in Australia; the end-user experience of the trial; and consideration of V2G from the perspective of fleets and transport. Considering these results together, a way forward for V2G centred on the needs and perspectives of the transport sector and end-users is articulated.

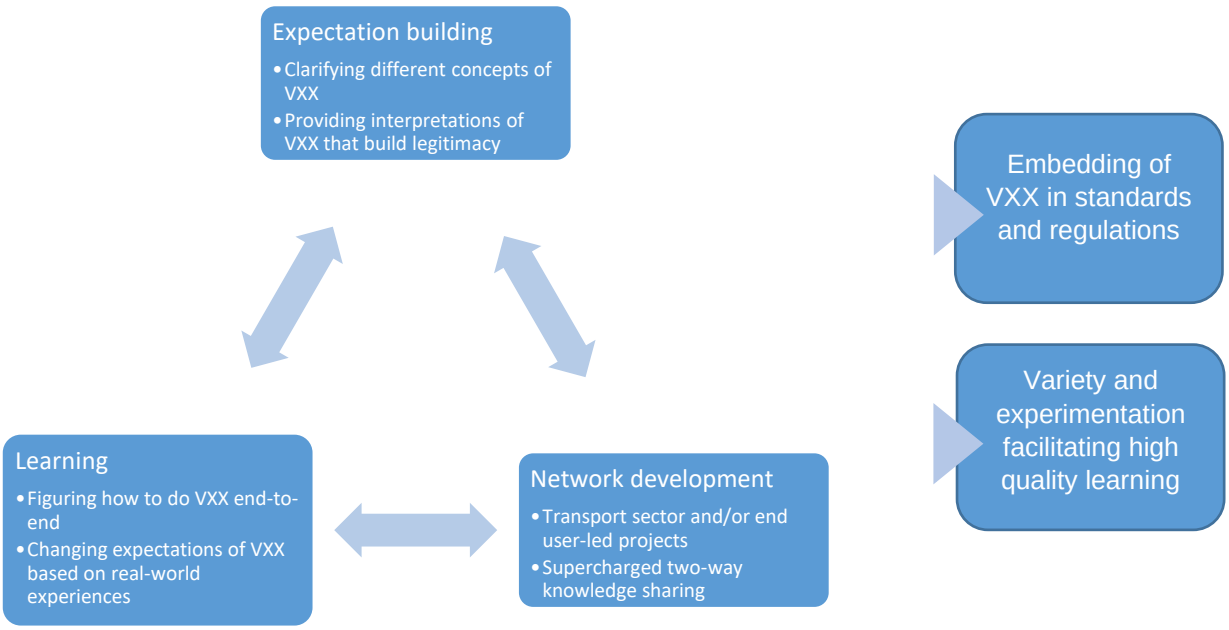
Our in-depth analysis of niche development revealed a strong long-term vision for V2G as an important part of a seamless and market-led integration of transport and electrical infrastructures. However, the steps necessary to reach this vision were unclear and uncertain. Some steps are largely outside of the influence of Australian stakeholders due to our status as an importer country, but work can be done locally to develop heuristics for V2G feasibility. Most importantly, a user-led approach to experimentation with the technology can help reveal reasons why end-users might choose to adopt V2G – a question which currently does not have a compelling answer. These activities also need to enlist transport stakeholders.

The interviews with the trial end-users revealed many details of how V2G fits into a fleet. They highlighted the importance of interoperability between different cars and chargers and exposed the points where seams appear. Through this feedback, we were able to articulate a vision for the seamless integration of V2G into a fleet from the perspective of the end user.

The final section of results investigated the adoption of V2G in fleets from the perspective of it being a transport decision or an energy decision. Fleets need to put their core business first, which once again emphasises that a seamless V2G design that runs as imperceptibly as possible in the background would be preferred. This means that the intermediary (or aggregator) would need to bear virtually all the risk. V2G might be uncontroversial in a fleet under these conditions.

V2G proponents also need to appreciate that transport stakeholders have great difficulty engaging with energy system concepts which are very complex and specialised. Furthermore, it is not always easy to find the right advisors as vehicle grid integration is so immature. On a similar note, it is hard to find and accommodate the right skills in their maintenance crews, especially when organisations are considering other technologies (such as different forms of bidirectional charging (VXX) or hydrogen fuel cells) at the same time.

Measures to support the development of V2G and VXX are shown in the figure below. A well-rounded approach to nurturing this new technology needs to build expectations based on clearer narratives and visible demonstrations that help build legitimacy. Stakeholder networks need to be developed that share knowledge effectively and are led by transport sector stakeholders and end-users. Learning needs to not only inform how the technology is deployed, but also leave space for different ideas to emerge in real world contexts. Key tasks ahead include adjusting existing standards, rules and regulations to suit the specifics of the technology, and supporting more varied experimentation that allows user propositions to emerge.


Expectation building
• Clarifying different concepts of VXX
• Providing interpretations of VXX that build legitimacy
Embedding of VXX in standards and regulations
Variety and experimentation facilitating high quality learning
Learning
• Figuring how to do VXX end-to-end
• Changing expectations of VXX based on real-world experiences
Network development
• Transport sector and/or end user-led projects
• Supercharged two-way knowledge sharing

1 Introduction

1.1 The REVS trial

In an Australian first, the REVS project demonstrates how commercially-available EVs and chargers can contribute to energy stability by transferring power to and from the grid. EVs inject power into the grid during rare events to avoid the possibility of shortfalls, and the vehicle owner will be paid when their vehicles provide this service.

Introducing the Realising Electric Vehicle-to-grid Services (REVS) trial

This report has been developed as part of the REVS trial. In an Australian first, the Realising Electric Vehicles-to-grid Services (REVS) project demonstrates how commercially available electric vehicles (EVs) and chargers can contribute to energy stability by transferring power back and forth into the grid, as required.

EVs will inject power back into the grid during rare events (to avoid possibility of blackouts) and EV owners will be paid when their vehicles are used for this service.

Employing 51 Nissan LEAF EVs across the ACT as part of the ACT government and ActewAGL fleet, the REVS project seeks to support the reliability and resilience of the electricity grid, unlocking economic benefits making electric vehicles a more viable and appealing transport option for fleet operators.

The REVS consortium covers the whole electricity and transport supply chains including ActewAGL, Evoenergy, Nissan, SG Fleet, JET Charge, ACT Government and the Australian National University. Together the consortium will produce a roadmap with recommendations that will accelerate the deployment of V2G nationally.

The project has been endorsed by the Australian Renewable Energy Agency (ARENA) and has received funding as part of ARENA's Advancing Renewables Program.

REVS is underway and will publish a final report in late 2022.

https://secs.accenture.com/accenturems/revs/

1.2 Purpose

The purpose of this Final Social Report is to report on the social research stream of REVS. The social research stream examined the preconceptions, experiences and priorities of people and organisations involved in providing, facilitating or using V2G, with the aim of growing our understanding of how V2G might develop in Australia. Principally, the research was based on interview data (refer section 2.2).

The previous Interim Social Report probed different use cases for bidirectional charging in terms of people's values and aspirations and discussed them in the context of policy and strategic planning. It found that there is a lot of uncertainty about the likely users and beneficiaries of V2G. Both fleet and private EV users have diverse motivations and reservations when it comes to allowing their vehicles to be used to support the grid. Both

practical issues regarding the design and installation of charging stations and the lack of trust that permeates customer relationships with energy providers in Australia are issues whose importance should not be underestimated.

This report aims to contribute to the user-centred development of V2G by examining it from three angles:

- How V2G technology development is progressing in Australia so far, and what is needed for it to develop further;
- Feedback from the REVS trial is used to pick apart the user experience of implementing V2G in fleets; and
- Looking ahead, what are the prerequisites, preconceptions and priorities of people working with fleets with regard to V2G.

The report will then make actionable recommendations for developing V2G according to user preferences, devising future V2G projects, and creating policies for nurturing and mainstreaming the technology.

1.3 Progress

The progress of REVS has been delayed for a number of reasons, and as a consequence, opportunities to collect data from end-users have been constrained.[1] The social data collection phase for this research was held back as long as was possible within the project timelines.

At the time that the latest data was collected for this report, 25 chargers across five of the 10 ACT Government trial sites had chargers installed, powered, and connected to the network. However, these chargers were only operating in unidirectional mode (unidirectional mode can still be used to provide V2G services, but only those based on drawing power from the grid and hence charging the EV battery). No chargers were participating in the market at this point, meaning that no income could be earned from providing V2G.

For the remaining sites, 16 chargers had been installed but were awaiting a site shutdown before they could be turned on. Nine chargers across three sites had not been installed yet. However, 47 of the 50 ACT Government vehicles had been delivered and were operating as part of the fleet.

The implication for this research is that end-users have not been exposed to a complete implementation of V2G. However, many aspects of full V2G would not be evident to the end users even if it were fully implemented. We were able to collect data relating to the installation process and a wide range of operational issues. The main limitations from the perspective of the end users were:

- RFID cards for ending any charging session had not yet been activated.[2] Instead, drivers begin and end charging sessions simply by plugging in or unplugging the charger from the car;
- Sites where chargers had not yet been switched on had not had the opportunity to use them; and

[1] Our Capability Developments report, due to be published at the same time as this report, provides details of the technical progress of the REVS trial.
[2] This is explained further in the Capability Developments report.

- The systems for managing vehicle availability had not yet been fully put into practice, meaning there could be some troubleshooting ahead involving users.

2 Approach

2.1 Theoretical framework

This section explains the theoretical frameworks that have guided the work: the multi-level perspective (MLP) of socio-technical transitions, and strategic niche management (SNM).

The MLP explains that technological change comes about through interacting processes between three analytical levels: Niche, regime and landscape (Figure 1). **Niches** are novel ideas that hold promise—like V2G and other forms of vehicle grid integration. Niche innovations are developed in protected spaces, buffered from market forces, and allowed to develop in real world contexts (such as trials) until they are sufficiently mature to compete with other technologies. Government policies can be used to create protected spaces for niches to develop.

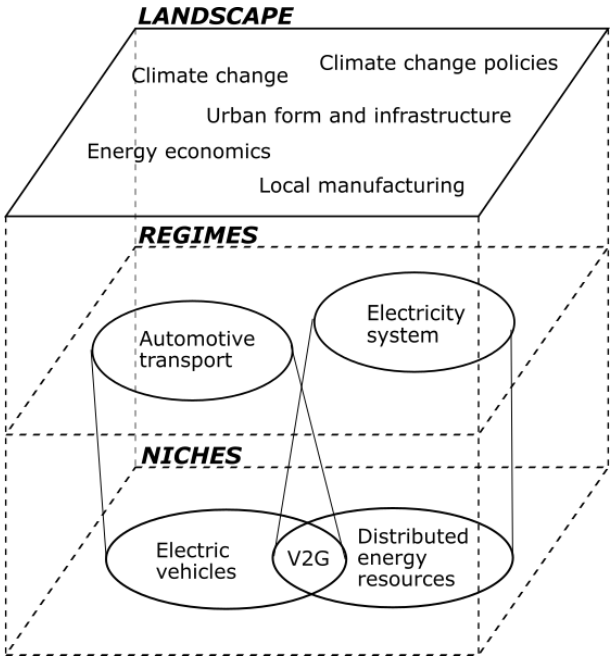


Figure 1: The multi-level perspective as it relates to V2G [1]. Reproduced with permission.

V2G is one technology among many that may become an important part of Australia's electricity and transport regimes in the context of climate change, increasingly affordable renewable energy, and other external pressures. The MLP [2] helps to explain how V2G might fit in to a larger picture.

Regimes are established ways of doing within institutions and infrastructures, encompassing engineers, users, stakeholders and the whole supply chain [3]. For a niche to develop, it might be necessary for a regime to change, redefining problems and how they are perceived and acted upon [4]. A good example of this is the way widespread rooftop solar has changed Australia's energy institutions and markets. **Landscapes** are deep structural dimensions of culture [5] that can be subject to developments or shocks. These can cause established ways of doing—regimes—to change. Examples of landscape-level effects are climate change or the coronavirus pandemic.

While the MLP describes sociotechnical change, SNM provides tools for developing niches. SNM describes the key processes that happen in niches: learning, network development,

and expectation building (Figure 2). These processes signify that, as a new technology develops, people learn about how to use the technology and what it could mean in social contexts; they enlist new stakeholders in using and supporting it; and they start to build a common vision for what the mainstream version of the technology will be. These processes are interdependent: for example, attempts to mainstream a technology without learning what it could mean to users, or without having important stakeholders on board to smooth its path and lend it legitimacy, are less likely to succeed.

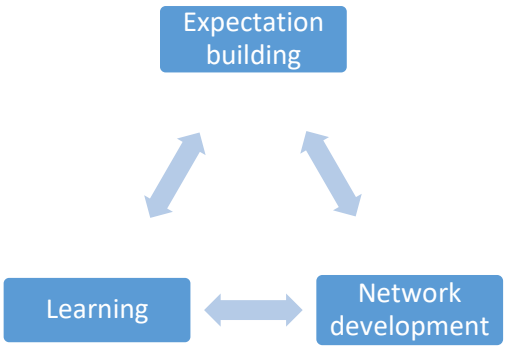


Figure 2: Niche processes.

Learning should include both first-order learning (how to do something) and second-order learning (incorporating feedback and reflexively altering what the end goal should be).

For the REVS project, the MLP provides a framework for analysing V2G's place within the bigger picture of the energy system, and SNM helps identify what is or should be happening among the parties who are developing V2G and among policymakers and intermediaries like ARENA.

2.2 Methods

This report builds on the Interim Social Report for REVS that was published in May 2021. The Interim Social Report was based on interviews with 35 participants across five different groups. This report draws on further interviews and focuses on three main groups:

- The REVS consortium – summarised results from an in-depth study published in the peer-reviewed journal *Environmental Innovation and Societal Transitions* in February 2022 [1]. In addition to interviews, the consortium participated in an in-person workshop in May 2021.
- REVS end-users – fleet, facilities and sustainability managers from the ACT Government covering the trial sites. One of these participants preferred not to be attributed, meaning that while their feedback is captured in this report, no direct quotes from them are used. Another participant preferred to respond to interview questions in writing. The second round of interviews was conducted in March and April 2022.
- Future fleet end-users – fleet and sustainability managers of organisations transitioning to EVs.

Table 1 summarises all interviews conducted as part of this workstream, not all of which are included in this report. The interviews were recorded, transcribed and analysed using QSR NVivo software using coding and theming techniques. In addition to the interview questions detailed in the Interim Social Report, the REVS end users were probed for insights regarding their day-to-day user experience of managing the vehicles and chargers for REVS.

Table 1: Summary of interviews.

Group	Description	Trial participant?	Interviews
REVS consortium	Members of the consortium team involved with management and day-to-day project delivery	Yes	11 Workshop
REVS end users	Fleet, facilities and sustainability managers of participating ACT Government directorates covering the 11 trial sites.	Yes	4 (pre) 5 (post)
Future end users – fleet	Fleet and sustainability managers of organisations transitioning to EVs. Includes private and government organisations covering Queensland, ACT, Victoria, Tasmania, South Australia and New Zealand.	No	9
Future end users – private	Currently or considering using an EV for private transport. Current users include both owners and lessees. All homeowners, including a range of life stages from first home to retiree. Most located in ACT, one each in Queensland and NSW.	No	6
Industry	Industry leaders in EVs and new energy technologies with potential future interest in V2G. Includes energy solutions providers, charger manufacturer/provider, energy retailer, energy strategist, architect and customer experience expert.	No	9
Total interviews			**44**

3 Results

This chapter is divided into three sections which explore, firstly, the development of the V2G niche in Australia through the lens of the REVS consortium; next, the experiences of the end-users of the trial vehicles and chargers; and finally, the perspectives of other fleet stakeholders who may be considering V2G in future. Together they explore the niche and regime processes which will help define the form of V2G and bidirectional charging as it develops, and provide actionable advice:

- Niche activities by the REVS consortium, how they support the well-rounded development of V2G, and gaps that require more focus (section 3.1);
- User responses to the V2G configuration that was delivered in the REVS trial, so that future efforts better meet the needs and expectations of users (section 3.2); and
- Configurations of V2G likely to be acceptable or preferable in fleets in the future (section 3.3).

3.1 Developing the V2G niche in Australia

This section sets out the state of existing efforts to develop V2G for Australia. It is based on a recent journal article by this report's authors [1] that examined in depth the development of V2G in Australia. Based on interviews and a workshop with members of the REVS consortium, it described the current strengths of the V2G niche and identified areas where further development is needed. It reflects the fact that even when REVS is complete, V2G will still be a work in progress.

3.1.1 Strengths

The strongest contribution REVS has made towards the development of V2G in Australia is in articulating a long-term vision for V2G, far in the future post-REVS. Envisaged are bustling markets for transportation and electricity that provide autonomous, seamless and on-demand services: both to people requiring transport, and to grid actors requiring sources of flexibility. V2G is seen as creating commercial opportunities that will accelerate the transitions toward the renewable grid and electrified automobility.

Secondly, there is a great deal of first-order learning occurring through projects such as REVS. This learning comprises the technical and regulatory problem-solving that is needed so that V2G and similar technologies can be deployed in real-world settings and participate in institutions such as the National Electricity Market. Second-order learning, on the other hand, is a gap, meaning that technology developers are not necessarily reflecting and adjusting their expectations for the technology to better fit it to the real (social) world.

3.1.2 Areas for development

The strengths of V2G development are tempered by some important gaps. Despite the clear long-term vision for V2G, expectations for V2G in the short term were found to be lacking for a number of reasons. Firstly, charging standards for V2G are currently fractured, with CCS2 likely to become the default standard for DC charging in Australia, but only CHAdeMO explicitly supporting V2G at present. As a result, it is currently difficult to see which vehicles, and via which standards, will be providing V2G beyond the immediate term. Secondly, there was a gap in understanding the economic case for V2G. Therefore there is a strong need for projects such as REVS to provide some heuristics for V2G feasibility in different settings. This will be a future output of REVS, and other projects will need to investigate the viability of

V2G in different types of premises (such as homes). Heuristics will then pave the way for repeatability, price and performance improvements as commercial implementations begin to emerge.

As well as better understanding the implications of V2G at different premises, end users have thus far had little opportunity to make sense of V2G. Projects are almost universally industry-led in Australia, which has meant that end users have had practically no role in identifying their own goals or problems to be solved and exploring their own interpretations of solutions. Greater variety of experimentation with what V2G can do is important to work towards a dominant form of the technology that can start to build momentum. This might not be V2G per se, but another bidirectional or controlled charging concept (collectively termed VXX) (Figure 3).[3]

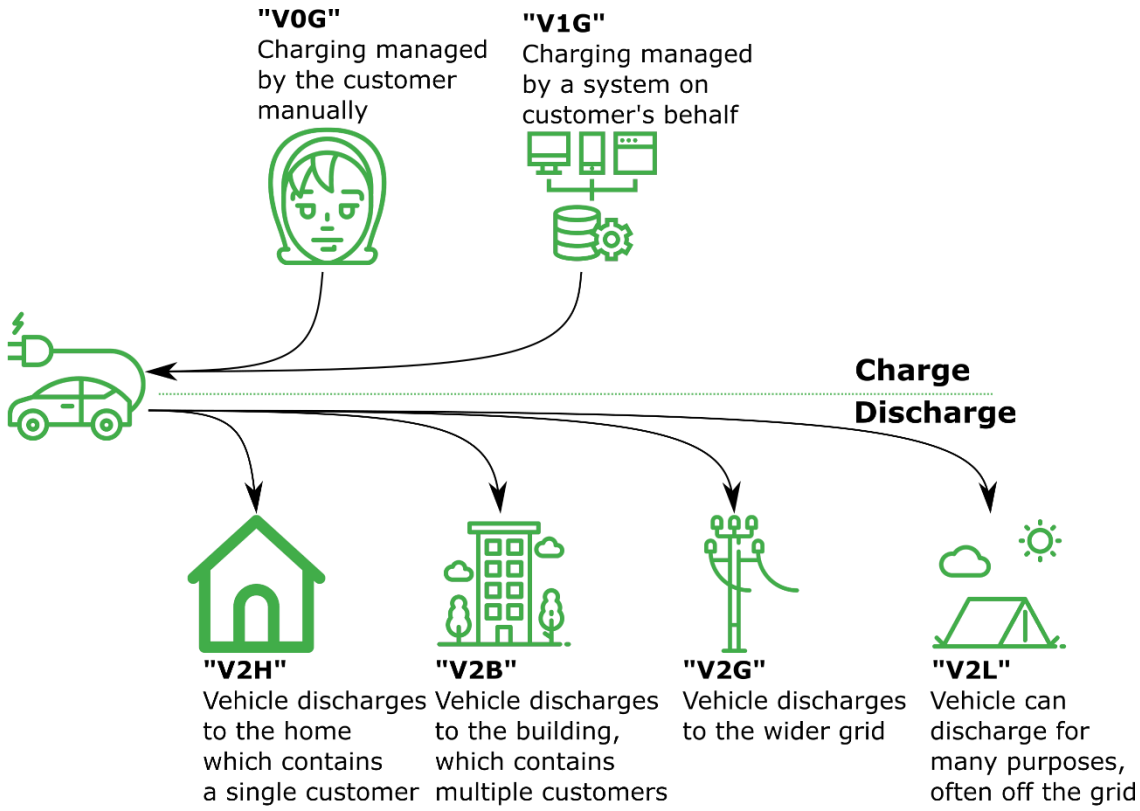


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Figure 3: Configurations of vehicle-to (or from)-anything (VXX).

Building momentum also requires a range of actors to support the technology and take a role in deploying it. The stakeholder networks forming around V2G in Australia so far tend to be very focused on the electricity grid and markets. However, teams deploying V2G tend to be highly dependent on technology developers from the transportation and EV charging industries—in other words, people from outside electricity grids and markets. V2G development can therefore be improved by enlisting and facilitating leadership from a more diverse range of stakeholders.

A further need is to understand the everyday challenges of people working to transition transport towards clean energy and their need for cohesive policies and trusted sources of

[3] Refer to our earlier report, The A to Z of V2G, for more explanation. https://arena.gov.au/knowledge-bank/the-a-z-of-v2g/

information. They are facing decisions not just about V2G, but EVs versus other technologies such as hydrogen fuel cell vehicles, and need to be able to have unbiased conversations with their clients and suppliers encompassing all technology options. In terms of policy, transportation is lacking a clear framework—even more so than the energy sector. The research highlighting a particular need for automobility transition policies to be more ambitious as well as consistent with electricity grid transition policies. For V2G to develop further, two-way exchanges of information and learning between actors across electricity and automobility need to be cultivated.

3.2 Trial end-users

This section aims to investigate the experiences and views of the trial end users in participating in REVS. The Interim Social Report documented preconceptions of V2G, as it was prepared before any trial end-users had viewed either the vehicles or the chargers, or received any training. It found that the end-users were anxious about business continuity while the vehicles and chargers were being deployed and concerned that changes to their procedures and parking arrangements would negatively impact drivers. They emphasised that drivers should not have to change their routines to accommodate the trial and called for transparency in sharing the trial's activities and outcomes, even if activities and outcomes weren't immediately relevant to daily operations.

This section documents feedback from the same cohort after integrating the REVS vehicles and chargers into their respective fleets. It covers the practicalities and implications of managing a mix of REVS and non-REVS vehicles and chargers as well as their user experiences with the vehicles, chargers and software. The final section will provide an overview of their experiences participating in REVS which will revisit the concerns raised in the Interim Social Report.

3.2.1 Mixing cars and chargers

The REVS vehicles are Nissan LEAFs which have two charging ports (Figure 4): on the left, a CHAdeMO port, which is for DC charging. This is the plug type that the REVS chargers use. On the right, the LEAF has a Type 2 AC charging port. This can be used to charge the vehicles with the other chargers that are used by the fleets, as these are Type 2. Aside from the REVS vehicles, the fleets include other Nissan LEAFs and Mitsubishi Outlanders, both of which use CHAdeMO plugs. In addition, there are other fleet EVs such as the Hyundai Kona and Ioniq which typically use Type 2 AC charging, however for DC charging they typically use the CCS charging standard. There are several implications (Table 2):

- Only Nissan LEAFs (and other CHAdeMO vehicles) can use the REVS chargers, the other vehicles cannot;
- Non-REVS Nissan LEAFs and Mitsubishi Outlanders could unintentionally provide V2G in the event they were plugged into the REVS chargers when a V2G event occurred. For LEAFs, this would be an operational issue rather than a technical or warranty issue (see also section 3.2.2);
- Nissan LEAFs (REVS or otherwise) can be charged using the other fleet chargers.

Furthermore, each REVS Nissan LEAF must use its own dedicated charger, for reasons explained in section 3.2.3.

Figure 4: Nissan LEAF charging from a Wallbox Quasar at the CHAdeMO (left) port. The Type 2 (right) port is visible by its orange cap. See also Figure 5 for a close-up view. Source: author.

Table 2: Interoperability between REVS and non-REVS cars and chargers.

	REVS CHAdeMO chargers	Non-REVS Type 2 chargers
REVS LEAFs	☑ Yes (dedicated)	☑ Yes
Non-REVS LEAFs	⚠ Yes (but not intended)	☑ Yes
Outlanders	⚠ Yes (but shouldn't)	⛔ No
Other EVs	⛔ No	☑ Yes

From the perspective of the end users, this interoperability (or lack of) creates a number of issues. Fleet managers do not necessarily assign a given car to a particular parking space and charger, and even if they do it is sometime necessary to move them around, for example if a charger is offline. However, for REVS, each parking space needs to be labelled for its specific vehicle. Bill, who manages two REVS vehicles and two Ioniqs, was looking forward to one of the REVS chargers being fixed so that he could assign the parking spaces.

> *We've made them specific plates because the vehicles have their own parking position. So it'd be nice to be able to utilise them, because they're REVS LEAFs and have their specific charger.* - Bill, fleet manager

One fleet manager, Tom, challenged the assumption that every EV needs a charger and explained how the interoperability issue constrained their plans to save money by rationalising the number of chargers serving a given fleet.

> *There's always been talk about in the future not having a car per charger or a charger per car as a cost saving measure. Whereas we're sort of stuck with the car per charger scenario. And*

also using a Hyundai Ioniq or one of the other vehicles I guess, they can't plug into these ones anyway because the plugs are different. - Tom, fleet manager

On the other hand, the fact that the REVS vehicles could use other chargers was fortunate, as there has been a long delay between receiving the cars and installing the chargers. Although the below quote from Grace might appear to suggest that one charger per car is preferred, it reflects the fact that their EV fleet had increased by 50% (from 15 to 22 Nissan LEAFs) without any new chargers being installed as yet.

> *Due to delays in the installation of the REVS charging infrastructure, the seven Nissan LEAFs that were delivered are required to share existing charge stations at their base location. This has an operational impact on staff as they need to organise to swap the vehicles throughout the day/week so they can all be charged and available for use.* – Grace, fleet manager

Multiple fleet managers noted that the interoperability issue was a surprise that they wish they had known about in advance. They questioned whether the REVS chargers were good for the overall transition of the fleet to EVs because of the reduced interoperability between vehicles and chargers.

3.2.2 Using the chargers

The chargers are the main point of user interaction in the trial. At time of writing, the operating chargers were in 'user mode', meaning users only need to plug or unplug their vehicle without interacting with the charger itself. When the trial is fully operational, the chargers will be set to 'remote control mode' which means that users taking a car out will need to swipe an RFID card in order to stop charging. This is an operational measure that ensures a V2G session can be ended when the car is needed for driving.

The chargers use green, blue and purple displays to indicate their status as ready, charging or discharging respectively. The amperage is also shown in colour. Unless the user knows what each colour means, there is little to indicate what mode the charger is in. In addition, the plug displays a red light when the vehicle is charging or discharging. These indications are shown in Figure 5.

Figure 5: Wallbox Quasar in green 'ready' mode; Charging plug showing red active charging light on the handle.

More information on a charger's operating status can be accessed via a smartphone app or a web app. These will not be made available to end users, as they are not designed to be

used in a multi-user environment. Due to the administrator controls available in the app, it must remain with the REVS team for the technology integration aspects of the trial.

The fleet managers were unaware of what the chargers' colour-coding meant as they had not yet received a handover or a set of manuals at the time of the interviews. Despite this information gap, those that were using the REVS chargers (in unidirectional mode) reported that the drivers had no problems operating the chargers, as it was as simple as plugging and unplugging. They did not envisage problems when the drivers need to use the swipe card to disengage the plug.

> *They just manage themselves. The people just use it when they need it, they plug in when they need it, and they just charge it overnight and drive it during the day.* - Bill, fleet manager

When the chargers are set to bidirectional mode, the fleet managers were not aware how they would know that a V2G session was occurring. However, this was not necessarily a problem for some fleet managers just so long as a charged car was available to staff when they needed it.

> *We're facilities and it's not a fleet manager's job to know that it's interacting with the grid.* - Bill, fleet manager

Others had not thought about how they would know if V2G was happening until asked in the interview, and were consequently keen to find out.

> *I believe EPSDD will give more information on this when the chargers are closer to being operational. At the moment, no information has been given as to how we will know when this is occurring.* – Grace, fleet manager

A second issue about using the chargers was being aware when a charger has a fault. For the REVS chargers, the REVS team will be notified of a fault but the fleet managers will not be notified (at least not automatically). Non-REVS chargers used by the fleets also do not provide automatic notifications to the fleet managers. Faults noticed by a driver—for example, the car is not charged up when it should be—are reported to facilities or fleet staff. This unclear process could result in anywhere between zero and two uncoordinated repair efforts being undertaken for a failed charger, depending on the assumptions used by the REVS team and the fleet manager.

> *I've got a representative guy out on site. He does a lot of housing work but then he supports me with the fleet because he's on site. So staff report things to him, whether there's been an accident or the charger's not working or whatever it goes through him. So he notifies me. That's the only real visibility we have in the sense of the chargers not working, basically the staff feedback.* - Tom, fleet manager

Although faults are undesirable, they are only a major problem if a charged car is unavailable. At present fleet vehicles are underutilised because many staff are working from home due to the COVID-19 pandemic, and REVS vehicles especially so for other reasons (see section 3.2.3). At higher utilisation rates, faults will become a bigger problem.

The final point about using the chargers is the issue of interoperability raised earlier in section 3.2.1, specifically the fact that non-REVS cars can use the REVS chargers and hence unintentionally participate in a V2G event. The second issue is that once the chargers are in remote control mode and hence require an RFID to end the charging session, anyone who has mistakenly used the charger and does not have the correct RFID card cannot unplug their car. This could affect members of the public or legitimate fleet users without the correct card, a risk that was not yet widely understood by fleet managers.

3.2.3 Managing availability

Determining the availability of each car for V2G at a given time has been a technical challenge for the trial. In order to bid into the market, the retailer needs to have a good idea of how much battery capacity is available to bid both ahead of time (days) and in a 5-minute timeframe. Because cars are unplugged and driven around, V2G must resolve this challenge – a challenge which is not shared with similar technologies in competition with V2G such as virtual power plants.

Multiple methods are needed for determining availability across both timeframes. Vehicle booking data obtained from the Bookingintelligence platform is used to determine availability up to four days ahead. Any subsequent bookings are also picked up 24 hours ahead. However, some vehicles are not listed on Bookingintelligence because they are always in use by the same person during their shifts, and listing them would add needless overhead. An example of this is frontline staff providing home nursing visits. These cars are assumed by the retailer to always be unavailable during the regular shift which is typically daytime on weekdays. This approach is termed a ‘static booking envelope’.

The second method for determining availability is using the charger status data from the charging provider, which is collected every five minutes. A high degree of certainty is applied to bids involving vehicles that are both not booked and plugged into a charger. If a car is plugged in, but is also booked—such as if a booked car was returned earlier than expected—a lower degree of certainty is provided in the bid. The same approach applies to car that are not on the booking system, and that are assumed to be unavailable for V2G, but happen to be plugged in. Figure 6 summarises these approaches.

The method for determining availability has implications for users. First of all, all of the REVS vehicles must be assigned their own dedicated charger that can only be used by one vehicle, because the availability method relies on both the booking (the car) and the charger. This creates a barrier to interoperability (see section 3.2.1) and adds an extra layer of operational and educational measures.

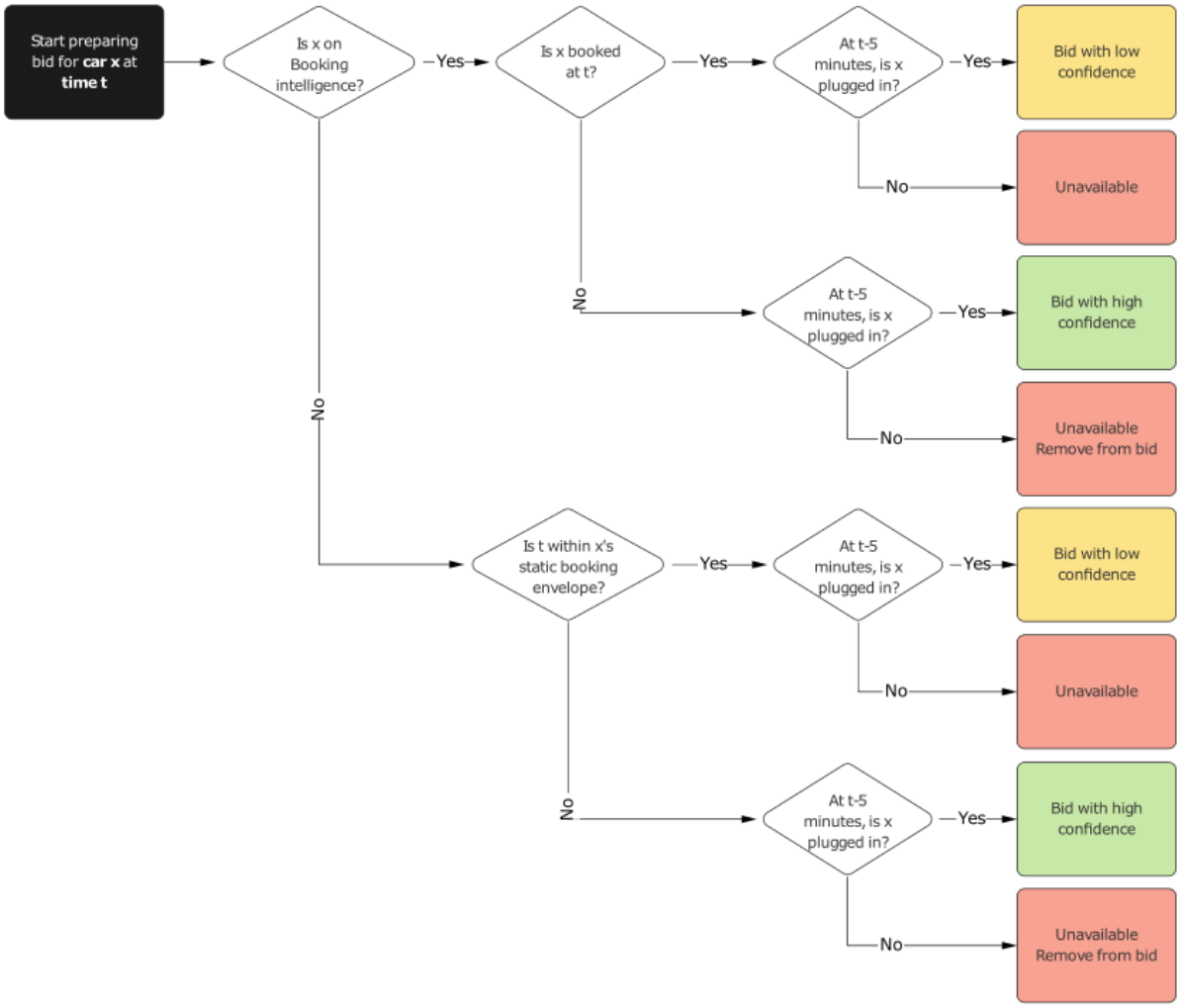


Figure 6: Flowchart for determining availability. Availability is determined four days ahead and revised 24 hours ahead.

The availability method does minimise risk to the vehicle users – it should not constrain the use of the vehicles and the greatest risk is to the retailer, that V2G sessions cannot be fulfilled. However, there remains some confusion about how availability will be managed and what impact V2G sessions will have on the fleet, as well as the impact that vehicle usage will have on the trial.

> *Well I should imagine the first thing I'll know [that a V2G session has occurred] is when someone goes to get a car first thing in the morning says it's empty*. – Bill, fleet manager

> *A couple of our cars might get taken out at that time, at 9 o'clock, or even earlier, they might want to go earlier, so to get access to the car is important. But they might get back at 12 o'clock and the car is still booked out for the rest of the day because they don't finish the booking, which you can do online, but a lot of people don't, they just come back and put the keys back whatever else, so you could be missing out on another three, four, five hours of charging the car [providing V2G] if that is the case.* - Tom, fleet manager

Despite inconveniences, the fleet managers are working constructively and certainly want the arrangement to be successful for all parties.

> *We'll work together with it and it works for both sides, that'd be perfect.* – Tom, fleet manager

For those vehicles listed on Bookingintelligence, REVS requires them to be grouped together. However, this can clash with existing ways of working. It makes the vehicles harder for prospective drivers to find because they are not listed where the drivers expect them to be. As a result, the REVS vehicles are being booked less frequently than the rest of the fleet. While this might be good for V2G availability, outside of a trial environment it can be problematic when underutilised vehicles are assumed to be superfluous and released from the fleet.

> *They don't come up with the other pool vehicles on our booking intelligence thing, they come up at the bottom so it tends to make people overlook them, that don't know they're there, or tend to book other vehicles first*. - Bill, fleet manager

> *So at NCH for example you've got two main resource types. You do the location, NCH, then the next one below that is either pool vehicles or the closed user group. So there's only two. But if you put the REVS in there there's three. So I think I gave feedback back to Michael asking is there any other way we can do this because it's not practical*. - Tom, fleet manager

The vehicles that are not listed on Bookingintelligence do not share this issue.

3.2.4 Participating in REVS

This final section discusses end-users' participation in REVS, their impressions to date and motivations for participating in the first place. A finding of the Interim Social Report was that end-users were worried about continuity of operations through the installation process – they needed to ensure that all of their vehicles were available to drivers without interruption.

As it turned out, the sites all received vehicles before any chargers were installed. Interim chargers of the same model, but only running in unidirectional mode, were installed at some sites while awaiting the bidirectional-certified chargers to arrive. This required some inconvenience and workarounds on the part of the fleet managers.

> *Possibly get proper chargers before you start? Just a thought.* – Bill, fleet manager

> *[Asked, would you participated again with the full benefit of hindsight?] Yes. However, it would have been extremely beneficial if the installation programme had aligned with vehicle procurement.* – Grace, fleet manager

The installation process itself went relatively smoothly similar to installing a regular EV charger, although some details such as mechanical protection (e.g. bollards) were initially neglected and later rectified. Handover and operational training were not carried out when the unidirectional chargers were installed. Instead, the intent is to provide a handover to fleet managers when the bidirectional chargers are installed.

> *So it's worked out fairly well in the sense of the transition to EVs out there, in the first instance anyway. Everybody is reasonably used to what's going on at the moment. And it didn't take them much to get that way. Pretty confident it will be fine with the new chargers as well. Obviously to be informed of what we need to do on our end. Which I'm sure will be all there.* – Tom, fleet manager

When asked to reflect on their experience, some fleet managers noted that getting access to the REVS vehicles was their main motivation – as they are striving to meet overall zero emissions fleet targets. This had made participation worthwhile, but unfortunately does not shed much light on what might motivate a fleet to adopt V2G in future.

> *Yes, because we get two vehicles. That's all. So yes of course I would.* – Bill, fleet manager

> *It's been good having the chargers there and having the EVs there because it was a good step and a good way for us to get those vehicles changed over and having the structure there. I think it's been good so far.* – Tom, fleet manager

On a broader level, REVS was still an interesting project to participate in and the fleet managers were keen to both understand the outcomes and make the drivers aware of how they are contributing to the electricity grid.

> *But again, we did as a directorate want to get into a project like this and have some experience in it, and be able to give feedback for the technology and everything. And moving forward with EVs in general I suppose. ZEVs and all that sort of thing.* – Tom, fleet manager

> *I'd like to see the results. Basically, once it's up and running properly, I'd like to obviously see that it is all reliable and everything as well. But having some results behind it too, some stats would be nice to see and hopefully it all goes the way it was planned.* – Tom, fleet manager

> *[I would like] For staff to be educated about the process and have an appreciation that they are assisting the power grid/Canberra community through the trial.* – Grace, fleet manager

For the fleet managers, the project is therefore about their fleet first. The grid is important, but it is not their direct concern.

3.3 Future fleet end-users

The Interim Social Report found that potential fleet users of V2G interpreted their interest through the lens of their organisation's climate change goals and strategies. As a result, V2G commercial offerings would need to be tailored to the organisation. A program of adopting V2G would need to fit in with their broader fleet transition activities, as well as with adjacent issues such as salary packaging of vehicles. Most importantly, their core operational requirements would always need to come first.

Operational needs tend to be priorities from the transport perspective, whereas V2G offerings relate to energy. This section aims to further explore the tensions and complexities of a fleet adopting V2G, divided into two parts: as a transport decision, and as an energy decision.

3.3.1 V2G from a transport perspective

When considering V2G from the perspective of the vehicles, different insights emerge. Firstly, rationale for considering using V2G includes improving asset utilisation, which is the defining argument for the technology. The future fleet participants were not convinced about V2G itself but one had recently encountered a similar idea:

> *Just before Christmas, with the unavailability of a lot of rental cars, our premier thought up an idea that we can give our cars that sit around over Christmas to the rental companies. I'm glad that didn't happen because it would have been chaos. But thinking outside the square like that, if he continues to think like that, I mean it could be something that government might choose to do, but I'm not sure how we would actually manage it*. – Michael, state government

Although sharing one's fleet during low periods might have broader economic benefits, the challenges it would pose to fleet managers appear undesirable.

One important question is whether V2G will drain vehicle batteries. There is a general assumption that it must, illustrated by the quotes from Stuart and Ethan below. However, this is not necessarily the case; in REVS, V2G is used to provide grid services that do not drain

vehicle batteries—at least, not a practical amount.[4] Unfortunately, V2G tends to be used as a catch-all term that could have multiple meanings, made even more confusing by terms such as V2X (vehicle-to-everything), V1G (managed charging), and so forth. Proponents therefore need to be clear about what their V2G system does and doesn't entail and what its practical impacts are.

> *When you've got a vehicle as part of a fleet that's by default linked to the NEM because it's plugged in and vehicle to grid and you've got an arrangement with your retailer and your distributor where there's a need to draw electrons from that battery and out of that car and when it's needed for its primary purpose the next day, the battery isn't full and that's going to impact on what it's used for the next day.* – Stuart, local government

> *I just don't know if people would want to put their hundred-thousand-dollar vehicles up for trailing when there's like perceptions of battery degradation and stuff* – Ethan, local government

Avoiding appreciably draining vehicle batteries is one way that a V2G arrangement can minimise risk to the vehicle user. Participants were clear that for them to participate in V2G, the proponent must be willing to take on all the risk such that vehicles are always available and charged to be used for transport.

> *We would say that if that's something they want to see as an agreement, then it would be their responsibility to demonstrate how that meets our requirements.* – Vanessa, territory government

> *You don't want to be faffing around with ok, well we can't use the service loan car fleet now during the day because that's the optimum time for solar. Well, then what was the point of having a service loan fleet? Because we can't use them for their primary purpose or we're about to have an outage we'd better rush and plug all these things in. You just want it to happen in the background. You don't want to have to think about it. You want it to be automated. So if there were any priority, I guess it would be user experience. It's got to be idiot proof and not require a lot of effort*. – Richard, dealerships and car share

> *We have an electronic fleet management system where people book a vehicle and all that. So there is a system there that knows what the vehicle's doing tomorrow, whether or not there needs to be an interface between that and the EV grid system to say, well, yeah, this vehicle was not booked tomorrow, so we can probably take a bit more out of it. But then someone will come in the office at seven o'clock in the morning and take it straight away for the next half an hour.* – Martin, state government

Many of the participants were preoccupied with beginning to transition their fleet to zero emissions, a challenging task. The issue with V2G is that it does not necessarily assist with fleet transition, although this may change as greater and greater volumes of renewables are integrated into the grid. However, transport people are learning the basics of the electricity grid and are not necessarily ready to engage with its more complex challenges. As Vanessa, who worked in transport planning, explained:

> *What I thought was one of the gaps and I have raised in part about whole of organization and I'm always coming from a novice perspective. So I will put that forward to anyone I'm talking to is you know, I like I said, I don't think there's a great understanding across the community of how things will sort of change.* – Vanessa, territory government

[4] For more details on the grid benefits of V2G, refer to our report The A to Z of V2G. https://arena.gov.au/knowledge-bank/the-a-z-of-v2g/

A problem that many fleet-owning organisations face is a lack of specialised knowledge in-house that can analyse and advise on planning and executing a low-emissions transition.

> *Project [decarbonising buses] is being done within business improvement part of [organisation], but it's a very small organisation so there's no "team"* – Kim, state government

> *Especially around infrastructure, even though I'm part of the Electric Vehicle Working Group I have sweet bugger all knowledge on the type of infrastructure that we actually need. And then you add on top of that, like upgrading cabling and all that stuff, we're really at a loss as far as that's concerned. And then, I mean, as far as government is concerned, I think I'm probably ahead of the curve as far as knowledge.* – Michael, state government

> *We're not doing much in house at all. Obviously it's all managed in-house, we're doing all the project management in-house and all the transport modelling and things like that are in house. The discussions, so we're leading the whole of government discussions on the energy sector and what that means. But with regard to the actual production of any research or strategies, particularly around the energy side, we would bring consultants in and we are a really thin team.* – Vanessa, territory government

Furthermore, there appears to be a lack of appropriately-skilled experts who can cross the energy-transport divide:

> *We went to market 12 months ago and if I were to find the skills of commercial, transport and energy, we needed all three and every consortium of suppliers that we receive—so most of them couple up with someone else—but most often it was two out of three, so we're sort of picking the best two out of the three.* – Vanessa, territory government

This lack of knowledge applied so low emissions transitions generally, whereas analysis and adoption of V2G requires a level that is greater again. This makes V2G not only hard to do, but harder to see the opportunities that might exist.

Organisations are nevertheless making progress with low emissions transitions with imperfect information. Many of the future fleet end-users were examining multiple low emissions transport technologies which meant that they perceived an opportunity cost for strongly (or entirely) favouring one technology over another. Again, V2G is a second step after electrification, which organisations may not be ready for. However, this creates a paradox because of the issue of transition timing (as detailed in the Interim Social Report) – organisations may not be willing to revisit V2G very soon after investing in EVs.

> *Technology choice partly depends on what is most suited for each area. So for example if hydrogen is produced in Launceston we might run hydrogen buses there, and run electric buses in Hobart. (Kim)*

> *I mean, I've always been a big supporter of hydrogen vehicles as opposed to electric, pure electric, purely for the fact of it actually gives us a similar experience to filling up your ICE vehicle, so pulling into a hydrogen station, you connect it up, five minutes, you pay for it and then you're gone. (Michael)*

Skills gaps extend further than planning and executing a transition. Organisations transitioning their fleet will need to source servicing and maintenance staff as well as different refuelling or recharging infrastructure. Often infrastructure needs to be retrofitted at existing sites, which can be very challenging due to limited space and electrical capacity.

> *We don't employ auto electricians at the moment, we have diesel mechanics. So we don't have in-house maintenance crew for new bus types. Will need to retrain or engage new staff or outsource.* – Kim, state government

> *New fuelling/recharging infrastructure will have to be accommodated on existing depots.*

> *There is no option to expand depots.* – Kim, state government

> *Putting in infrastructure will be the hardest thing to do, especially for retrofitting infrastructure at major hospitals or whatever else, which is where a lot of our cars actually sit.* – Michael, state government

The future fleet end-users we spoke to mainly turned to transport industry sources for information and guidance. These included national bodies such as the Australian Fleet Managers Association (AFMA), the Institute of Public Works Engineering Australia (IPWEA). They also turned to the Electric Vehicle Council (EVC) and the Australian EV Association (AEVA), although some participants had reservations about relying on information from groups that focused on or biased certain technologies. International bodies of note included the International Association of Public Transport (UITP) and the Center for Transportation and the Environment (CTE).

Energy sector information sources such as ARENA knowledge sharing were not cited by participants, although many noted that they found government reports and consultant reports useful. They also searched the internet and took care that sources were reliable. Countries at the forefront of EV adoption (such as Norway) were targeted, as were local specialist firms such as JET Charge.

3.3.2 V2G from an energy perspective

V2G's benefits relate to the energy aspect, whether that is the production of services required by the grid or the earning of energy-related financial benefits for the vehicle owner. Conversely, any impacts are borne by the transportation aspect, such as use of stored battery energy or loss of availability for driving. There are other overlapping aspects including climate change, property and buildings.

Therefore, in an organisation, a proposal to adopt V2G is likely to come from people concerned with energy; for example, energy managers or sustainability officers. This section includes results from the perspective of organisational energy use and its relationship to V2G adoption.

The participants speculated on the rationale for adopting V2G. It could be attractive due to its potential to earn income, because this could improve their budget position and/or competitiveness:

> *Either generating income or increasing self-sufficiency, as both will lead to lower expenditure.* – Kim, state government

> *From the organizational perspective it's definitely financial because the covid shutdown has impacted CBDs, and as part of that, a large part of our funding stream is from car parking.* – Ethan, local government

However, a decision to invest in technologies like solar PV, batteries or V2G has an opportunity cost when weighed up against other energy-related measures such as energy efficiency improvements. The difference is whether the measure only provides financial benefits to the organisation, or whether it provides co-benefits such as the improvements to indoor environment quality provided by energy efficiency measures. Of course, as was detailed in the Interim Social Report, greenhouse gas reduction can also be an important organisational goal. The point is that V2G is one of a range of options with different benefits.

> *We would prefer to put the money into fixing the building, making the building efficient before we add, like I said, a PV system, which all that's doing is adding another source of energy. It's not fixing the building*. – Martin, state government

A departure from the energy aspects occurs because V2G involves vehicles, which further complicates issues like standards. V2G needs to comply with standards that were written for the built environment by experts from that industry. The future fleet participants had already encountered difficulties implementing new energy technologies involving EVs:

> *Within this industry there's been quite a bit of criticism about Standards Australia when it comes to this. And yes, I've worked a lot in the solar industry and HVAC and obviously electric vehicles as well. And I think there is a case for them being risk averse. They go a little bit overboard. – Stuart, local government*

4 Discussion and Recommendations

4.1 Summary of findings

V2G is envisioned as a seamless part of future electricity and transport systems facilitated by markets. However, visions for the immediate term are missing because development of the technology is caught up in fractured charging standards, uncertain economic viability and practical difficulties. In addition, transport actors and vehicle end-users are to a large extent missing from conversations and research about V2G, even though both groups are essential to its development.

The research with REVS fleet end-users initially revealed anxieties about negative impacts on business continuity during installation and vehicle availability during operation. Since then, their fears have generally not been realised, especially because vehicle availability risk has largely been borne by ActewAGL. However, practical issues of interoperability between vehicles, chargers and parking spaces, as well as questions about charger handover and management processes, have emerged. These findings provided the means to articulate an ideal user experience for fleets, which will be done in the next section.

The research with future fleet end-users initially emphasised the need for V2G offerings to be tailored to organisational goals without affecting core business. These two aspects correspond to the facts that, generally, the benefits of V2G relate to energy, and the risks or costs relate to transportation. With regard to benefits, V2G could offer attractive improvements to the organisation's economic or environmental position, but would likely be in competition with other energy measures such as renewable energy and energy efficiency.

On the transport side, proponents can expect gaps in knowledge around what V2G (or other bidirectional charging concepts) means exactly in terms of battery draw. Proponents also need to appreciate that many people working in transport have a limited understanding of the complexities of energy systems and may be outsourcing a lot of expertise. A further need of organisations working on transitioning their fleets to zero emissions is access to trustworthy and technology-neutral information. Given the importance of engaging the transport sector in developing V2G (per section 3.1), we provide recommendations on this topic later in section 4.3.

The last two recommendations sections tackle projects and policies. Projects can bring end-users and other under-represented stakeholders into the co-creation of V2G, which will be important to envisioning V2G concepts that are acceptable or attractive to vehicle owners. Policies can create a positive selection environment for V2G such that when opportunities arise for V2G to enter the mainstream, there is greater probability of success.

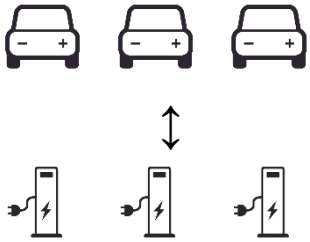
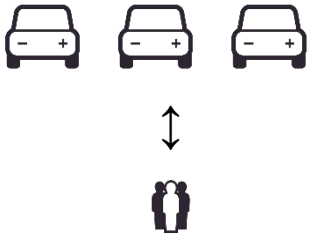
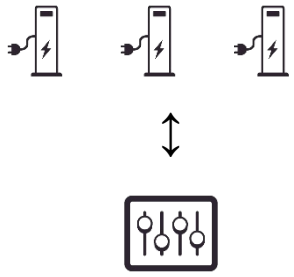
4.2 What would a good user experience look like?

Studies of the acceptability of V2G have focused on private vehicle owners rather than fleets and have assumed a participation model similar to a VPP, where a person shares the capacity of their battery with the grid via an intermediary such as an aggregator. Some researchers (e.g. [6], [7]) have argued that V2G is better suited to fleets because private vehicle owners are likely to be reluctant to want to share their asset. However, we were not able to find any social research on V2G adoption in fleets.

The results presented here have suggested that V2G might be acceptable and even uncontroversial for a fleet so long as it doesn't affect core business. There were however few

indications as to why a fleet-owning organisation might be motivated to adopt V2G. Rather than dwelling on this question, it may be more constructive to envisage what an acceptable form of V2G might be for fleets, and design a system that most closely meets this ideal (Table 3).

Table 3: An idealised seamless implementation of V2G from the fleet perspective.

	All vehicles in the fleet use the same charging plug standard (including vehicles not participating in V2G)	Vehicles can be parked and charged anywhere
	V2G does not rely on vehicles being assigned chargers - each vehicle is permitted to use any charger at any time	Vehicles can be parked and charged anywhere
	Intermediary bears all availability risk	V2G does not affect vehicle availability for transport (e.g. due to battery health or minimum contracts)
	V2G participation does not affect discoverability of the vehicle in booking systems	V2G does not affect vehicle utilisation
	Fleet managers have real-time, automated data on V2G sessions and charger faults	Fleet managers know the status of all chargers
	A comprehensive handover occurs that focuses on fleet operation	Fleet managers know how to respond to different operational circumstances

Residential or private commercial V2G arrangements typically consist of a single EV behind a home energy meter. In most commercial concepts of V2G, this arrangement includes a contract with minimum plugged-in hours that ensures availability for the intermediary. A fleet, however, consists of multiple vehicles for which historical utilisation data is usually available.

This opens the door to different methods for determining availability based on diversity in usage demand.[5]

An issue with the seamless fleet V2G concept is that it depends on the technology being sufficiently developed such that standards are universal, software integration is complete and intermediaries and fleet managers have all the information they need. This state of development can only be reached if fleets are willing to participate in trials and early adoptions of V2G—like REVS—as they are necessary for identifying and ironing out seams. Some changes like plug harmonisation are not entirely within the control of technology-taking economies like Australia's, but can be influenced through government actions.

4.3 Recommendations

4.3.1 Developing V2G through projects

In order to develop V2G generally, future V2G projects need to have variety, and place greater emphasis on the objectives of transport sector actors and end-users. This will assist the development of V2G by helping illustrate the "missing piece" between the technological concept and its future mainstream adoption.

Discussion of topics like V2G from the perspective of the electricity system is very difficult for transport sector actors to engage with, because it relies on a certain level of specialist knowledge. However, actors who are responsible for planning and implementing zero emissions transport strategies have specific questions and concerns around V2G as well as a more generally need for information that is trustworthy and technology-neutral.

Examples of future project areas that could be fruitful include:

- Developing V2G fleet concepts that prioritise transport concerns of vehicle availability, interoperability, battery capacity, and battery health;
- Developing heuristics for feasibility of V2G, comparable with and/or packaged with other measures such as rooftop solar or energy efficiency;
- Developing V2G business models where electricity sector actors bear the up-front costs;
- VXX concepts that can meet different objectives for fleet-owning organisations private vehicle owners—not necessarily focused on electricity markets; and
- VXX concepts tailored to different types of premises and fleets.

4.3.2 Developing V2G through policy

Before detailing policies for VXX, it is essential to note that participants across the REVS project have emphasised that the primary policy need is for a cohesive national plan for transitioning transport away from fossil fuels.[6]

Policies can use strategic niche management concepts to create an environment for V2G/VXX that both protects the developing technology from commercial pressures, but exposes it to real world pressures through projects. These are depicted in Figure 7: activity within a niche should include interlinking processes of learning, expectation building and

[5] For example, based on past history, at a given time and day x% of the fleet is usually not being driven and is available for V2G participation.
[6] The recent Transport Facts report (co-authored by an author of this report, along with other independent experts) provides an exemplar. https://transportfacts.org/

network development. To date, only learning “how to” and long-term expectation building have been strong (refer 3.1). Signs of a healthy niche emerging are where the technology becomes embedded in standards and regulations, and where high-quality learning about “why”—taking in multiple objectives and interpretations—has taken place.

The different projects suggested in the previous section can assist by testing a variety of concepts; policy can support this process by allowing projects to operate in “sand-pits” of alternative regulatory environments that respond to objectives beyond only those of the electricity industry. Policymakers can also directly participate by opening government fleets up to VXX experimentation, as has been done with REVS.

Policymakers should actively absorb the outcomes of projects in order to help make sense of them as a suite of approaches and, as interpretations of what the technology does start to become dominant, embed VXX in standards (or expand/normalise the “sand pit”). Examples of this could include steps toward charging plug harmonisation and adjustments to grid-connection frameworks. These types of measures help to align the various actors across electricity and transport so they can work in concert.

As VXX concepts have become clarified and actors are working together, policies can provide incentives for more mainstream consumers to access VXX.

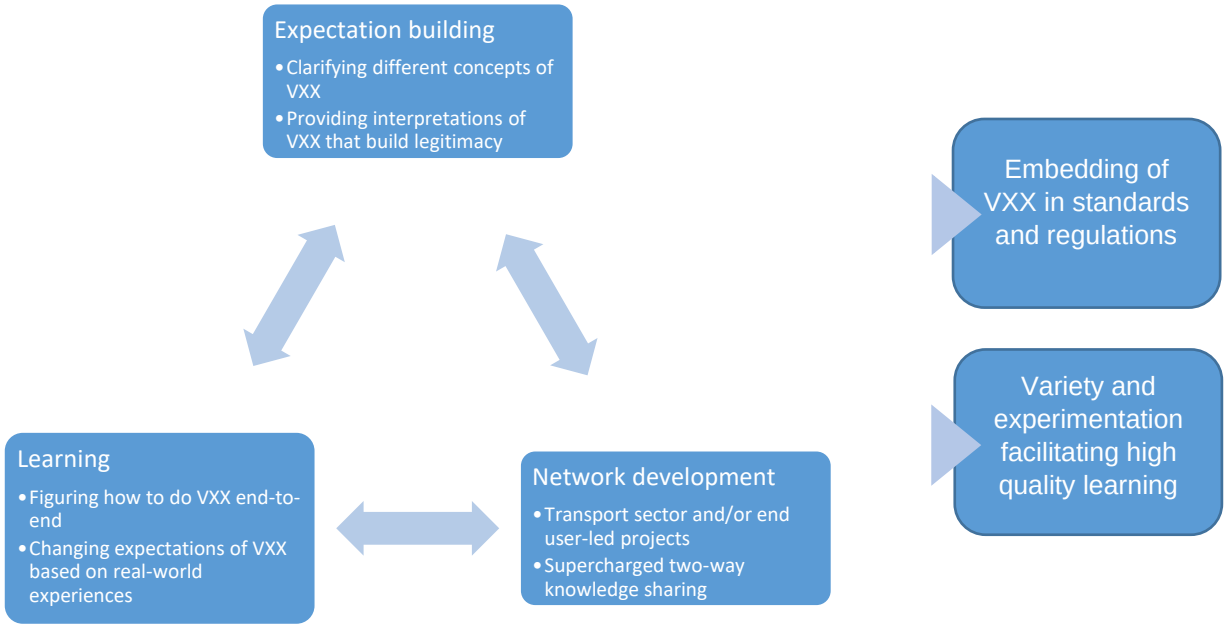


Figure 7: Interacting niche development processes (L) and indicators of healthy niche development (R) [8].

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