Australian National University

EV owner perspectives on V2X

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Based on focus groups with EV owners

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Executive Summary

This report presents findings from five online focus groups involving 15 electric vehicle (EV) owners and users exploring perceptions of bidirectional charging technologies. The research was commissioned by AusNet to better understand how EV owners view Vehicle-to-Load (V2L), Vehicle-to-Home (V2H) and Vehicle-to-Grid (V2G) technologies, including perceived benefits, concerns, requirements for participation and reactions to potential V2G programs.

Participants represented a highly engaged cohort of EV users. Many were already managing complex household energy systems involving rooftop solar, home batteries, advanced charging infrastructure, automation systems and dynamic electricity tariffs. As a result, the findings provide insight into the perspectives of likely early adopters of bidirectional charging technologies.

A clear preference hierarchy emerged across the participant group. Participants were most receptive to V2L, followed by V2H, while V2G attracted the greatest caution and the largest number of participation conditions. V2L and V2H were generally viewed as technologies that provide direct household benefits while remaining under household control. In contrast, V2G was more often viewed as a commercial arrangement involving external stakeholders, leading participants to place greater emphasis on compensation, fairness, transparency and control.

Participants identified several potential benefits associated with bidirectional charging. These included:

- Backup power during outages and emergencies.
- Improved use of renewable energy and solar generation.
- Better utilisation of the EV battery asset.
- Reduced household energy costs.
- Potential support for electricity networks and local communities.

However, participants also raised several concerns. These included:

- Lack of clarity regarding battery warranties.
- Potential battery degradation.
- High upfront costs of bidirectional charging equipment.
- Loss of control over vehicle charging and battery availability.
- Uncertainty regarding the value proposition and financial returns.
- Questions about whether EVs represent the most effective resource for broader grid support.

Having the ability to control vehicle battery activity emerged as one of the most important themes throughout the study. Participants consistently expressed a desire to maintain oversight of how and when their vehicle battery could be used. Common requirements included the ability to set minimum battery reserves, override charging or discharging events, receive notification of system activity, and ensure sufficient charge remained available for mobility needs. Another key theme was the need for adequate financial compensation which was widely regarded as a prerequisite for V2G participation. Participants evaluated V2G as a commercial proposition and expected compensation to reflect the value provided, costs incurred and potential risks associated with participation. While participants differed in the level of financial return, they considered acceptable, there was broad agreement that value-sharing arrangements should be transparent and fair.

Participants also highlighted the importance of visibility of V2X processes and understanding charging and discharging options. Many wanted clear information about why a discharge event was occurring, who was benefiting from it, and how financial returns were being calculated. Some expressed stronger support for programs that directly benefited local communities or local network reliability than for broader market-based participation.

Perspectives on emergency and outage scenarios differed from routine V2G participation. Many participants were more willing to contribute energy during emergencies, particularly where benefits to

local communities were visible and immediate. However, others prioritised retaining energy for their own household resilience and mobility needs. Responses were strongly influenced by participants' previous experiences with outages, local reliability conditions and household circumstances.

The study also highlighted the importance of household dynamics. Participants frequently acted as the primary manager of EV charging and household energy systems within their households. Several noted that successful adoption of V2X technologies would require solutions that work not only for technically engaged energy enthusiasts but also for less engaged partners and family members. Participants repeatedly emphasised the importance of automation, simplicity and "set-and-forget" functionality for broader adoption.

Overall, the findings suggest that interest in bidirectional charging exists among current EV owners, but participation, particularly in V2G programs, is likely to depend on program design rather than technology alone. Participants were most receptive to arrangements that:

- Preserve user control and flexibility.
- Offer fair and meaningful compensation
- Protect mobility needs through minimum battery reserves.
- Provide transparency (and visibility) about charging and discharging.
- Minimise complexity through automation.
- Fit within existing household routines and practices.

These findings provide insight into how highly engaged EV owners currently understand and evaluate V2X technologies and highlight important considerations for future V2G program, tariff and customer engagement design.

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Acronyms, definitions and codes

AC	Alternating current
AI	Artificial Intelligence
API	Application Programming Interface
App	Application
c/kWh	Cent per kilowatt-hour
DC	Direct current
DER	Distributed energy resources
DOE	Dynamic operating envelopes
EV	Electric Vehicle
EVs	Electric Vehicles
EVSE	Electric Vehicle Supply Equipment
ICCU	Integrated charging control unit
kW	kilowatt
kWh	kilowatt-hour
NSW	New South Wales
OCPP	Open charge point protocol: An open communication standard that enables EV chargers and charging management systems to exchange information and coordinate charging operations.
P1, P2, ...	Participant 1, Participant 2…
V2G	Vehicle-To-Grid: Vehicle exports electricity to the electricity grid, supporting network operation, energy markets, or grid services.
V2H	Vehicle-To-Home: Vehicle supplies electricity to a household behind the meter, including backup power during outages and emergencies.
V2L	Vehicle-To-Load: Vehicle supplies electricity directly to appliances, devices or equipment through onboard power outlets.
V2X	Vehicle-to-Everything: Umbrella term for technologies that enable an EV battery to export electricity to loads, homes, buildings or the electricity grid.
VPP	Virtual power plant: A coordinated group of distributed energy resources, such as EVs, home batteries and solar PV systems, that operate collectively to provide energy, flexibility or grid services.

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1. Introduction

This report describes the outcomes of a qualitative exploration of electric vehicle (EV) owner and EV user perspectives on bidirectional charging. Understanding particulars about possible participation in bi-directional charging is undertaken in the context of Australia's transition to net-zero emissions, the electricity system's role in this transition, and the growing pressure on electricity networks to orchestrate energy use so that infrastructure is not oversized to meet peak demand.

Bidirectional (or V2X) charging allows an EV battery to both draw electricity from, and supply electricity back to, a load, premises (e.g. a house) or the grid. Vehicle-to-everything (V2X) is an umbrella term for nascent technologies that apply this capability: vehicle-to-load (V2L), where the vehicle powers appliances directly from its own outlet; vehicle-to-home (V2H), where a vehicle powers a household behind the meter, including potentially as backup during grid outages and emergencies; and vehicle-to-grid (V2G), where the vehicle exports directly to the grid[1]. V2X technologies are anticipated as promising tools that can help better support EV charging on electricity networks and network needs. Various V2X technologies allow EV batteries to both draw electricity from and supply electricity back to the home or grid, offering the potential to support the grid, for example, during peak demand periods or times of low or high voltage. V2X also has potential to provide households greater control over their own energy use, including access to stored EV battery energy in emergencies. Despite this potential, little is currently known about how Australian EV owners perceive the usefulness of V2X, or whether they would be willing to adopt various forms of V2X in practice.

To address this gap, AusNet has funded this research to investigate EV owners' and users' responses to bidirectional charging, particularly V2L, V2H and V2G technology. The study explores what might encourage EV owners/users to use V2X, and concerns they may hold, including in relation to costs and financial benefits, potential impacts on batteries, convenience, and whether the technology fits realistically within everyday routines.

To capture EV owner/user perspectives, we conducted a series of five online focus groups, with participants who mostly live in Victoria. A qualitative, focus-group approach was chosen because collective discussion is well suited to exploring perspectives on nascent energy system technologies such as V2X, and allows surfacing of experiences, trade-offs, and uncertainties. Sessions were recorded, transcribed, and analysed thematically to identify key patterns, motivations, contexts and concerns shaping participants' attitudes toward V2X. This research reports outcomes of the focus groups and contextualises these insights using other relevant, contemporary electric vehicle and vehicle to grid research project findings from ACES research. The findings from this research are intended to help AusNet design programs, incentive structures, and customer communications that more accurately reflect the needs, expectations, and concerns of EV-owning customers as bidirectional charging technology becomes more widely available.

2. Research approach - overview

This project explored EV owners' and users' perspectives on bidirectional charging using focus group, with a particular interest in Victorian EV owners and users as participants. Five focus groups were held with 15 participants. The project involved:

- Identifying the research focus with AusNet.
- Planning the research, including focus group design, scheduling and discussion guides.
- Obtaining Human Research Ethics approval from ANU.

[1] These groupings are sometimes defined differently. E.g. the National Bidi Roadmap defined V2G as anything where the vehicle is electrically connected to the grid, which includes many elements included in V2H in the definition above. Others define additional terms like V2B where vehicle energy supplies buildings including many homes.

- Recruiting and screening participants.
- Conducting and recording focus groups.
- Providing vouchers to thank participants.
- Transcribing, checking and de-identifying data.
- Analysing data.
- Reporting and contextualising findings.

Focus groups and qualitative thematic analysis were used in this research because they are well suited to exploratory research on emerging technologies. The approach enables detailed examination of participant's experiences, motivations, practices, concerns, decision-making processes and contextual influences. This exploratory approach is particularly useful when investigating emerging technologies such as V2X, where behaviours, expectations and understandings are still emerging. However, this technique cannot be used to predict prevalence of any given occurrence identified. Participants represent a group of current EV owners who were generally highly engaged with EV charging and energy management practices, making the study particularly valuable for understanding the perspectives of early adopters of bidirectional charging. Some contextualisation is provided with the reporting of results to position findings in wider research contexts. The findings provide detailed insight into how current EV owners think about V2X technologies and can inform future program design, communications and quantitative research examining the prevalence of these perspectives across broader populations.

Further details about the methods used can be found in ***Appendix A. Methods***.

3. Participants

Fifteen participants were interviewed via five online focus groups between May and June 2026. All but two participants were from Victoria, with the remaining two from Queensland and NSW (Table1). All but one participant was male. Participants owned a wide range of EV models. They reported owning Tesla model S and Y, BYD Atto 1, Atto 3 and Seal, Hyundai Ioniq and Kona, Kia EV5 and EV9, Geely Ex5, Nissan Leaf and Audi Q4E. Battery size ranged from 38.4 kWh to 100 kWh. Most owned their car except for four participants who leased it. Where participants mentioned family vehicles, we have noted this in Table 1 as well. Overall, the sample was predominantly male, concentrated in Victoria (with Victoria the preferred location of participants), with diversity represented in the range of EV ownership experiences, vehicle models and charging arrangements.

Table 1 Participant demographics

Participant	**Gender**	**State**	**Electric Vehicle**[1]	**Vehicle Ownership**
P1	Male	Victoria	Hyundai Kona	owner
P2	Female	Victoria	Audi Q4 E – Tron Quattro 555 (2025)[2]	lease
P3	Male	Victoria	Tesla Y	owner
P4	Male	Victoria	BYD Atto 3	owner
P5	Male	Victoria	Hyundai Ioniq (2021)	owner
P6	Male	Victoria	Geely EX5 (2026)	lease

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Participant	Gender	State	Electric Vehicle[1]	Vehicle Ownership
P7	Male	Victoria	Tesla Model Y Long Range	lease
P8	Male	Victoria	Hyundai Ioniq (2021) and BYD Atto 1 (2026)	owner
P9	Male	Victoria	BYD Atto 1	owner
P10	Male	Victoria	Second hand Kia EV9	owner
P11	Male	NSW	BYD Seal, wife has plug in hybrid	lease
P12	Male	Victoria	Kia EV5	owner
P13	Male	QLD	Tesla Model 3, Model Y	owner
P14	Male	Victoria	Tesla Model 3 (2019), daughter has BYD Atto 1	owner
P15	Male	Victoria	Nissan Leaf x3, Model Y x2	owner

Table 1 notes: 1=Primary EV used by participant, plus other EVs in the household (if provided), 2 = date vehicle purchased/leased (if provided)

All participants attended the focus group in their private capacity as energy users and householders. There were two people who noted having jobs that connected with EVs, EV charging, and related technology. Many participants reported owning rooftop solar, home batteries, EV charging infrastructure and having fully electric homes. Focus group discussions made apparent that many participants had the financial capacity to purchase EVs, chargers and related equipment, physical environments suited to home charging, and substantial experience managing distributed energy resources in their day-to-day lives. The group can therefore be characterised as having high capacity to install distributed energy resources (DER) and integrate EV charging into household routines. This is an advanced infrastructure environment relative to the broader population of the current and future EV owners.

These sample characteristics shape how the findings should be read. Participants closely resemble the likely early adopters of V2X in that they were technically engaged, well-resourced, and predominantly male. Relevant resources and capacity looked like the ability to afford an EV or multiple EVs, space to have chargers in private garages, comprehension of the chargers, the batteries and the implications of charging patterns. Participant perspectives therefore offer valuable insight into the group most likely to take up bidirectional charging first. They are less representative of future mainstream users, and findings should be applied with that in mind. Other useful participants sample characteristics include them reporting a diversity of EV makes and models, charger types and practices, locations of participants, and household types. Further discussion of participant characteristics is shared where relevant through the results and discussions sections.

4. Results

Results of the focus groups are presented below and relay insights about EV charging behaviour, perspectives on bidirectional charging including V2G and on finance-related aspects. Results are reported in the following sections:

- Section 4.1 - Overview of results
- Section 4.2 - EV charging behaviour reported by participants
- Section 4.3 - Perspectives shared on bi-directional charging

- Section 4.4 - Perspectives shared on V2G as a specific technology useful to networks
- Section 4.5 - Responses to a V2G scenario discussed, and
- Section 4.6 - Perspectives shared on financial rewards and cost.

These results are structured to provide information on what was discussed in the focus groups. Pre-focus group survey questions, focus group questions and explanations provided in focus groups can be found in Appendix A.2, A.3.1, and Appendix A.4. Further detail of results can be found in Appendix B (survey results). Appendix C (Analytic notes) includes information not reported in the main results on motivations for owning an EV, the best and worst aspects about owning an EV, and what participants have learned since first buying an EV. Please also note we have included some results from another related project in Appendix D that provide some comparison and context.

4.1. Overview of results

Participants represented a highly engaged group of EV owners who were already actively managing charging, electricity tariffs and household energy systems. While they were generally positive about bidirectional charging, willingness to participate was strongly influenced by financial returns, maintenance of personal control, confidence in battery performance and warranty arrangements, and the perceived value of V2X services to both households and the wider energy system. Key themes and quotes that emerged during analysis are summarised in Table 2.

Participants were generally **highly engaged** with EV and energy technologies. Several enjoyed optimising charging behaviour and developing automated systems, although many noted that broader uptake of bidirectional charging would require simple and reliable **automation** that could be used by less technically engaged household members. Several participants emphasised the fun or "gamification" elements of energy optimisation for them in their homes. Only some of the participants in the study currently owned a vehicle that had technical bidirectional capability, and only one had a bidirectional charger.

Participants described a **wide range of charging practices**. Most charged primarily at home and used public charging mainly for long-distance travel or during periods when home charging was unavailable. Charging decisions were shaped by a combination of electricity prices, solar generation, state of charge, household routines and convenience. Participants varied considerably in how actively they managed charging, ranging from simple timer-based approaches through to highly customised automated systems that integrated EVs with solar, batteries and wholesale electricity pricing.

Overall, we found that participants were **interested in bidirectional charging**. Participants expressed the strongest support for V2L, followed by V2H, with V2G generating the greatest caution and the most conditions on participation. Participants acknowledged several **benefits** of bidirectional charging which include making use of the battery investment, saving money by using cheap green energy, environmental benefits of using solar or renewable energy at night, and stabilising the grid. Participants generally distinguished between V2L and V2H, which were often valued for direct household benefits, and were more likely to discuss financial returns, value sharing and compensation when discussing V2G

A recurring theme across discussions was the importance of retaining **control** over vehicle use and battery charge. Participants generally wanted clear visibility over when their vehicle would charge or discharge, the ability to override automated actions, and confidence that energy would remain available when required. Another recurring theme was that participation in V2G would need to represent a worthwhile **commercial proposition**. Participants frequently discussed financial returns, value sharing, payback periods and compensation arrangements, and many indicated that environmental or community benefits alone would not be sufficient to justify participation. While participants varied in the level of return they expected, there was broad agreement that the benefits received should reflect the value provided and any associated costs, risks or inconvenience. Other concerns were the lack of **warranty** for batteries used for V2G, damage to the battery due to additional charging cycles, and the very high upfront cost of a bidirectional charger. Moreover, participants questioned whether V2G was in fact the **best way to stabilise the grid**: There was however interest in V2L to support participants homes during an emergency or to just flatten peaks.

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Perspectives on **emergency** use of vehicle batteries were mixed. Some participants prioritised retaining battery capacity for their own household during outages or extreme events, while others expressed willingness to support neighbours or broader community needs during emergencies. In both cases, expectations depended on how much energy might be required and how often these events would occur.

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Table 2 Bidirectional charging themes

Theme	Quote
Bidirectional charging has to be a commercial proposition	"I'm very happy to participate in all sorts of things with it. I probably wouldn't do it out of just the kindness of my heart, and it would be for some sort of financial incentive." P8
	"I wouldn't necessarily be like Robin Hood in selling, draining down my battery or selling the power in my car unless it was commercial for me" … "I'd want that to be lucrative or, you know, a really good return … I wouldn't just do it for the sake of it or for the environmental benefit" P10
	"The distributors and the retailers are pretty … commercial, and I would be pretty … commercial as well in selling to the grid. So, it would be all about the price, the spot price and whether it was worth that in me exporting". P10
	"If I'm exporting from my car and I'm being paid 10 cents and then that energy is being sold to my neighbour for 42 cents, someone's making 30 cents because they've used my battery in my car" P13
	"If they're not going to share the full value of what they get out of my battery, then I'm going to not feel very happy about what they're doing with it." P13
Support for bidirectional charging – allow for dynamic exports	"I don't quite understand why my export is limited to that extent because I have no interest in selling it one or two cents in the middle of the day. If I was going to sell it. … I would be selling it, …, in the peak evening period or the peak early morning period to maximise my feed-in at a time the grid needs it, but AusNet have imposed like this 1.8-kilowatt limit …, give these customers a mechanism to get onto dynamic exports." P12
Concerns with bidirectional charging:	
Warranty	**"**None of the car manufacturers in Australia will support this in the battery warranty and in fact they will void the battery warranty. So, to me that is a concern." P7
	"The warranty argument just annoys me terribly. It's not supported under Australian consumer law. A company can't just void your warranty because you've used vehicle to grid on your car. They can, if they demonstrate that the damage caused to your vehicle was because you were doing vehicle to grid, then they can deny repairs on that basis. But they can't just run a black line through your warranty." P13
	"I'd happily take the risk on warranty" P12
Battery degradation	"I'd have to be earning enough money from the arbitrage to be able to make up for the fact that I'm putting wear cycles on my on my battery" P14

Theme	Quote
Cost of bidirectional **chargers** vs revenue of V2G	"I'm not so sure that 6 bucks three times a year is going to afford you a $10,000 vehicle to grid unit" P15
Will the car be charged or available when needed?	"If you have a contractual requirement to, … have it plugged in during this time. You can't unplug it … there would have to be a big financial incentive for that because … that's my car …, if I can't drive it between 8:00 or 5:00 and 7:00 or something, then that's a big problem" P6 "If it was everyday drawing lots of energy from the battery … it would probably not be OK" P8 "We all make the mistake of getting ready for a road trip and not plugging it in, like not often, but if it happens and if you add to that scenario that your house might be stealing power from your car and you've forgotten to switch it off, it can probably get quite frustrating." P15
Benefits: save money, the environment and community	
Making use of **investment in the car battery**	"What attracts me to it is obviously leveraging the significant investment in your car battery for your house" P9
Using cheap **green electricity saves money**	"My electricity bills every month is a credit" P13, P9
Environmental benefit: optimise use of energy – use green energy during the day and export at night to displace coal and gas	"This is sort of where I start feeling a little bit good for myself. I'm buying cheap green energy during the middle of the day. I'm sucking up solar. In fact, I'm just sucking up the solar from my neighbours … Then at night-time when I'm exporting, I'm actually displacing those coal and gas generators up here in Queensland" P13 "The price of electricity is a very good analogue for how green the grid is at a particular time as well. So that effectively lets me optimise for carbon emissions." P14
Community benefit: benefiting people in their immediate vicinity – also see community under use during emergencies.	"When I'm charging my car and my house during the middle of the day, I'm actually soaking up the excess solar from, I don't know, maybe 10 of my neighbours in my street. And the same thing happens at night when I'm exporting, I'm actually supplying 5 or 10 of my neighbours their electricity." P13 "One of the advantages of vehicle to grid is if there is a blackout and I'm not able to replenish my batteries because my solar is not working or whatever, we always drive the vehicle somewhere else, go and recharge it and then bring it back and run the house for another day or another couple of days" P13

Theme	Quote
Use during emergencies – mixed	
Wanting to **use** battery **for own emergency**	"I'd be quite annoyed with myself if out of bad luck I sold the battery down and we had a blackout. So, I'd like to keep the battery in that sort of emergency situation, at least have enough in it." P10
Community minded and happy to **use** battery **in emergency situation** – some but not all had this view	"Much more encouraged, rather if they said, there's an outage in your area or there's a particular reason why we're doing this, can you please plug in your vehicle to assist? And then, well, yeah, it's going to encourage me to kind of go, okay, I want to do that, I want to help" P6 "I am community minded. So even if there was a small benefit and it helped people, then I would be inclined to do V2G as well" P9 "You just indicate the times at which you're willing to have power taken out of it, the car or the battery, and you're paid for it" P11
Views on various V2X	
Is V2G the best method for stabilising the grid? also see commercial proposition	"I do see the reasons why vehicle to grid makes sense for stabilising grid. I'm just not sure how you make that, you know, how you warrant that for the for the user?" P15 "From a grid perspective, community batteries and VPPs and having solar and static storage, I think, is a much smarter, reliable solution for every community" P15 "I'm a fan of a V2L. I think every vehicle should have that capability … I would encourage everyone on the planet to get solar panels and a battery. …. When it comes to thinking about using a vehicle battery as a storage mechanism to support grid side…I don't see the reason why you would do it because your car's probably not there all the time, and it's a very random … it's never going to be a reliable solution and to and just add an extra 25, 30% to a vehicle purchase to do that doesn't seem like a smart" P15
V2L versus V2G – many were keen on V2L but less keen on V2G,	" ...your inverter shuts down and everything shuts down and you know you don't have power when everyone else doesn't have power. If you have vehicle to load, you have the ability to run the essential devices in your household during any of those times." P15 "… as far as vehicle to load, fantastic for backup, fantastic for, you know, if you do want to use it for short-term powering of your house or whatever, or, you know, just individual items, but beyond that, maybe vehicle to home, but not the vehicle to grid kind of thing." P15 "…much more interested in V2H than V2G" P2 "I actually got a V2L system installed in my house, and that was basically … preparation for that cyclone" P13
Need for automation – getting others to use	"Over time, this will automate to the point where people disinterested in it can use it" P9

Theme	Quote
bidirectional charging will require automation.	"This requires a lot more manual intervention than the average bear. Not everyone's going to be like P15 out there, plugging **** in and out at 3 o'clock in the morning" P14
	"Quick, quick check on the Amber app to see what the current power price is before you turn the dishwasher on is a very different thing from, okay, please ensure that your, that car is plugged in between this hour and this hour" P14 [Amber is an electricity retailer with a dynamic wholesale price reflective product.]
	"Yeah, fixing things is fun, and tinkering and everything else, but you know, it's got to pass the partner test, you know, the partner who's completely non-technical – does it actually work" P14
Interest in energy consumption and gamification	"My experience with people who would attend something like this and are interested in energy plans is that it's actually an interest. It's gamification in many ways. And you do need to be a bit fairly nerdy to get into this stuff. And it's interesting. People who don't have that mindset just find this all completely boring and too complex." P9

4.2. EV charging behaviour

4.2.1. Where and how participants charge

Participants were most likely to charge at home. Public and fast charging was mostly reserved for road trips, holidays, the early period of ownership before home charging infrastructure was fully set up (for P8 and P10), or for when living in an apartment where there was no charging infrastructure on personal property (for P8).

Participants described a variety of charging arrangements. Two participants charged from standard power points (GPOs) (P9's 10A point and P8's second vehicle). Dedicated, higher-capacity charging equipment (EVSEs) were described by most other participants. Several participants (P8, P9, P14, P15) operated more than one charger and more than one EV across a household, with different charging approaches across the different households, and for different cars within a household. More effort and/or automation was deployed to charging the primary car in households with more than one EV, with a more relaxed approach to a secondary vehicle.

The presence of multiple EVs within some households added complexity to charging practices. In households where partners, children or young adults also drove EVs, charging was not always coordinated according to a single optimisation strategy. Participants reported that one household member (i.e. the participant reporting it to us) often took primary responsibility for managing charging arrangements and EV energy use, while other household members plugged in vehicles according to convenience or their own travel needs. Other household members were reported as following some basic rules of thumb where this was beneficial overall, but they were not expected to follow complex charging strategies that the primary person might use. This suggests that EV charging decisions were often shaped by household routines and practical considerations rather than purely technical optimisation. Having one person primarily responsible for understanding and managing any complexity to the charging routines in a household aligns with previous research on energy use and energy related micropolitics in households (Cook et al., 2016; Gabriel and Watson, 2013; Martin, 2022).

Participants varied considerably in the complexity of their charging environments. Some relied on relatively simple charging arrangements, while others reported spending quite a bit of effort managing their charging (e.g. getting up at night to plug/unplug). Some charging situations described had rather complex charging sets ups – e.g. one type of charger on one wall of the garage, another type of charger on the other wall, and they would use those in curated ways (for example, P14 and P15). Some participants (P9, P12) demonstrated familiarity with the battery chemistry of their EV and understood the implications for charging. For example, being more willing to leave the vehicle at a high state of charge due to having a Lithium Iron Phosphate (LFP) battery or avoiding charging too high due to having a Nickel Manganese Cobalt (NMC) battery in their EV.

4.2.2. Triggers for plugging in, and charging frequency

Four main overlapping triggers to charge were identified across the group. These were: the state of charge of the EV battery, electricity costs and the time of these, when solar export was available from onsite/private solar, and opportunistic plug-in of chargers according to times when home.

State-of-charge triggers are when EV owners charge their vehicle when it reaches a threshold state of charge. Several participants spoke of different specific threshold states of charge such as 5% (P15), 20% (P11), 30% (P1), and 40-50% (P8). P1 described starting thinking about plugging in around 30% (especially with a drive planned in the next couple of days) and usually did not charge above 50–60% unless it's a particularly sunny day; P8 described plugging in their EV (an Ioniq 5) once it drops to 40–50%; P11 described letting their EV (a BYD) run down to 20% topping up to 80%; P15 aimed to arrive home with around 5% remaining and then charged.

Price/time-window triggers were the most commonly reported triggers with: P1 charging in relation to a 10am–3pm off-peak rule; P6, P7, P8, P9, P13, and P14 all charge around a specific free or cheap electricity window (commonly the 11am–2pm “solar soaker” time window); P10 charged overnight on a cheap tariff (4.5–5c/kWh) and deliberately avoided the 3–9pm peak window; and P15 similarly avoided charging between 3–9pm to avoid peak pricing.

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Solar-export triggers were noted**:** P1 had a specific automation rule to charge whenever solar export exceeds ~2kW (switching off again below ~2.5kW). Others also used various approaches to "charge on solar" (P8, P12, P13).

Convenience and opportunistic triggers were also reported and presented an example of where approaches could be diverse**:** Regular charging could be seen in P9's "always be charging" philosophy and P12's plug-in whenever at home. P11 plugged in their plug-in hybrid after almost every use as well, but this was more necessary for them due to its small battery. Some other participants plug in most days the car is home (P7, P9, P12, P13) while others plugged in more occasionally, on a needs-basis, e.g. P8 used a different approach for their second EV, a BYD Atto 1: they only plugged it in when a second car was needed, and it was also sunny. Notably, several participants with low weekly driving distances (P6, P8) didn't need to charge daily but still tended to think about it around their usual free power-window time, out of habit.

A recurring **household-logistics trigger** also occurred: P15 used technology to prevent charging during peak pricing because other family members plug in unpredictably; P11 charges in advance overnight if his wife has an unusually high-mileage day ahead; P12's wife checks the app to decide household activities like baking or heating so they use available free/solar power where possible.

4.2.3. Charging management (timers, automation, manual control)

Participants manage charging in one of three ways: manual charging, using both manual and automated systems and fully automated systems.

Using the smarts built into the vehicle

P6 only uses the car's built-in timer (11am–2pm) with no separate smart controller or home automation, describing himself as " not as advanced" as other participants. P10 combines a Kia app automation process with manual overrides (including setting an alarm to manually start overnight charging).

Combining manual charging with automated charging

There was a notable reality that even with automation, most charging still included a manual element.

P8 runs two different regimes for his two EVs. He runs fully manual, no-automation charging on the BYD, as a deliberate choice after having considered and rejected a smart plug due to load-rating concerns, and runs solar-diverting automation on the Ioniq 5. P9 currently manages manually but is transitioning to a fully automated 'Sigenergy' system and is notably cautious about trusting full AI-driven automation, preferring to retain some control. P11 mostly leaves the car to "charge when it wants to" but sets an 80% cap to protect battery longevity. P12 runs a mix of automated routines with solar trickle-charging as a scheduled midday charge and manual, seasonally adjusted interventions (deliberately draining his home battery into the car ahead of the free window in summer).

P15 is a partial outlier — despite having "smart" charging capability (Tesla API integration via Amber) on two of his six vehicles, he describes his overall management approach as "a mix of manual control and scheduled timers, rather than full automation," with one charger (a 'T-Power') having no scheduling capability at all and requiring constant manual adjustment.

Fully - or substantially - automated charging

P1 built a custom system using 'Home Assistant' open-source software, custom sensors, and a relay plug, with three layered rules (off-peak window, solar-export threshold, low-state-of-charge trigger) via the car's API. Notably, P1 provided clarity in the focus group discussion about automation's limits — stating the system "isn't perfect," with an unreliable low-charge trigger that sometimes fails to fire, requiring manual override. P1 also relayed that the reasons he is charging using their 'Home Assistant' based system is "purely personal inclination" and self-describes as an engineer and "a nerd" who likes to tinker, adding that without that inclination, he'd simply plug in "when it seemed like I should."

P7, P13, and P14 described some of the most complex charging arrangements in the participant group. P7 built a custom 'Raspberry Pi' system (EVCC.io + a Home Assistant) that manages charging, his 'Powerwall' battery, and dynamic load balancing (adjusting charge speed every 15 seconds to avoid tripping the main switch on over current) with no daily manual intervention required. P13 runs a fully custom home automation system managing two EVs, a home battery, and other major loads (pool pump,

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air conditioning, hot water) according to live pricing, although even this system required him to manually decide which of his two EVs to charge or discharge at a given time. P14 uses the VPP Amber's vehicle API to fully automate charging based on a self-set wholesale price threshold, having previously built and maintained his own automation system before switching to Amber's managed VPP service for simplicity.

4.2.4. Rationales for charging behaviour

Six rationales for charging behaviour were identified.

- **Cost minimisation—** nearly every participant aims to exploit free or cheap electricity windows (P1, P6, P8, P9, P10, P13, P14) or avoiding peak pricing (P10, P15).
- **Gamification** - P1 attributes his elaborate automation setup to personal character ("a nerd... likes to tinker") rather than any practical requirement and openly acknowledges he'd manage just fine without automation. This closely echoes P9's "gamification" framing and P7's enjoyment of his own technical setup
- **Preferring simplicity**: P6 chose not to over-engineer his setup given his low driving needs; P9 values keeping some manual control because he doesn't fully trust automation; P8 deliberately keeps his system simple enough that his wife doesn't need to think about pricing or timing at all.
- **Household logistics** include P11's wife's variable work mileage, P15's multi-driver household, and P8's mornings spent away from home (limiting use of the free midday window). These all directly shape when and how charging happens.
- **Environmental benefits:** P13 and P14 recognise that cheap charging is lower-carbon charging (since cheap periods tend to coincide with high renewable generation), and P13 values helping to flatten local grid peaks for his neighbours.
- **Battery health considerations:** P11 caps charging at 80% for longevity; P9 and P8, by contrast, are both relaxed about deep-cycling (0–100%) based on their own research/experience (P8 notes no observed degradation after four years), demonstrating differing views regarding the significance of battery degradation. Some participants grounded this perception on the battery chemistry of their vehicles, recognising Lithium Iron Phosphate (LFP) batteries higher cycle life and lower sensitivity to state of charge (P7).

4.3. Perspectives on bi-directional charging

Key themes on bidirectional charging are outlined in Table 2. Detailed results are presented below.

4.3.1. Overall attitudes: attractions and concerns

Nearly all participants were attracted to the concept of bidirectional charging. In particular they were interested in V2H, and V2L, but were more cautious regarding V2G. A number of participants use V2L (P8, P12) and V2H (P12, P13) and one participant already uses V2G (P13).

- **Backup power / resilience** is the most commonly cited attraction. P2 values a home or car battery, for wild weather events. P4 was the strongest advocate for V2H in the group, due to lived experience of roughly two cumulative months of power outages over four years (including a week-long outage). Others were interested in off grid uses, like for CPAP machine, camping, induction cooktop, and event catering urns. P6, P8, P9, P13, P14, and P15 all frame their interest primarily around using the car as a source of household or emergency backup power, rather than an income-generating asset.
- **Relevance of V2G as grid support** was discussed. P1 questioned whether EVs remain the most appropriate grid-support resource now that home batteries are becoming more common. He suggested grid operators would prefer everyone have a static home battery rather than relying on EVs, which are mobile and only intermittently available and that V2G would have been more compelling as a concept before home batteries were widespread. P11 and P15 expressed related concerns, although their focus was on the usefulness of EVs for grid support (from the perspective of the grid operator) rather than on the role of home batteries.

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- **Extending existing home battery/solar investment** was a major theme. P7, P8, P11, P12, and P14 describe the car as a natural extension of a home battery/solar system they already have, adding capacity rather than replacing anything.
- **Financial/market participation** is an attraction for a smaller subset. P3 was open to V2G "in principle" if the feed-in tariff is high enough, framing it as fundamentally an incentives question rather than a technology question. P7 and P13 frame bidirectional charging as "another avenue" for the same price-arbitrage game they already 'play' with their home batteries.
- **Broader systemic/environmental** appeal was also evident. P7 frames it as part of the path to "a 100% renewable grid," and P13 values the community/local grid-support angle (helping flatten voltage swings for his neighbours) alongside financial and environmental motives.
- Discussion of **emergencies and using EV batteries for them** generated a mixed response. Some wanted to maintain their batteries for personal use; others were happy to us EV batteries to help the grid. Participants happy to help the grid qualified their comments by noting that supporting emergency use depended on how much and how often the battery use would occur. Emergencies of a grid nature and emergencies of a household nature were noted, and at times these were anticipated to come into conflict. E.g. P3 could see that it was important for the car to be prepared, even after a V2X event.

Bi-directional charging concerns cluster around five issues:

1. **Battery warranty risk** was the most frequently raised concern for P6, P7, P10, P13, and P14. At the time of these focus groups, no Australian EV manufacturer supported bidirectional discharging when connected to the grid under the vehicle's standard warranty. Several participants (P7, P13) argue this stance is overly cautious given that EV batteries are known to outlast the vehicle and are being repurposed into stationary storage products.
- **Loss of control over the vehicle** was shared by P6, P8, and P15. The car isn't a fixed household asset like a home battery, and any scheme that might leave the car under-charged when it's needed to drive was relayed to us to be seen as a hard limit, not a minor inconvenience.
- **Cost of bidirectional hardware** was noted by multiple participants. P4 pointed out that indicated that cost of hardware would matter, distinguishing between an expensive DC bidirectional setup (~$10,000, which he's unwilling to pay) and a more affordable AC-based system (which he would adopt at a "normal price range"). This suggests that **cost sensitivity may also hinge heavily on *which* bidirectional technology is being discussed**. P9, P11, P12, and P15 also flagged the price of bidirectional chargers (commonly cited in the $5,000–$10,000+ range, or a 25–30% premium on the vehicle itself) as a barrier to adoption, independent of their attitude toward the underlying concept of bi-directional energy exchange.
- **Connection capacity limits** were noted. P12 was concerned that his network operator (AusNet) had imposed a flat 1.8kW export limit on his property due to local solar saturation, which he sees as a bigger obstacle than the technology itself. P7 had built a complex charging management system to avoid tripping their main switch due to overcurrent induced by charging.
- **"Mental load" fatigue with active price management-** Both P1 and P4 describe trying dynamic/VPP-style electricity plans (via a retailer who shares wholesale dynamic process with customers) and finding the ongoing effort of monitoring prices not worth the savings. Both want a "set and forget" system rather than one requiring constant attention, and both expect this same fatigue would apply to an actively managed bidirectional charging scheme.

Scepticism about the suitability of EV battery grid connection to support the grid

Several participants (P4, P11, P15) expressed scepticism about whether individual EV batteries could reliably support the grid, given that cars are frequently away from home and drivers will want to preserve enough charge to keep driving. These participants suggested that neighbourhood batteries may be more effective.

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4.3.2. What would motivate use, and how behaviour would change

Most participants say they would use a bidirectional charger if they had one today, though the "why" varies:

- P1 would want it provider-managed as a virtual power plant operating within pre-set constraints (a defined minimum floor). P1 wants a "set and forget" experience and doesn't expect his daily charging behaviour to change much.
- P2 wants a defined, bounded release window — e.g. a known 48-hour outage period — so she can plan and control exactly how much power is released, rather than an open-ended or unpredictable arrangement.
- P3 is motivated by clear financial incentives (citing a retailer plan paying roughly $1/day for not consuming during peak as a possible model), but still hesitant about the risk of his battery being drained right before he needs to drive to work.
- P4 has a kind of V2H infrastructure in place (a changeover-switch setup supplying ~2.4kW to essential loads). His stated behaviour change would be adopting a similarly priced AC-based system, not a DC one.
- P5 currently charges only as needed (retired, doesn't drive daily) and says he'd likely leave the car plugged in more under a bidirectional system, but notes he can't yet participate since his current vehicle isn't bidirectional-capable.
- P6, P8, and P9 confirm they'd use it primarily for cost reduction and backup power rather than active profit-seeking. P8, in particular, frames this clearly: "It is all about reducing cost and my own grid consumption", not maximising earnings.
- P7 and P13 either use bidirectional charging (P13 owns and runs a ‘Sigenergy’ system) or are eager to build automation around it the moment it's available (P7).
- P10 is positive but motivated by a mix of "fun" and commercial return. He says he wouldn't participate in a purely altruistic, low-return way; "I wouldn't necessarily be like Robin Hood".
- P11 and P15 are more equivocal. Both say they probably wouldn't use one given their current setup, primarily because their existing home battery/solar system already meets most of their needs making a bidirectional charger redundant.
- P12 and P14 were conditionally positive. P12 runs a DIY V2L-based workaround and would extend it to a full system if the payback made sense. P14 says he'd use it to extend his existing home battery/arbitrage strategy but states that his interest is personal/hobbyist rather than reflecting a belief in strong general utility.

Several participants expressed a preference for automated, low-effort participation over active, hands-on management (P1, P4, P5, P8 and P14). Others (P7, P13) would prefer to build their own automation around a discharge schedule.

As noted earlier, participants were effectively a range of early adopters of EVs and EV charging approaches and insights need to be considered in this context. The participants also have infrastructural (DER) capacity, management of DER in place (automated and manual), were prepared to test approaches and had technical knowledge and technical capability. There was also a positive overall feeling towards new technology. For example, one participant repurposed a set of EV batteries they changed out for use as a stationary house battery. The demographic and contextual insights indicate a participant cohort that have been learning and continue to learn about EVs and how they can stretch their interactions with them.

4.3.3. How participants understand and compare V2G, V2H, and V2L

Most participants expressed greater comfort with simple backup-power use (V2L) than home-support use (V2H), and greater comfort with V2H than grid-facing use (V2G). Participants were particularly wary of ceding all control to a third party (retailer, VPP operator) and especially if there aren’t suitable overrides to the third party (retailer, VPP operator) actions. P2 is "much more interested in V2H" than V2G, valuing the ability to use her own solar herself with fewer unknowns and more control. P4 is not

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interested in V2G as he is a high-mileage driver and therefore rarely has spare capacity, and his current feed-in tariffs are near zero. P4 also describes V2H as "very interesting," given his experience with extended outages. P5 draws the same distinction — V2H barely changes net household grid consumption (since the home stays grid-connected regardless), whereas V2G's entire value proposition is a benefit to the grid, which is why he believes V2G needs proper financial compensation in a way V2H doesn't. P15 agrees with P5's argument. P6, P8, P11, and P12 all described a preference for household-focused uses of stored energy over grid-facing uses.

Further participant understandings and comparisons were:

- P1 compares charge/discharge power capability. EVs often have a larger energy capacity than a home battery, but the maximum discharge power limit is comparable. He believes V2G's main grid benefit is smoothing everyday peaks and troughs, not covering major generation shortfalls, which he argues are simply too large for distributed batteries of any kind to meaningfully address.
- P5 distinguishes between V2H and V2G. V2H mainly benefits the household with only minor grid impact (shifting when you draw from the grid), whereas V2G exports from a much larger battery, meaning far more benefit flows outward to the grid, which is why, in his view, V2G requires a proper financial equation in a way V2H doesn't.
- P4 frames the V2G/V2H distinction through a rural/regional lens. He sees community batteries as better suited to handling bulk local supply, with EVs playing a supporting "top-up" or "ride-through" role rather than being the primary grid asset and is sceptical about scale, doubting there would be enough EVs in his (regional) town to meaningfully help during a real outage. He separately raises voltage regulation as an interesting, distinct use case, having observed daily voltage swings of around 15V in his area that he thinks EVs could help smooth.
- P6, P8, and P12 all draw the same basic distinction: V2H is about your own home, V2G is about other people's needs (the local network, the broader grid, or the market), and each is more immediately comfortable with the former.
- P11 expressed this distinction helpfully, relaying that: "V2G helps more people or the whole network," whereas V2H is about his own building's needs.
- P7 and P13 who are technically sophisticated participants both frame V2G less as a different concept and more as a different scale of automation/control. P7 notes that if he connects to a sophisticated automation platform for V2G he wants to "orchestrate his entire life around it" (to make good use of it). P13 stresses that V2G is really just the physical mechanism (power moving from vehicle to grid), and that the more important distinction is who controls when that happens.
- P15 was particularly sceptical of V2G. He ranks V2L as the highest, is "open to V2H but not sure," and is "not convinced by V2G" at all, primarily because he doesn't believe individual vehicles can be a reliable grid resource. This is because drivers prioritise their own mobility over grid support, and there's no guarantee enough vehicles will be plugged in at any given time.
- P14 sees legitimate value in V2H/blackout backup for people on unreliable grids (like himself) but is not positive about V2G for grid stability and highlights a cognitive burden: maintaining a battery at 60% "useful for both charge and discharge" means remembering to manually override full-power charging ahead of any unplanned long trip. This would provide an extra mental load a standard EV owner doesn't have.

Benefits and disadvantages of V2G vs V2H:

- The financial upside is the most commonly cited V2G-specific benefit. P7 saw V2G as "another revenue-generating dimension". P11 thought V2G could provide return-on-investment argument for the expensive equipment.
- Safety/equipment risk during emergencies was a concern raised by P11. He was worried that expensive equipment could be damaged if something goes wrong during a major grid event (this concern was not mentioned by other participants).
- Reliability at scale was one of P15's concerns with V2G. The same concern doesn't apply to V2H since it depends only on his own presence, not a whole neighbourhood's.

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4.3.4. Willingness to participate in bidirectional approaches

All participants expressed conditional openness to bi-directional charging, however all also had some concerns. Table 3 below shares the key conditions noted.

Table 3 – Participation in V2X

Participant	Would participate?	Key condition
Participant 1	Yes, for routine grid operations	Compensation should match the value provided. Grounded expectation on costly diesel-generators used during emergencies.
Participant 2	Conditionally	Notice tied to her own routine; won't pay to build reserves that are then taken as they would prefer to charge during the 3-hour free window.
Participant 3	Conditionally	3–4 days' notice; more open for emergencies (e.g. bushfires) if compensated.
Participant 4	Yes, narrowly	Self-managed via API, not VPP-controlled; rare/short events preferred; "made whole" is enough for small events.
Participant 5	Yes, for normal V2G; more for emergencies	Wants wholesale-linked pricing normally, higher rate for emergencies; informal sharing for small-scale neighbourly help.
Participant 6	Yes, broadly	Fair, tiered pricing (routine/peak/voluntary-disaster); no forced lock-out from his own car.
Participant 7	Yes, enthusiastically	Wants full automation and control; positive about REVS/FCAS-style low-impact automatic participation.
Participant 8	Yes, conditionally	Wants a bidirectional (not one-way) arrangement, fair value-sharing, and the ability to unplug at will.
Participant 9	Open to all, case-by-case	Wants concrete scenarios; evaluates via three self-defined criteria (no negative effect / clear benefit / helps others).
Participant 10	Yes	Purely commercial — "all about the price"
Participant 11	No (for V2G) — happy with V2L only	Well-served by his home battery; cost of upgrading isn't justified.
Participant 12	Yes, conditionally	Wants clear pricing/incentive structure; prioritises his own household's needs during emergencies
Participant 13	Already participates	Requires a fair value split (≥20c/kWh, matched against what neighbours pay).
Participant 14	Yes, conditionally	Needs a clear, short payback period; installation cost ($6,000–10,000) is a major barrier
Participant 15	Uncertain/limited	Would need a larger-capacity vehicle to make the economics work; cost and unclear compensation limit him

Enticements and limits to participation

Participants noted several ways V2G could be made more attractive to them. They also noted several factors that would limit their participation.

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Enticements noted for V2G were:

- **Fair, simple pricing** was the most common request. Thinking as they discussed pricing, P6 proposed a 15c/kWh payment for grid services with no daily connection fee; P7 though a percentage discount (30–40%) on daily supply charges tied to a discharge threshold could work; P13 set a floor of 20c/kWh based on his own degradation-cost calculation.
- **Tiered/contextual pricing** was also proposed. P6 proposed a pricing structure with:
    - Routine/standard daily discharge where they would be happy with "the same" rate as everyone else.
    - Higher rates for rare, high-value peak events where they felt a higher rate would be fair, given the scale of value being generated at those times.
    - Disaster/community-support response pricing for which they did not expect payment at all.

  P8 and P13 both expressed the same underlying principle: a fair share of the value created, not just a flat token payment.
- **Reduced financial risk/barriers to entry,** with P14 wanting shorter payback periods and rebates; P11 noting his home battery was only viable because of government funding at the time, implying that similar support could shift his V2G calculations to be favourable.
- **Battery warranty extensions** were flagged by P7 as a potentially "extremely attractive" incentive alongside cash payments.
- **Larger-capacity vehicles** could influence involvement with P15 saying he might get involved in V2G if their EV had a much larger battery, since the economics don't work on a smaller capacity car.
- **Being helped/asked directly, with a reason given** could be a positive influence. P6's point from Part 1 recurs here: being told the specific reason for a discharge event, e.g. "there's an outage in your area", could motivate beyond any financial incentive.

Limits to participation and issues the make involvement off limits were:

- **Loss of control** and related one-direction-only discharge is the most frequently cited hard limit that would put people off participating in V2G. P6, P8, and P13 all state that a scheme draining the battery without restoring it or without the participant's ability to define limits, is unacceptable.
- **Cost/complexity mismatch** was noted by a few participants. P6 says overly complex, highly conditional schemes will cause him to disengage, regardless of the potential reward. P14 and P15 both cite hardware cost as their primary limiting factor.
- **Uncertainty about compensation/timing** was a limiter. This was P12's biggest limiter as not knowing how long an emergency event might last would make him reluctant to export power he might need himself. P15 cites uncertainty about how battery-impact costs would be repaid to him as a specific limiting factor.
- **Existing solution "good enough"** is seen as a limiter. P11's low receptiveness is explained by this factor and provides a good example. His home battery already meets most of his needs so there's little marginal incentive to add V2G-specific investment.
- **Battery health practices** were influential. There were aspects of battery health that participants would not compromise on. P15 stated that if a scheme required keeping the vehicle at 100% state of charge (which he understands would accelerate degradation), he'd be negative about being involved.

State-of-charge limits

State of charge was discussed in relation to whether it affected people's comfort with participating in bidirectional charging. Comfort with a lower state of charge varies with each participant's personal risk

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buffer, with the majority preferring a range between 40-60%. Two participants were happy with 20-30% (P12, P13) and two participants were not concerned with minimum limits (P8, P9).

Participants were generally not troubled by the idea of running a lower state of charge (40-60%) in exchange for participating in V2G. Some participants (e.g. P4 and P5) made specific requests for control over state of charge such as the ability to ”flick a switch” to increase state of charge, or additions of floor/celling state of charge. Some (e.g. P6, P9, and P11) stated they could plan around V2G, particularly where they have a backup vehicle or predictable driving patterns. The more important condition, repeated across several participants, is visibility to retain the ability to plan around charge levels themselves and exert control over charging when needed, rather than being surprised by an unplanned low charge.

Further related points were:

- P1 wants a hard ‘floor’ of V2G use and is undecided between 40–60%. He is comfortable with the car being taken to 100%, seeing no short-term harm in that.
- P3 assumes an automated minimum floor of ~50% would be necessary to avoid being caught out before needing to drive to work.
- P4 was flexible and said this flexibility was context-dependent rather than fixed. He was comfortable with a 50% minimum on a light-driving day but wants zero discharge on days with long trips (300km round trips) planned. He wants the ability to "flick a switch" to manually set how much can be used on a given night and notice of high-energy-need days usually weeks in advance.
- P5 wants confidence via a guaranteed minimum before enrolling or committing to V2G and frames his comfort level using a share-trading analogy. He won't "sell" (discharge) below a defined floor and is happy to "sell" above a defined ceiling provided personal minimums e.g. "always able to drive 50km" which are clearly set and reliably honoured.
- P6 was comfortable with state of charge down to ~25% (about 80–100km range), reasoning that sudden long trips are rare.
- P8 was not concerned about state-of-charge limits at all, given a combined household battery capacity across two EVs and a home battery of roughly 130kWh.
- P9 was comfortable from 100% down to 0%, since he has backup vehicles including a diesel four-wheel drive for urgent trips. He would only set a floor ~50% if the EV was his only car.
- P11 needs at least 40% state of charge for day-to-day comfort and avoids exceeding 80% except for long trips.
- P12 currently keeps his EV (a Kia) at a 20% floor and says he'd keep this the same under a full bidirectional system.
- P13 has a ‘Sigenergy’ system with a built-in taper (full rate to 30%, reduced rate 30–20%, no discharge below 20%), which he considers a sensible built-in safety margin.

Financial return

Nearly every participant considered financial return to be a requirement and an influence on participation:

- P3 references a specific existing retail-plan model (~$1/day for demand response) as a benchmark for what would feel like a fair incentive.
- P5 proposes a specific rate expectation, something like $5/kWh when the wholesale market hits $15/kWh. He expects a meaningful share of extreme price events to flow through to him, not just a flat modest rate.
- P4 says current feed-in tariffs (near zero) don't come close to justifying the wear on his batteries, and he's watched import prices without being willing to "give away" his exports for nothing.
- P9 said that a $5,000 install cost "must be covered as a financial return alone."

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- P10 wants a "profitable", not merely break even, return.
- P11 needs a reasonable ROI, noting his home battery was only viable because of government rebate funding he used at the time.
- P14 calculates that a $9,000 install with a 5-year payback target would need to earn $69 every two weeks to be worthwhile. He separately notes that replacement battery costs and therefore the underlying economics, vary hugely by vehicle brand.
- P15 frames the 25–30% cost premium on a bidirectional-capable vehicle as simply not worth it currently. He wants a bidirectional V2G solution priced similarly to a standard AC wall charger, something he doesn't expect to see soon.

Requirements for control and other concerns shaping receptiveness

Several participants raised concerns beyond financial calculation:

- P2 wants a few days' notice, tied to her own routine. She wants reserves built during her free 10am–2pm window or via home solar and says that she would not want to pay (in cost or inconvenience) to build up reserves that are then taken from her without her benefiting from the arrangement.
- P3 wants roughly 3–4 days' notice, mainly so he can slow-charge to 100% beforehand. He suggests a simple early-warning text message ahead of a forecast event as a workable, low-tech model.
- P4 requirements include:
    - Strongly preferring to not hand over control to a VPP/operator, rejecting typical VPP models where an organisation can "do whatever" with the vehicle. His preferred model instead is a real-time API he can automate himself, with the ability to set his own blackout/override windows (e.g. "don't touch my car for the next 24 hours").
    - He cites a negative experience with an automation product, where override commands took 30 minutes to 4 hours to take effect, compared to his own home-built system, which responds within seconds.
    - He describes himself as a "niche use case" (high-mileage, technically capable) and doesn't expect the system's default/majority design to necessarily suit him.
    - He specifies acceptable frequency and duration to be roughly half a dozen times a year, in short windows (10–15 minutes of discharge within a ~5-minute call-up window), with shorter, rarer events being more acceptable to him than frequent or lengthy ones.
    - On compensation for rare, short events, he'd be satisfied with being "made whole" (net-zero cost — energy taken returned at the same price); for anything drawing a larger chunk of his battery capacity, he'd want proper, above-cost compensation.
- P9 includes "helps others" as one of his three evaluation criteria, alongside "no negative effect on me" and "what's the benefit".
- P6's voluntary, no-payment tier for disaster response reflects a community-minded perspective.
- P13's wants fair compensation contrasting his own ~10c/kWh payment against a neighbour's 42c/kWh retail rate, which he frames as being about equity, not just getting a good deal.
- P12 distinguishes between grid stability, which he sees as a "higher order need", and energy market participation, a more commercial motivation. However, he notes most typical consumers likely don't make this same distinction and simply care about the per-kWh return.

4.3.5. When expectations change: emergencies and storms

Several participants distinguish between routine, everyday participation and emergency/disaster scenarios, generally becoming more receptive, not less, in an emergency.

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- P1 lives in Melbourne with rare outages (last one was roughly six years ago and lasted 30 minutes). Backup power isn't a personal motivator for him, though he acknowledges this would likely be very different for people on rural single-wire-earth-return (SWER) power lines, showing awareness that his own low-need profile isn't universal.
- P2 sees a battery (home or car) as clearly advantageous during wild weather events, though cost remains her main barrier to acting on this.
- P3 would be more open to participating for an emergency (citing severe bushfires as an example), but still wants a financial incentive attached and questions who pays for it in an emergency scenario.
- P4 expressed particularly strong support for V2H, drawing on extensive experience with power outages. He had experienced roughly two months of outages over four years, including one lasting a full week and as a result had infrastructure installed.
- P5 lives in regional Victoria where fires and storms cause more than one outage a year and has a home battery. He is however sceptical that a car adds much value in emergencies because during major fire events the grid itself typically fails at the source (damaged poles and wires), meaning a vehicle can back up your own house but has limited capacity to help others when the surrounding network is unsafe or down. This differed from the views expressed by P6 and P7, who saw greater potential for EVs to support communities during disasters.
- P6 reported a real-world example where the company Tesla deployed portable chargers to disaster zones in North America, encouraging owners to bring cars back to power affected communities. He draws a direct comparison to trucking in water or food, but with energy instead.
- P7 frames disaster/blackout response as the use case that he's most inspired by and most receptive to, ahead of routine daily participation.
- P8 has experience of a multi-hour outage (a windstorm-caused event) and successfully ran his household off his home battery/solar system within the 9kW load limit of their inverter; and prefers to retain manual control over any storm-preparation charging feature, rather than have it trigger automatically.
- P9 reported that blackouts are rare for him, so this isn't a major personal driver, but he says it "would be lovely to have an EV there as a backup," and his clearest ask is that a bidirectional system should provide blackout power "as cheaply as possible."
- P10 takes a different stance from the "help others" framing. In an emergency his priority would shift to preserving his own charge rather than exporting or selling it, saying he'd be "quite annoyed with myself" if he'd sold down the battery right before a blackout.
- P11 has adequate outage backup via his home battery but would value a bidirectional system that could handle larger loads (air conditioning, pool heaters) that his current setup can't fully support.
- P12 has a generator inlet and home battery. His main ask is to make bidirectional charger installation and network export-limit approval easier.
- P13 installed V2L in preparation for a cyclone (Tropical Cyclone Alfred) that ultimately didn't hit as forecast. The experience reinforced his view that a vehicle can be driven elsewhere to recharge and brought back to extend backup power during a prolonged outage, a use case he considers valuable.
- P14 has direct experience of a prolonged outage (a car hitting a power pole, followed by unannounced network repair works) that left him with only ~20% home battery charge for several hours. P14 had to fall back on a separate manual backup system. He believes bidirectional systems are more valuable for people on weaker, rural grids like his own, rather than for typical urban households.
- P15 values V2L because some home battery/inverter systems automatically shut down during a blackout to protect the network leaving households without power despite having a battery installed. He sees vehicle-based backup as a way around that specific failure mode.

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4.3.6. Financial and impact expectations

At the end of each focus group, we presented participants with the following scenario: **assuming a vehicle-to-grid (V2G) program accessed 20% of their EV's battery once every two weeks on average**, we asked them to consider whether they would participate, what financial incentives or rebates they would expect, and what information they would want to see — both before participating (to understand how the program works) and during participation (to understand what had actually happened).

Participant responses to the scenario had many parallels to the responses they had about V2G in general, but with additional context driven by the concrete scenario example.

Many were receptive to grid participation, sometimes visually relaxing when we showed the scenario. For several participants, knowing the grid side use case of their grid support was important. Some participants were more receptive to grid use of their V2G system than market use.

Below are the responses from a selection of participants.

- P6 is open to participating. He wants a modest, simple deal: no daily connection fee and around 15c/kWh for exported energy, working out to roughly $3 every two weeks, and he's explicit that the amount doesn't need to be large. His main information need is being told why his car is being discharged (a specific reason like "there's an outage in your area" motivates him more than a generic scheduled arrangement), plus upfront clarity on the scheme's structure and what happens if he doesn't meet minimum participation.

- P7 is enthusiastic and ready to participate. Rather than a flat per-kWh rate, he wants a percentage discount on daily supply charges (30–40%). His clearest requirement is resolving battery warranty uncertainty alongside technical/regulatory clarity (OCPP compliance, DNSP export rules) before he'd commit.

- P8 worked out his own numbers: on his 70kWh Ioniq 5, 20% is about 14kWh and wants both a per-kWh energy payment (15c/kWh) and a separate availability payment (50c–$1/day) for reliably staying plugged in, noting the arbitrage only works if he's charging cheap/free before discharging. He also flags the cost of bidirectional hardware itself as a real barrier: they stated prices of $7,000–8,000 for units like the Wallbox Quasar or Sigenergy versus under $2,000 for a standard charger. He wants some additional support to cover that cost.

- P9 would consider participating, but his central condition is that the battery must never be drawn on when he needs it. He expects a high payment rate (40–50c/kWh) although he also floats an alternative model — free charging for a set period instead of per-kWh payment. His information needs are about predictability and trust: he wants to understand exactly what triggers a discharge event, what control he retains over it, and clear notification whenever one occurs.

- P10 confirms he'd participate if the price clearly beats peak retail rates. proposed two different tariff arrangements: a lower rate for participants who keep discharge-timing control themselves and a higher rate for those who hand that control to the operator. His main information need is knowing which of those two models he's signing up for before he commits.

- P11 expressed limited interest in V2G participation, saying V2G generally isn't worth the cost or effort given how well his existing home battery already covers his needs but he offers an alternative: if the program guarantees his car is restored to its starting charge level after an agreed, unused window, he'd be willing to contribute that capacity for free, with no payment needed at all. His priority is restoration, not revenue. He wants to know the specific times power could be drawn so he can opt in and afterward wants visibility/confirmation that the restoration promise was actually kept.

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- P12 is conditionally supportive if the scheme is executed the right way in terms of pricing and market structure. He wants to know how much he'd be paid and how much notice he'd get, but his most distinctive point is structural: he questions whether it should matter, from the network's perspective, whether the required energy comes from his car battery or his home battery, He'd rather have flexibility about the energy source than a scheme that requires the vehicle specifically.
- P13's participation is conditional on the price. He set a hard floor of 20c/kWh based on his own estimated battery degradation cost, and he emphasised the importance of fair value sharing through an example: if his neighbour pays 42c/kWh on a standard offer while he's paid only 10c/kWh for his export, that's an inequitable split, and the gap only feels worse during genuine price spikes. He wants clarity upfront on who controls the discharge decision and how pricing works, and wants ongoing, continuous visibility into how much he's paid per event relative to what the scheme operator captures, so he can keep auditing whether the arrangement stays fair over time.
- P14 frames participation around a clear financial target: he needs $69/fortnight in earnings to justify a $9,000–10,000 installation on a 5-year payback. He's open to letting the operator control his car remotely if he sets the minimum state of charge himself and wants to understand how this would interact with any other uses of the charger. His main uncertainty isn't financial but technical: he's unsure whether the resetting/OCPP connectivity would work reliably.

In addition to this scenario question in the focus groups, we included Appendix D which provides background information from an ARC Linkage Project that included a recent survey of residents in major Australian cities, including Melbourne. Appendix D presents the survey findings for Melbourne. The survey was conducted at the end of 2025 and examined residents' EV awareness and attitudes, drivers and barriers to EV adoption, familiarity with vehicle-to-grid (V2G) technology, willingness to participate in V2G programs, factors influencing participation decisions, and policy preferences and rankings.

4.4. Financial returns in relation to retailers and plan types

In this section we aggregate perspectives on V2X related energy tariffs and retail plans. There is some overlap in themes with other sections.

Across participants there were several different retail plan types in use. Many were taking advantage of "free energy" plans that have a zero-cost window at peak solar times. Some were taking advantage of different kinds of plans that offered feed in rebates.

Several participants were (currently) with Amber, connected to their dynamic retail product, and noted they can make financial returns from this. Others had tried Amber but found it didn't work for them because: of technical issues (e.g. issues with automation), or dynamic pricing was too hard to integrate into their daily life.

Some participants used retail offers that included solar feed in rebates at peak times, such as ones offered by GloBird or ZeroHero. Users of these plans described actively deciding how much energy they had spare to feed in during peaks.

None of the participants stated currently being involved in a 'virtual power plant' (VPP), however many had implemented various forms of energy orchestration, either themselves or using approaches provided by their energy retailer. Retailer related orchestration activities can be associated with VPPs, but this association wasn't made by participants. Some participants had considered joining VPP aspects of a retailer product (e.g. the VPP component of the Globird or ZeroHero offer).

- P1 tried dynamic pricing and got tired of constantly monitoring prices. He would prefer bidirectional charging be managed by a provider, who have an attractive proposition for their participants, but wants a fully "set and forget" experience rather than active engagement.

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- P4 also tried dynamic pricing for a month and found that it was not worth the small savings they saw. He prefers a system he can automate once and forget.
- P7 runs solar/price automation but he isn't currently brave enough to go on a dynamic pricing plan yet because Melbourne weather makes solar/battery arbitrage harder and his solar/battery systems aren't large enough to play the game confidently.
- P8 doesn't have the time/energy for active management. He has an electricity plan giving him a 3-hour free window (11am–2pm) plus a cheaper overnight rate (8c/kWh), which he makes use of.
- P9 mentions his current plan's peak-time export allowance up to 10kWh/evening with a lucrative feed in tariff and is considering switching to a higher feed-in-rate plan (~45c/kWh) via a different provider to increase returns once he has more capacity to export.
- P10 has retail plan with a cheap overnight rate (4.5–5c/kWh, midnight–6am) and he avoids the 3pm–9pm peak window (45c/kWh).
- P11 tried a dynamic pricing product and lost money due to software bugs (buying high, selling low). He gave it up after six months.
- P13 explored different retailers and settled on a dynamic pricing product, enabling very cheap midday charging. He runs active spot-price arbitrage through it and his bills run as a net credit most months. However, he does not use a vehicle feature that is offered by the retailer (and is related to the dynamic price product he uses), because it doesn't support his specific types of vehicles. He instead runs his own custom automation system on top of the retailer's pricing data.
- P14 uses a dynamic price retail product and uses his retailer's access to his vehicle's API to automate his Tesla's charging, with a self-set wholesale price (10–12c/kWh). His BYD does not have this API integration, so he manually checks the retailer app instead.
- P15 also has a dynamic pricing product and charges EVs when the pricing is "cheap" and he enjoys optimising. He also uses wholesale pricing signals as a self-managed trading approach. However, his access to the retailers API broke for about a month due to a vehicle-access issue, and he was still resolving this at the time of the focus group. He also mentioned 5 years of VPP experience (with Origin) that had been for his home battery only, not vehicles.

5. Discussion

Overall, while participants were cautious about bi-directional charging, they were receptive at a conceptual level. Participants were most receptive to V2L where EV batteries are discharged to supply load that is not connected to the grid. Many were already using V2L in different ways, including as a form of backup power. Participants were also interested in V2H and its potential to help them manage household energy use. V2G generated the most caution, with participants setting several conditions to their participation related to costs, battery impacts and expected benefits. Despite these concerns, many were still receptive to V2G if it could be delivered to them in ways that aligned with their needs and expectations.

The characteristics of the participant group are important for interpreting these findings. Participants represented a highly engaged, mostly male, cohort of EV owners and users, many of whom were already familiar with V2X concepts and active in managing EV charging and household energy use. Many reported having rooftop solar, home batteries, advanced EV charging infrastructure and experience with dynamic electricity tariffs. Several used automation systems or customised charging arrangements to manage charging behaviour. As a result, participants frequently considered V2X within a broader household energy ecosystem rather than as a standalone technology. Their responses provide insight into the

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perspectives of current and likely early adopters of V2X technologies. At the same time, the conditions and concerns identified by this relatively knowledgeable and engaged group suggest that simplicity, visibility, control and a clear value proposition may be even more important for broader consumer uptake.

5.1. Key Factors

Key factors for participants when considering bidirectional charging include:

- Control and autonomy
- State of charge
- Awareness and visibility around charging and discharging
- Financial value and compensation
- Reliability, emergencies and context, and
- Interest and capability.

5.1.1. Control and autonomy

The most prominent message to emerge from the discussions reported here is that participants want bidirectional charging on their own terms. While participants varied in their levels of enthusiasm for V2X technologies, many wanted to retain the ability to influence when and how their vehicle battery was used. Participants framed their vehicle as a transport asset first and an energy asset second and were reluctant to enter into bidirectional charging arrangements which could negatively impact vehicle availability for transport.

Control over car charging was discussed in several ways, such as the ability to: override charging or discharging events when needed to meet personal travel requirements; decide when and how to participate; prevent surprise discharging; and adjust participation settings when household circumstances change. This was seen to be easier to effect with V2L and V2H where the applications remain under household control. V2G was viewed less favourably because it was perceived that these forms of autonomy and control over charging and discharging would be less available.

The importance placed on control reflects the everyday realities of car ownership. Participants described a variety of household circumstances, travel patterns and energy needs that influence charging decisions. For these participants, confidence that they could meet transport needs while retaining the ability to respond to unexpected events was a prerequisite for considering wider participation in V2G programs. Consequently, future bidirectional charging programs may benefit from providing users with clear controls, flexible participation options and straightforward mechanisms to override or adjust system settings when required.

5.1.2. State of charge

Participants expressed the need for control over their car charging in a variety of ways, including minimum battery percentages, available driving range and emergency reserves. State of charge was a key factor on participant's minds in considering participation in V2G initiatives. While participants varied in the battery levels, they regarded as acceptable, when specific minimum state of charge levels were stated, they were around 40-60%. Participants also discussed the importance of being able to direct vehicles to change faster or to a higher state of charge when they required it, for example ahead of trips, and to opt out of discharge events or temporarily prioritise mobility over energy services.

These findings suggest that state of charge should not be viewed as simply a technical setting within a V2G system. For participants, battery charge represented mobility, flexibility and preparedness. As a result, confidence that mobility requirements will be protected appears to be an important prerequisite for participation in bidirectional charging programs. Clear minimum settings, transparent operating rules and the ability to adjust preferences may therefore be important design considerations for future V2X offerings.

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5.1.3. Awareness and visibility around charging and discharging events

Visibility and transparency were important enabler of participation in bidirectional charging. Across discussions, participants expressed a desire to understand what their vehicle was doing, why it was doing it, and what the consequences would be for them. Many indicated they would be more comfortable participating in a V2G program if they could see upcoming charging or discharging events, receive notification when events occurred, and retain the ability to opt out when required. The ability to anticipate system behaviour was closely linked to participant's broader desire for control and confidence that their mobility needs would be protected.

Participants also wanted explanations that enabled them to understand the purpose of charging and discharging events. For some, understanding why their vehicle was being used was almost as important as the financial return associated with participation. Several participants distinguished between supporting their local distribution network and participating in broader energy market activities. Some expressed greater willingness to contribute energy where they could see direct benefit to their local community or network. This suggests that information about purpose and outcomes of V2G events may influence perceptions of value and willingness to participate.

Transparency around financial benefits was also considered important. Participants wanted visibility over how value generated through V2G participation was distributed across different stakeholders. In particular, some questioned how benefits would be shared between vehicle owners, retailers, aggregators and network operators, and expressed concern about situations where others might receive a disproportionate share of the value created. Visibility over payments, benefits accrued, and the basis on which compensation was calculated was therefore viewed as an important component of a fair V2G arrangement.

Taken together, these findings suggest that participants sought systems that were understandable and "decodable". Beyond the technical operation of V2G, participants wanted sufficient information to understand what was happening, why it was happening, how it aligned with their own priorities, and what benefits they were receiving in return. Providing clear information, transparent value-sharing arrangements and visibility over system actions may therefore be important in building trust and supporting participation in future V2G programs.

5.1.4. Financial value and compensation

In contrast to V2L and V2G, financial considerations were central to participants' assessments of V2G. While participants identified a range of potential benefits associated with bidirectional charging, financial return was generally viewed as a prerequisite for participation in V2G rather than an additional benefit. Participants repeatedly described V2G as a commercial arrangement and evaluated it in terms of costs, risks, effort and expected returns. Concerns about battery degradation, warranty impacts and the cost of bidirectional charging equipment further reinforced expectations that participation in V2G should be financially worthwhile.

Participants were conscious of the current economics of V2G. They noted that bidirectional chargers are currently expensive and feed in tariffs are low. Where specific figures for participation were stated, they varied between $1 per day to $69 every 2 weeks. Some also grounded their expectations of returns on energy market prices. For example, one noted that if market prices were $15/kWh, then they should receive at least $5/kWh. This suggests that perceptions of fairness may be as important as the absolute level of compensation offered.

Participants in this study were already actively engaging with electricity pricing and retail energy offers. There were a diversity of retail offers in use by participants. Many had taken advantage of the "three for free" energy plans, and several expended significant efforts to move energy use into this window. Some were on tariffs that provided feed-in rebates in the evening peak (such as GloBird Zerohero), and some were on a dynamic pricing product (such as Amber). One participant already had a V2G charger and was using it coupled with a dynamic price energy plan to reduce their energy use. Their awareness of these financially beneficial tariffs and their use of them, often needing a bit of effort and planning, indicates that financial incentives can be effective.

Compared with findings from other DER programs, participants in this study appeared to place greater emphasis on achieving a positive financial outcome rather than simply avoiding financial disadvantage or

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collecting some form of 'involvement' bonus or payment. In many early-stage DER optimisation trials we and other researchers observed participants comparing benefits against the effort required to participate, and they tended to seek assurance that they would at least be no worse off (for example, please see (Boyle et al., 2023)). While previous trial participants did also discuss what is fair remuneration, discussion in these V2X focus groups stood out because of the clarity of responses. For many participants in this V2X study they confidently and clearly expected both fair compensation and a clear financial benefit for an EV connection with the grid. This may reflect the characteristics of the participant group, many of whom have experience with home batteries and EVs and are staying aware of relevant information, including costs and savings, were already experienced in responding to electricity prices, managing household energy systems and seeking financial value from existing energy technologies. The DER trial participants in comparison, were a more mixed groups and may have been relatively unfamiliar with DER when taking part in the first year if the trial. The standout confidence of this group about the value of their participation is both notable and indicative that there is a high level of knowledge that can seed back into the community from their understanding.

Overall, the findings suggest that the value proposition for V2G extends beyond the level of payment offered. Participants wanted confidence that compensation reflected the value provided, that costs and risks were recognised, and that the distribution of benefits between customers and other energy-system actors was transparent and fair.

5.1.5. Reliability, emergencies and V2X/V2G

Participants' perspectives on bidirectional charging often changed when discussions shifted from routine operation to emergencies and power outages. During emergencies and storms, participants often described a higher willingness to support their local communities than on a normal day. However, this willingness wasn't universal. Some participants preferred to retain their EV's battery capacity in case they needed it during emergencies, particularly where they anticipated needing transport, backup power, or flexibility during uncertain circumstances.

Participants' views on emergency use were strongly influenced by their personal circumstances and prior experiences. Those who had experienced extended outages, lived in areas with less reliable electricity supply, or had invested in backup energy systems were often more attuned to the value of V2X for various forms of resilience. Conversely, participants with limited experience of outages were less likely to view backup power as a primary motivation for participation. Concerns relating to health needs, family responsibilities, travel requirements and local conditions also shaped how participants evaluated the potential use of EV batteries during emergency situations. This dynamic, in relation to emergency use, aligns well with other DER trial research where contextual influences such as regionality, electricity supply, reliability and more greatly influenced positions taken in relation to back up and emergency support. See, for example South Australia's energy export DOE program for constrained networks (Government of South Australia, 2024, 2013), CONSORT Bruny Island Battery trial findings from a regional location (Watson et al., 2019), the NSW coast Surf microgrid project from a bushfire impacted environment (Chalaye and Ransan-Cooper, 2023) and Project Symphony's social report from a reliable suburban network (Boyle et al., 2023).

These findings suggest that perceptions of V2X are closely linked to how participants understand reliability and resilience within their own lives. Rather than responding to a single concept of "emergency support", participants evaluated potential participation through the lens of their existing experiences, vulnerabilities and preparedness strategies. As a result, the value of V2X during emergencies is likely to be understood differently across households and locations. Programs seeking to leverage EVs as resilience resources may therefore benefit from recognising the diverse contexts in which customers experience outages and assess the risks and benefits of participation.

5.1.6. Interest and capability

Participants in this study demonstrated high levels of interest in EVs, charging technologies and household energy management. Many were already actively managing charging behaviour, using advanced electricity tariffs, coordinating multiple DER, and experimenting with different approaches to household energy use. Several participants had developed automated charging systems, while others were manually adjusting charging behaviour in response to electricity prices, solar generation or

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household needs. Participants also described creative uses of existing V2L functionality and expressed a willingness to learn about and experiment with emerging technologies.

These characteristics are consistent with participant group representing a cohort of early adopters. While there was considerable variation in technical capability and the complexity of charging arrangements, participants had generally invested substantial time, effort and resources in understanding EV ownership and household energy management. Some enjoyed optimisation and experimentation as hobbies, while others had gradually developed expertise through years of EV ownership and interaction with energy technologies. The findings therefore provide insight into how highly engaged EV owners currently understand and evaluate V2X opportunities.

The study also highlights that early adopters are not a homogeneous group. Participants varied in their levels of technical expertise, enthusiasm for automation, willingness to manage complexity and interest in participating in energy markets. This suggests that even within a highly engaged EV-owning population, V2X programs will need to accommodate different preferences, motivations and levels of capability.

The experiences described by participants also illustrate how knowledge and familiarity with new technologies develop over time. Many participants reflected on lessons learned through EV ownership, including changes in charging behaviour, increasing confidence in battery technologies, and growing understanding of electricity markets and home energy systems. As V2X technologies become more widely available, it is likely that broader groups of consumers will follow similar learning pathways, although they may require simpler systems and greater support than the participants in this study.

For network businesses and other energy-sector organisations, these findings highlight both the opportunities and challenges associated with engaging early adopters. Highly engaged users can provide valuable feedback, identify emerging issues and help reveal new use cases for technology. At the same time, their preferences and practices may differ from those of future mainstream users. Understanding how consumer expectations, knowledge and capabilities evolve as familiarity with V2X increases will therefore be important for the design of future programs, products and communication strategies.

5.2. What V2G designs appeared most acceptable?

Participants consistently preferred V2L, followed by V2H, with V2G receiving the greatest scrutiny. This preference appears to reflect the degree to which each technology enables participants to capture benefits directly while maintaining control over their use. V2L and V2H were generally perceived as tools which remain under household control and deliver benefits directly to the household. In contrast, V2G was perceived as delivering value to external parties and therefore attracted greater attention to issues of compensation, fairness and control.

Participants did not reject V2G outright. Rather, there was a series of conditions under which participation would be considered acceptable. These included minimum battery reserves, retaining override capability, receiving visibility of system actions, and receiving compensation that reflected the value provided. Participants were generally comfortable with arrangements that supported their own energy needs first and broader system needs second.

Participants were broadly supportive of automation but not of surrendering control. Many already used automated charging systems and recognised that large-scale V2G participation is unlikely to occur if users are required to actively manage charging and discharge events. However, automation was expected to operate within user-defined limits and remain transparent. In this sense, participants appeared comfortable delegating decisions to technology provided they retained the ability to understand, monitor and override those decisions when required.

Participants distinguished between different beneficiaries of V2G. Several were more receptive to supporting local communities, local network reliability, or emergency response than to market-based energy trading. This suggests that participation may not be determined solely by the size of a financial incentive. The perceived purpose of a V2G program and who benefits from it may also influence willingness to participate.

The widespread ownership of home batteries among participants also shaped responses. For many, home batteries already met the functions they most valued from energy storage, including backup power and solar self-consumption. V2G was therefore often assessed against an existing energy-storage asset rather

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than against having no storage at all. This reduced the perceived incremental value of V2G for some participants and suggests that uptake pathways may differ for households that already own batteries compared with those that do not. Participants' scepticism regarding EV availability suggests that some consumers may view community batteries as a more dependable network resource than EV fleets.

Taken together, the findings suggest that V2G uptake is likely to depend less on enthusiasm for the underlying technology and more on program design. Participants were most receptive to arrangements that were understandable, transparent, financially worthwhile and aligned with existing household practices. Programs that minimise complexity, preserve user control and clearly communicate both household and network benefits appear likely to be more acceptable than arrangements that require substantial behavioural change or ongoing management effort.

5.3. What this means for households and program design

Previous research has shown that the adoption and use of distributed energy resources are influenced not only by technology and economics, but also by household relationships, routines and decision-making practices (Cook et al., 2016; Gabriel and Watson, 2013; Martin, 2022; Oliveira et al., 2025). The findings from this study are consistent with the broader understanding we have of how householders interact with their homes in relation to energy (including CER and EV) technologies. Participants frequently described EV charging as something embedded within everyday household life rather than as a purely technical activity. Travel needs, family schedules, multiple vehicle ownership and differing levels of interest in energy management all influenced how charging was undertaken.

A notable observation from the focus groups was that participants often appeared to act as the primary EV or energy manager within their household. These participants were typically the people most familiar with charging arrangements, electricity tariffs, solar PV, batteries and emerging V2X technologies. In households with multiple EVs or multiple drivers, one individual often took responsibility for managing charging decisions, automation systems and energy-use strategies. Other household members were frequently described as participating in simpler ways, such as plugging vehicles in when convenient or following established household practices without necessarily engaging in the underlying optimisation.

This household context helps explain differences in responses to V2L, V2H and V2G. Participants were generally most comfortable with V2L because it was already familiar, relatively simple and remained entirely under household control. V2H was also viewed positively because the benefits flowed directly to the household and could readily be incorporated into existing energy-management practices. By comparison, V2G often introduced additional layers of decision-making, coordination and uncertainty. Participants were not necessarily opposed to V2G, but they were more likely to ask questions about compensation, battery reserves, control arrangements and how participation would affect everyday household routines.

Several participants referred to the need for charging arrangements to be simple enough to work for partners, children or other household members who were less interested in energy management. The frequently cited need for automation and "set and forget" functionality appeared to reflect not only a desire for convenience, but also recognition that household participation cannot rely on every member having a detailed understanding of energy markets, charging schedules or V2G operating arrangements. The "partner test" discussed by participants is particularly instructive here: while some participants enjoyed optimising energy use, they recognised that broader adoption would require arrangements that function reliably for less engaged household members.

The presence of multiple EVs within some households further highlighted these challenges. Participants described situations where adult children, partners or other family members used EVs with different charging patterns and priorities. In these households, charging decisions were not always coordinated around a single optimisation strategy. Practical considerations such as convenience, travel needs and vehicle availability frequently took precedence. This suggests that V2X participation occurs within a household setting where responsibilities, priorities and levels of interest may differ between users.

Taken together, these findings suggest that successful uptake of V2X technologies may depend on how well they fit within existing household practices. Participants appeared willing to learn about and experiment with new technologies, particularly V2L and V2H applications that deliver clear and immediate household value. However, the greater complexity associated with V2G highlights the

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importance of simple interfaces, automation, flexibility and clear user controls. Programs that are designed around the realities of households, rather than around idealised assumptions of rational and highly engaged users, may be more likely to achieve sustained participation.

The predominance of men within this sample is also consistent with broader evidence that early adoption of emerging energy technologies is currently male-dominated in Australia (Hajhashemi et al., 2024; Mortimore et al., 2024). As V2X technologies become more mainstream, recruiting a more diverse participant cohort should become increasingly feasible. Future research involving a more gender-diverse participant group may identify different household practices, priorities and experiences relevant to V2X adoption.

6. Conclusion

This study explored how a group of current EV owners and users perceive bidirectional charging technologies, including V2L, V2H and V2G. Participants were generally positive about the concept of bidirectional charging and recognised a range of potential benefits, including backup power, improved use of renewable energy, household energy management and support for wider energy-system needs. However, acceptance varied across different forms of bidirectional charging. Participants were most receptive to V2L, followed by V2H, while V2G attracted the greatest scrutiny and the largest number of participation conditions.

A central finding was that participation in V2G was viewed as contingent on maintaining personal control, protecting mobility needs and receiving fair value in return. Participants consistently expressed a desire to retain visibility over what their vehicle was doing, the ability to set limits and preferences, and the option to override system actions when required. Financial compensation was considered important, but so too were transparency, trust, clarity regarding battery impacts and confidence that household needs would continue to be prioritised.

Participants also demonstrated high levels of engagement with EVs, charging technologies and household energy management. Many had already invested in rooftop solar, home batteries, advanced charging infrastructure and automated energy-management systems. As a result, they often evaluated V2X as part of a broader household energy ecosystem rather than as a standalone technology. Their perspectives provide insight into the expectations and concerns of likely early adopters of bidirectional charging technologies in Australia.

The findings highlight the importance of designing V2X and V2G programs that work with existing household practices rather than requiring substantial behavioural change. Participants frequently described one household member acting as the primary manager of EV charging and household energy technologies, while other household members engaged with these systems in simpler ways. This suggests that successful V2X uptake is likely to depend not only on technical performance and financial value, but also on whether systems are easy to understand, simple to operate and capable of fitting within everyday household routines.

Participants were most receptive to systems that were understandable, flexible, financially worthwhile and capable of fitting into everyday household routines. As bidirectional charging technologies become more widely available, attention to control, transparency, simplicity and household circumstances is likely to be as important as the technical capabilities of the technology itself. While the participant group was predominantly male, highly engaged and relatively well-resourced, the study provides valuable insight into how potential early adopters currently understand and evaluate V2X opportunities. Future uptake is likely to depend not only on technological development, but also on how effectively programs align with the needs, expectations and realities of households.

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Declarations

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

AI use

Microsoft Copilot and Claude Fable 5 were used to assist with drafting and editing manuscript text, including supporting restructuring of sections, converting unstructured notes and moving thematic summaries into prose, and improving clarity, coherence, and narrative flow. All AI-generated text was critically reviewed, revised, and validated by the authors. The authors accept full responsibility for the interpretation, accuracy, and integrity of the final manuscript.

Appendix A Methods

A.1. Human Research Ethics Application at ANU

Human Research Ethics approval for this project was obtained from The Australian National University (ANU). An ethics application was submitted and subsequently approved on 11 February 2026. Following this approval, the project commenced in accordance with the approved research protocol.

A.2. Preparation of focus group (questions, breakout groups decision)

The focus groups were designed around three main sessions, each structured to explore key topics relevant to the project objectives. A set of guiding questions (please see these below) was developed to initiate and facilitate discussion among participants, while allowing flexibility for participants to raise additional insights and perspectives. During the planning phase, it was decided that if more than six participants attended a session, breakout groups would be used to facilitate greater participation and enable the collection of richer and more detailed data from all participants. The proposed focus group format and discussion questions were shared with AusNet for review and approval prior to implementation.

A.2.1. Focus group questions

A.2.1.1. Session 1: Introductions about you and EVs

- What can you tell us about your journey so far as an EV owner and user?
- Why did you get an EV? What were your motives for purchasing your EV/using your EV?
- What's it like to own an EV? What are the best and worst things about the EV?
- What have you learned from being an EV owner?

A.2.1.2. Section 2: Perspectives on EV charging

How do you charge your EV?

- at home, public destination, fast charger.
- If home, also is it a dedicated charger, or just a power point.

What practices/triggers do you have to indicate when it is time to plug your vehicle in to charge?

- What triggers you to plug in? e.g. Time, state of charge, price, location (e.g. at home)
- How often do you charge your EV on average? E.g. daily, twice a week, etc

How do you manage when you charge/how long you charge?

- Do you use timers, use a system to manage automatically, through practices (e.g. The user might just plug in during off-peak periods)
- Why do you charge your EV the way you do?
- does work or some life requirements structure your use?

A.2.1.3. Section 3 part 1: Perspectives on bidirectional charging

What are your thoughts on bidirectional charging?

- What attracts you to it?
- What would concern you about it?

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What would motivate you to get and use a bidirectional charger?

- If you had a bi-directional charger today, would you use it? If so, how would you use it?
- How might your charging behaviours change if you had bidirectional charging?

What might be your requirements to uptake/use bidirectional charging?

- Are there limits in how your vehicle could be used for bidirectional charging? E.g. max/min state of charge
- Are there use cases you would be more receptive to than others?
- Are there financial limits?
- What if your battery level had to be a bit lower to be involved?

When might your expectations on the bidirectional charging system change?

- E.g. during emergencies like storms
- How might you charge/use your EV differently during emergencies?
- What could a bidirectional charging system do to better support you? E.g. provide power during a blackout

A.2.1.4. Session 3 part 2: focusing on V2G

What are your perspectives on V2G?

- How does this compare to V2H? To V2L?
- What are the benefits/disadvantages of V2G over V2H for you?
- Are the use cases for V2G different? How so?

What do you think of the solutions of V2G, V2X, and other bidirectional ideas posed?

- Would you participate in V2G, V2H blackout, or V2G emergency or all of them, or none?

Thinking specifically about V2G? Would you participate? Why or why not?

- What might entice you to participate?
- What might limit your participation? Are there things that are off-limits for you?
- Would there be other motives/values/cases that you would be more/less receptive to? See list above

A.2.1.5. Scenario question:

What would influence your decision to participate in a V2G program, assuming a V2G program accessed 20% of your EV's battery once every 2 weeks on average: Would you consider participation? What financial incentives or rebates would you be looking for? What information would you like to see? Before you participate: To help you understand the program? During participation: To understand what happened?

A.3. Recruitment of participants

Participant recruitment for the online focus groups involved advertising the project through relevant channels and community networks (Australian V2G Community Facebook group, the Australian Electric Vehicle Association (AEVA) Victoria Branch, the BYD Australia Owners Club Facebook group, and the

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Tesla Australia Owners Club Facebook group) inviting interested individuals to complete a pre-focus group survey that included participant information and consent procedures (Please see below). While the information we received on each participant seemed aligned with what was expected, at the first focus group, we identified that some of the participants were using Artificial Intelligence (AI) generated answers. We identified AI and real participants during that first focus group. We found that the AI participants were interested in the participant vouchers handed out after involvement. We reported the event to ethics and explained our adjustments to procedure to deal with this AI participant challenge. Ethics noted AI generated participation is a growing problem and registered our adjusted procedures.

For all further focus groups, we conducted brief screening meetings of approximately five minutes with potential participants with videos on. During these meetings, prospective participants were asked a further series of screening questions to confirm that they were real participants, met the study's eligibility criteria and were part of the project's target population before being invited to participate in the focus groups. This procedure was successful and identified all AI participants. After confirming eligibility criteria, participants attended the focus group discussions. All AI participant data were removed, and only real participant data was used and real participant numbers reported.

A.3.1. Pre-focus group survey questions

The initial survey asked for information about:

- Postcode/Suburb or State
- Car model
- Battery (kWh)
- Range (km)
- Relationship (Owner, Regular user (not owner), Leaseholder)
- V2X familiarity (Yes, I am quite familiar, I have heard of it, but I don't know much detail), and
- EV usage purpose.

A.3.2. Consent

Consent text shared at focus groups is below.

Consent for online focus groups

In this survey, we are seeking your consent to participate in an online focus group to explore electric vehicle user perspectives on bidirectional charging. We also ask questions about your EV which will help us prepare for the focus groups.

Participation in focus groups is voluntary – you can choose not to attend if you prefer. Within the focus group, you are welcome to skip any questions or leave at any time. We do tend to check with people here and there to see if they have something to say, but you are welcome to skip, even if we prompt.

Risks
If someone would like a contribution removed after the session we will attempt to do so, but it may be difficult to remove specific contributions as it is a collective group conversation.
While every effort will be made to de-identify data, there is a small chance you may be identifiable. We ask that participants respect the confidentiality of group discussions. Please follow Chatham House rules.

Benefits
Although participants will not personally benefit from the study beyond receiving gift vouchers, the broader advantages—namely improved understanding of customer preferences and behaviours related to V2X or bidirectional charging—significantly outweigh any risks. With this research we aim to expand knowledge in an area where both industry and academia currently face a substantial gap that is about EVs

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and interaction with the grid.

Data storage
Data will be securely stored on ANU systems for at least five years. De-identified data may be shared with other researchers for future analysis.

For more information, please contact:
Dr Phillipa Watson, phillipa.watson@anu.edu.au, Dr Kim Blackmore, kim.blackmore@anu.edu.au, Dr Yeliz Simsek, yeliz.simsek@anu.edu.au.
The information sheet for this research is provided https://energysystems.anu.edu.au/electric-vehicle-user-perspectives-bi-directional-charging. We can provide further details on the projects through the email addresses above.
The ethical aspects of this research have been approved by the ANU Human Research Ethics Committee (Protocol H/2026/0775).

On the next page, we ask you whether you consent to participate in a focus group.

Focus group discussions will be recorded and transcribed. All data will be de-identified before analysis and reporting. Insights will contribute to a report for AusNet Services, who are a large energy network company in Victoria. They are interested in factoring in electric vehicle user insights as they design systems related to electric vehicles.

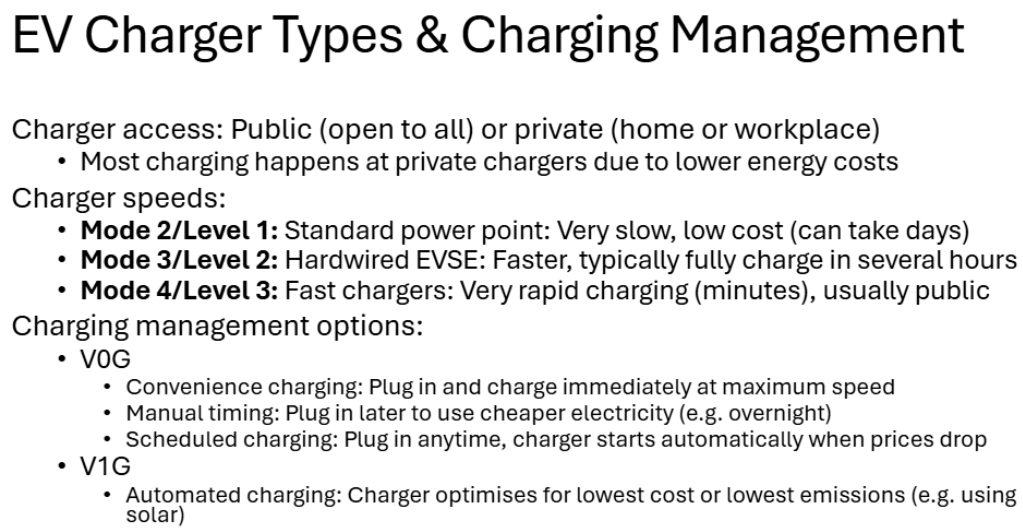
We may develop other publications as well because your information will help us with understanding a big gap related to bidirectional use of batteries. All reporting and publishing - anything going to AusNet or into the public realm - will be anonymised so no one can be identified. Where we quote from the discussion, we will replace names with a generic identifier such as 'focus group participant', or 'EV owner/user'. If anything you say seems potentially identifiable, we'll check with you before including it.

Do you consent to participating in an EV users focus group?

A.4. Explanations made during focus groups

Participants were given brief explanations about EV charging and bidirectional charging. We share the slides related to these explanations here.

Session 1 explanation slides:



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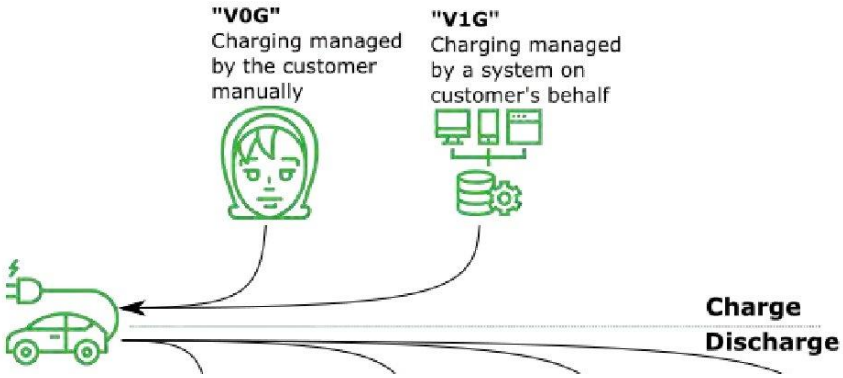
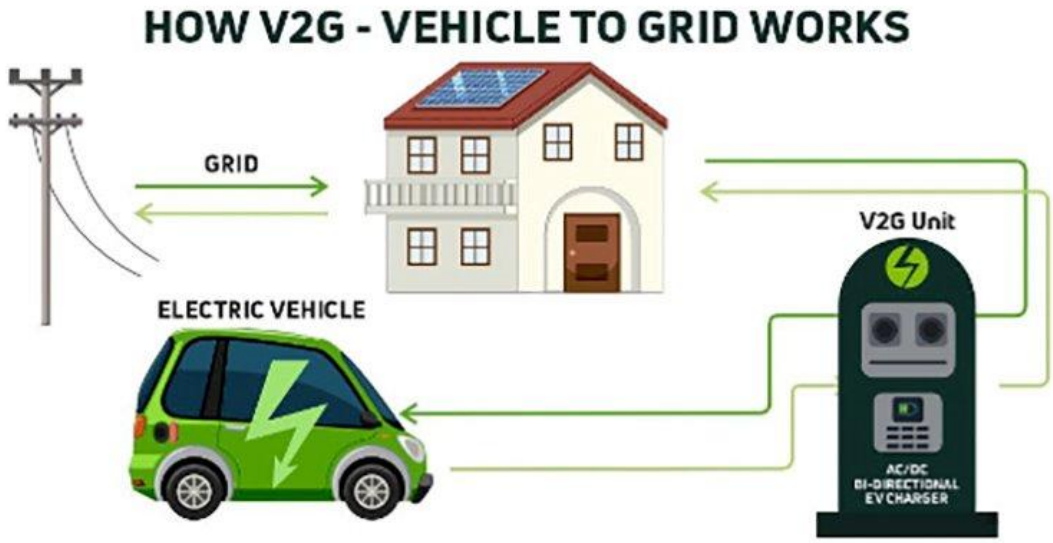
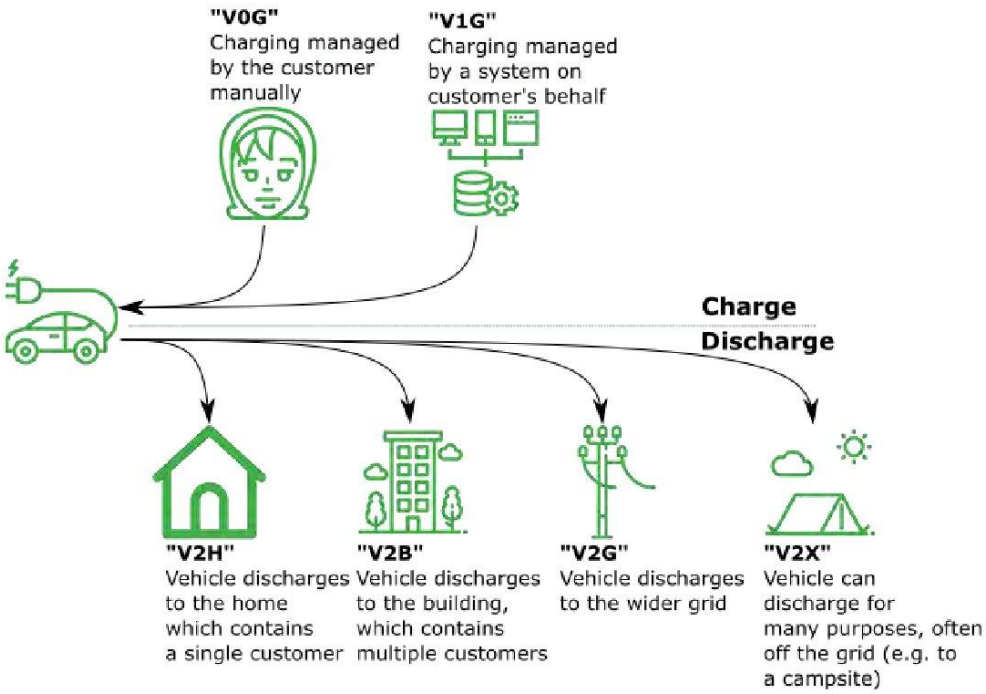


Session 2 explanation slides:





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Session 3 explanation slides:

Vehicle-to-Grid (V2G): What It Delivers

Purpose: Uses EV batteries to support the electricity system, beyond basic driving

Key uses:

- **Balance supply & demand**: Charge during excess renewables, discharge during shortages (daily use)
- **Support local networks:** Absorb solar peaks, reduce demand during extremes (a few days/year)
- **Emergency response:** Short-term support during outages or generator failures (rare)

System benefits: Less new generation, storage, and network investment needed

EV owner participation: Via dynamic prices, virtual power plants, or grid-connection requirements

Trade-off vs V2H/V2X: V2G shares battery control with the grid (usually for payment), while V2H/V2X stays owner-controlled

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A.5. Conducting focus groups and recording meetings

In May and June 2026, we conducted five focus groups via Microsoft Teams on ***4th of May, 5th of May, 7th of May, 26th of May, and 2nd of June***. Each focus group lasted approximately two hours. All sessions were recorded, and transcripts were subsequently generated from the recordings for analysis.

A.6. Transcript cleaning process

Following the focus groups, all transcripts were reviewed against the corresponding audio recording to verify accuracy and correct any transcription errors, and de-identified to remove any identifying information and transcription errors. All transcripts were de-identified by replacing participants' names with generic identifiers (e.g., Participant 1, Participant 2, Participant 3). Any personally identifiable information was removed, including details such as participants' place of residence, employer, and other information that could potentially reveal their identity.

A.7. Analysis

Several members of the research team independently conducted a read-through analysis of the transcripts and recorded their observations, reflections, and preliminary themes. We had two team members at a minimum go through each focus group transcript and we discussed emerging insights. As a triangulation technique (which is important in qualitative analysis) and to check for different perspectives and summaries of the emerging themes and insights, we ran the deidentified transcripts and research insights through AI software. Background information was provided to AI by us as part of asking it to identify themes and insights. As AI is based on large language models, this is an effective use of its processes.

Insights from individual analysis and from AI processes were then both then included in the report. AI assisted to ensure overarching, synthesised ("mega") themes included key points from across the dataset. The mix of human and AI-generated themes and insights were then subsequently reviewed, refined, and combined by the research team to produce the final thematic framework used.

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Appendix B Pre-focus group survey results

Most focus group participants were from Victoria (n = 13), with one participant each from New South Wales and Queensland, indicating that the sample was heavily concentrated in Victoria as shown in Figure B1.

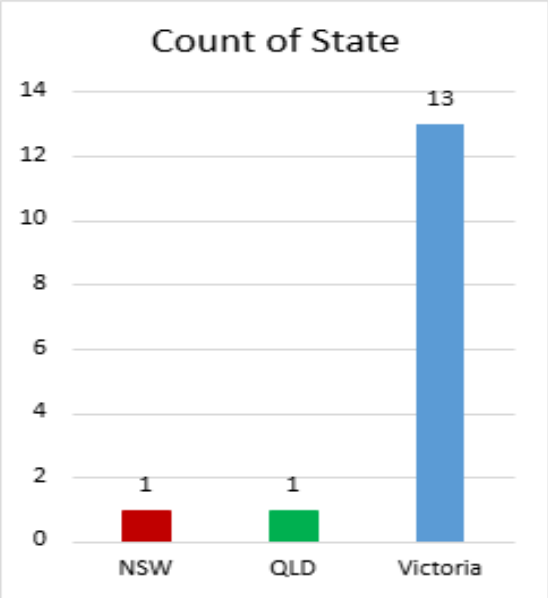

Figure B1. Count of state -focus group participants

Tesla vehicles, particularly the Model Y and Model 3, were the most common EVs reported by participants. Other vehicle brands included BYD, Hyundai, Kia, Audi, and Geely, demonstrating a diverse mix of EV ownership (Figure B2).

Figure B2. Car brands - focus group participants have/leased

As presented in Figure B3, Participants reported using EVs with battery capacities ranging from approximately 38 kWh to 100 kWh, reflecting a variety of vehicle types and performance characteristics.

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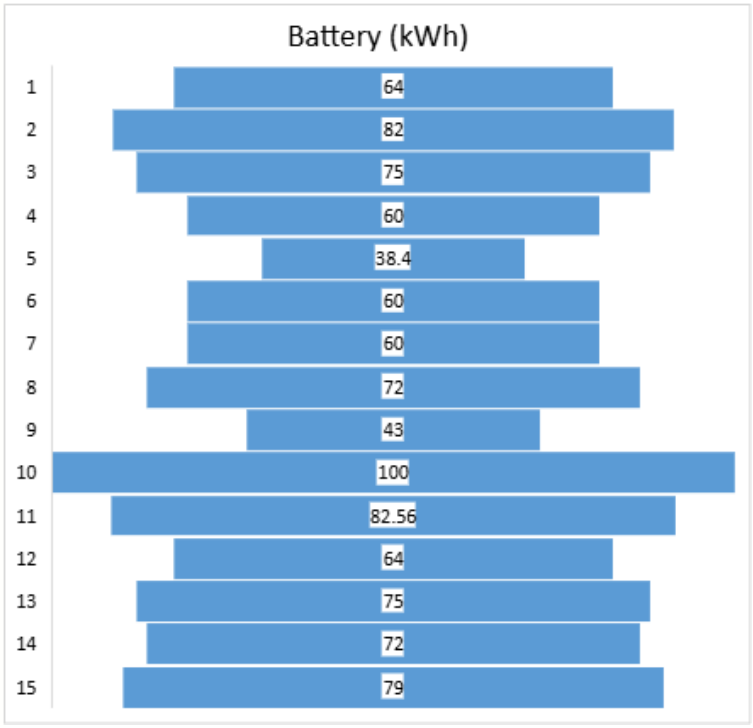

Figure B3. Battery capacity of cars- focus group participants using

The reported driving range of participants' vehicles varied between 250 km and 533 km, with most vehicles providing a range of around 400–500 km (Figure B4).

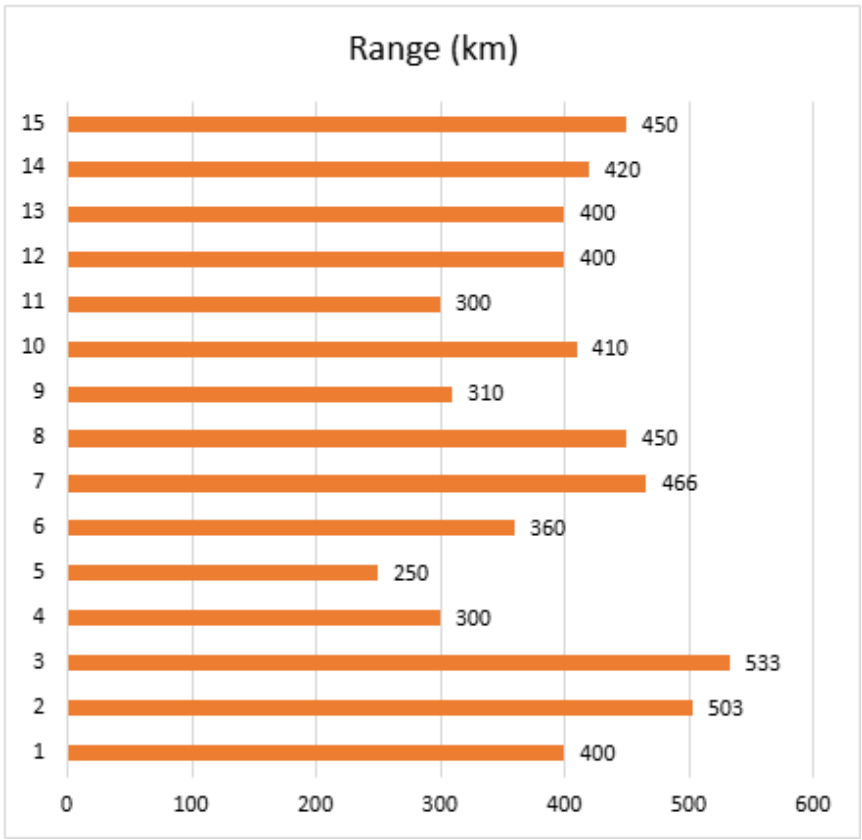

Figure B4. Vehicle range - focus group participants using

Most participants were vehicle owners (n = 11) as presented in Figure B5, while three participants were leaseholders and one participant was a regular user but not the owner of the vehicle.

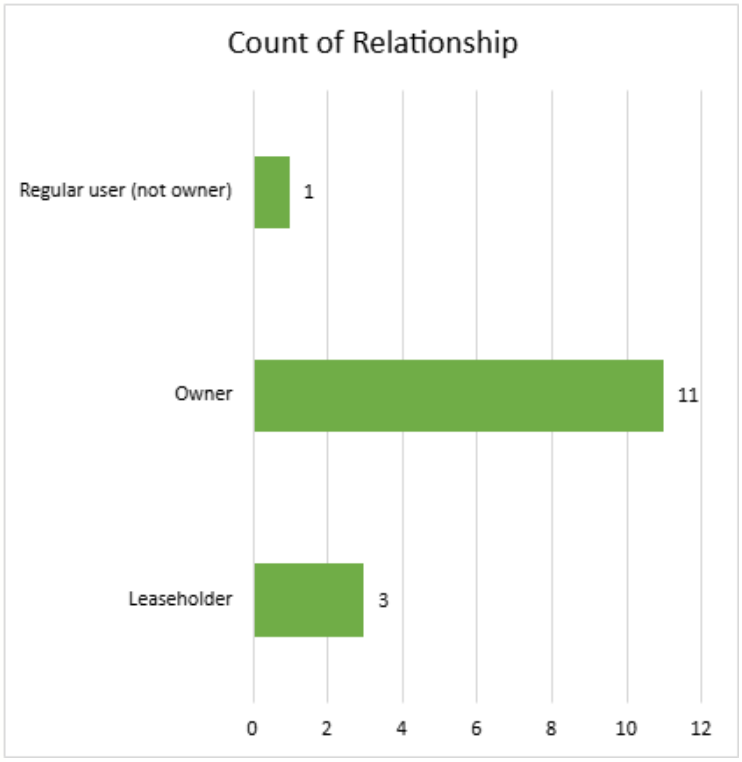

Figure B5. Relationship status with car – focus group participants

The majority of participants indicated they were quite familiar with Vehicle-to-Everything (V2X) technology (n = 12), while three participants had heard of V2X but reported limited knowledge of its details (Figure B6).

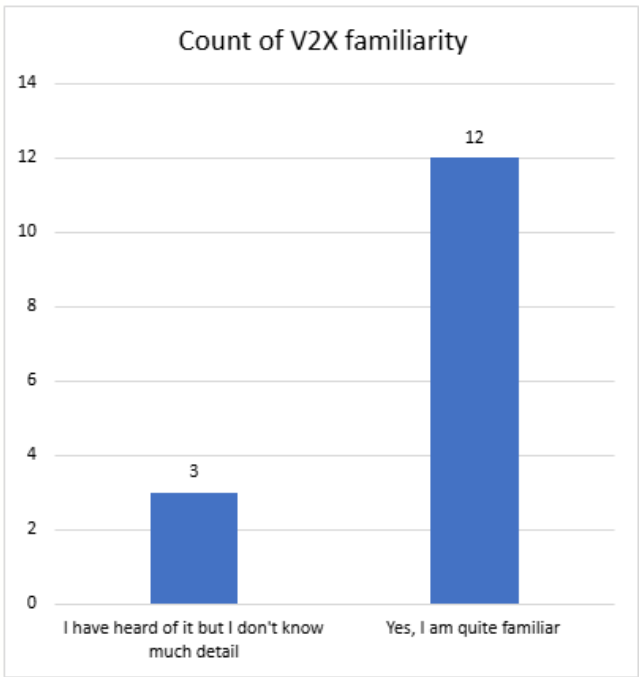

Figure B6. Count of V2X familiarity of focus group participants

Focus group participants answers for EV usage (summary):

EVs are primarily used as everyday vehicles, serving a wide range of purposes including commuting, school runs, errands, shopping, and transporting family members. Many respondents rely on their EV as the main household car, supporting both weekday work travel and regular local trips. Usage also extends to leisure activities such as weekend outings and occasional longer-distance travel, including interstate trips and holidays. While some users report irregular or lower-frequency driving, others use their EV daily, often benefiting from home charging—sometimes powered by rooftop solar—making EVs a flexible option for both routine travel and longer journeys.

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Appendix C Analytic notes

C.1. EV journey so far

Across the participants, four broad journey types were visible and are described here.

Family-car replacement, practically triggered (P3, P6, P8):

These participants replaced an ageing or now-too-small family vehicle, with the EV purchase decision folded into a car they needed to make anyway:

- P3 upgraded from a 12-year-old car (a Corolla) that had become too small after the arrival of a third child — but frames the EV choice itself as something they'd "always planned" as their next car, not a last-minute decision.
- P6 replaced an ageing hatchback once repair bills started mounting, with timing sharpened by a (temporary) concern that a novated lease tax benefit might be ending.
- P8 needed a family car that could fit a pram and car seats and chose the Ioniq 5 partly because it offered a notably larger battery than similarly priced alternatives at the time.

End-of-life vehicle replacement, swayed by the numbers (P4, P5):

Two participants describe a more deliberative, numbers-driven path to EV ownership after their previous vehicle reached the end of its useful life:

- P4 was initially shopping for internal combustion engine (ICE) options (Qashqai, Corolla) after a 20-year-old car died but switched after a solar app repeatedly showed that his household's excess solar export could cover his ~40,000km/year of driving.
- P5 replaced a 400,000km diesel car about five years ago, at a time when EVs were still notably more expensive than today — framing the decision as one step in a decades-long personal decarbonisation journey that began with installing solar panels in 1986 and included a period living off-grid.

Established multi-EV households integrating solar and home batteries (P2, P7, P11, P12):

- P2 got an EV in December 2025 via a novated lease, made more economical by government incentives, enabled in part by recently installed home solar.
- P7, P11, P12 (as previously summarised) all run EVs alongside home batteries and all-electric or largely electric households, with varying degrees of success and sophistication. E.g. the range includes P7's elaborate custom automation to P11's more troubled experience (a failed charger, losing money during time with a dynamic, market exposed retail offer).

Long-tenured enthusiasts and technical experts (P13, P14, P15):

These three participants have owned EVs the longest (5–13 years) and run the most sophisticated setups in the group, with journeys characterised by progressive technical escalation. This escalation includes P13's flat-rate-to-active-V2G arc; P14's decade-plus of enthusiasm before purchasing; and P15's evolution from a single 2013 Leaf to a six-vehicle fleet they use some of for a 'local host' style car hire business.

C.2. Motives for getting/using an EV

Across all participants, motives cluster into six recurring categories, usually appearing in combination rather than alone:

Cost/value: is the dominant motive across nearly all fifteen participants, whether framed as fuel-cost avoidance (P2, cites "recent fuel price pressures"), general cost savings versus petrol (P3, P4), or running-cost minimisation more broadly (P6, P8, P9, P10).

Environmental/climate motivation: Key for P2, P3, P4, and especially P5, whose primary motive is cited as environmental, alongside cost. This nuances the earlier finding that environmental motivation was "rarely the sole or primary motive", with P5 as a clear counter example, environmental motivation

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can be the primary driver for at least some participants, not merely a secondary rationale layered onto a cost-driven decision. (That there is a primary focus of some on environmental drivers aligns with broader understanding we have of household participant groups in CER and EV projects and programs.)

Practical/household fit: as a driver/motive was clearest for P3 who had a third child outgrowing the old car, and P8 who was needing to fit prams/car seats.

Financial incentive structures (novated leases, government incentives): were drivers for both P2 and P6, suggesting this policy lever was a meaningful factor in at least two of the fifteen journeys.

Independence/self-sufficiency and personal enthusiasm: were drivers as previously noted for P14 and P15.

Relational/household-harmony motivation: P7 remains the clearest example of this less common motivation category.

C.3. What it is like to own/use an EV: best and worst aspects

Best aspects:

Affordability of home "filling up" is stated as the best aspect by P3, echoing the cost theme raised elsewhere but framed around the charging experience itself feeling cheap and easy.

Overall driving experience improvements: P5 notes that beyond the environmental/cost rationale, EVs are simply "a better driving experience overall": less vibration, less noise, less pollution, better technology, and less servicing required. And a quiet, smooth driving experience was noted by P8.

Long-distance driving is easier than expected, thanks to route-planning technology both P3 and P5 describe successfully completing long regular road trips (Melbourne–Gold Coast for P3; Melbourne–Mount Gambier and Coffs Harbour for P5, despite a small-battery vehicle) and crediting built-in route-planning tools with removing much of the anticipated difficulty.

A supportive EV owner community: P3 highlights how willing other EV owners are to help each other, citing EV-focused Facebook groups as a valuable resource.

No more petrol stations / no fuel smell: raised independently by P8 and P15.

Low running cost / easy home charging: a near-universal positive (P6, P8, P9, P10, P13, P14, P15).

Enjoyment of automation/optimisation as a hobby: P7, P13, and P14 all describe enjoyment in building and refining their charging/energy systems, not just tolerating the effort.

Vehicle-to-load as backup power: P8, P12, and P15 report using V2L during outages or for practical backup purposes.

Worst aspects:

Charging app fragmentation is a widely shared frustration. P4 flags needing 8–10 different apps to use different charging networks and separately criticises poor maintenance within one charge network they have used. P5 echoes this almost exactly, listing six charging apps/networks he has to juggle, and notes more broadly that EV charging is dependent on internet/app infrastructure being available and working.

Regional/rural charging infrastructure gaps are a concern. P4 flags weak charging coverage along the Great Ocean Road, and minimal coverage past Sale/Bairnsdale heading toward NSW, which is a concrete, geographically specific infrastructure gap not raised elsewhere.

Range anxiety is an initial concern but resolves with experience. P2, P4, and P5 describe range anxiety as an early-ownership concern that either diminished significantly or disappeared with more driving experience. P4 states it "isn't a real issue in practice" once he'd adjusted, and P5 describes arriving at destinations "not stressed at all" despite planning long trips around a small-battery vehicle's limitations.

Minor day-to-day software quirks, distinct from major reliability failures, were issues for P3 who mentions occasional unnecessary lane-correction interventions on his EV as a minor, low-stakes annoyance.

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Early-adopter reliability issues: P8's EV ICCU had a charging-controller fault (that is well known) and took months to resolve; P15 similarly describes early "dumb" chargers and (relatively notable and inconveniencing) ongoing integration struggles.

Public charging friction and road-trip anxiety: P8 describes extra planning, stress, and uncertainty around public fast chargers; P10 flags the much higher cost of public charging relative to home charging (45c+/kWh vs. ~5c/kWh overnight at home).

Smart-charging/automation integration failures, even for expert users: P15's charger has never worked properly with their Home Assistant software, and he describes being up at 3am manually moving vehicles between chargers; P14 notes that one of his EVs lacks the API integration that his other EV has, forcing manual price-window management; and P13 finds some Home Assistant-based automation "time consuming and useless."

Multi-vehicle/multi-driver management complexity: P15's six-vehicle EV household is the clearest example of a complex EV and charging environment, and P14's two-EV household (with asymmetric charging capability between the two cars) reflects the same underlying issue at smaller scale.

Failed/unsupported hardware: P11's 'smarter' charger failed and wasn't covered under warranty, forcing a downgrade to a more basic charger; his dynamic, wholesale market exposed electricity plan/VPP trial also lost him money due to software bugs.

C.4. What participants have learned

Several participants offered reflections on lessons learned from EV ownership, which cluster into the themes below.

Range anxiety was originally a concern for many participants, but, notably, with time this **became less of a concern**. P4 states that a 5% charge on arriving home is "no concern" once you're used to it, and P5's willingness to regularly drive 650km trips in a small-battery car, arriving relaxed, makes the same point through demonstrated behaviour rather than just stated reflection.

Charging infrastructure fragmentation (apps, network reliability, regional coverage) **is a bigger practical friction point** than the vehicles themselves. P4 and P5's near-identical complaints about juggling multiple charging apps, combined with P4's specific regional coverage gaps, suggest that from the user's perspective, the software/infrastructure layer of the charging ecosystem (not the car) is where meaningful improvement is still needed.

The **EV owner community is** a **valuable, informal support resource**, as is seen in P3's experience with EV Facebook groups, their communication/advice is a softer, social-infrastructure that is distinct from the more technical influences elsewhere in the dataset.

Charging mindset shifts from "petrol thinking" to "phone thinking." P6 describes this transition as moving from range-anxious, empty-tank charging to relaxed, frequent top-ups — once he learned his vehicle's battery chemistry wasn't at risk from this pattern.

Full automation in charging is not yet fully reliable, even for highly capable users. P15 notes that despite a home built around automation and APIs, "there's still a surprising amount of manual intervention required." P14 echoes this, describing his experience as needing either full automation or manual management. A partial, semi-automated middle ground doesn't really work well in practice.

Being an early adopter carries a risk, but the technology matures over time. P8 frames his integrated charging control unit (ICCU) fault as a cost of being an early adopter, noting manufacturers have since fixed the issue in later models. P13 frames his own journey as evidence that the broader technology and market are "maturing", from requiring expert-level tinkering to increasingly offering simple, "just works" solutions for mainstream users.

Older EV batteries retain value even once driving performance declines. P15 notes his old, removed Nissan Leaf battery packs, now down to ~55% state of health, still have plenty of useful life left as stationary home storage.

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Appendix D ARC EV uptake project Melbourne results

This background information is from an ARC linkage project which included a recent survey of residents in major Australian cities including Melbourne. This section describes the results for Melbourne. This survey was completed at the end of 2025.

Questions 1-10 – awareness and attitudes

Table D1. Q1-10: Survey results of questions related to awareness of and attitudes towards EVs and charging infrastructure- MELBOURNE

Q1 - How familiar are you with electric vehicles (EVs) mentioned above?	**Very familiar**	**Somewhat familiar**	**Not very familiar**	**Don't know anything about them**	**I only just heard about them through this survey**
	23%	54%	21%	2%	0%
Q2 - Do you currently own or lease an EV?	**Yes**	**No, but I have owned/leased one in the past**	**No, but I have driven an EV before**	**No**	
	10%	3%	6%	80%	
Q3: If you were to buy a car today, how likely is it that you would choose an electric vehicle (EV)?	**Very likely**	**Somewhat likely**	**Neutral / Not sure**	**Somewhat unlikely**	**Very unlikely**
	18%	32%	22%	10%	18%
Q4: If you had an EV today, could you charge an EV at/near your home?	**Yes, already charging or could charge with an accessible power point in the garage/near where the car is parked at home**	**Yes, I could charge at other accessible public charging stations such as malls etc**	**Yes, I could charge at a street charging station close by**	**No, I could not**	**I don't know**
	30%	18%	19%	19%	14%
Q5 - What is your overall opinion of EVs?	**Very positive**	**Somewhat positive**	**Neutral**	**Somewhat negative**	**Very negative**
	16%	34%	27%	14%	9%
Q6. Which of the following best describes your perception of EVs?	**Environmentally friendly (Yes/No)**	**Expensive (Yes/No)**	**Reliable (Yes/No)**	**Inconvenient to charge (Yes/No)**	**Innovative (Yes/No)**
	49%/51%	61%/39%	21%/79%	42%/58%	33%/67%

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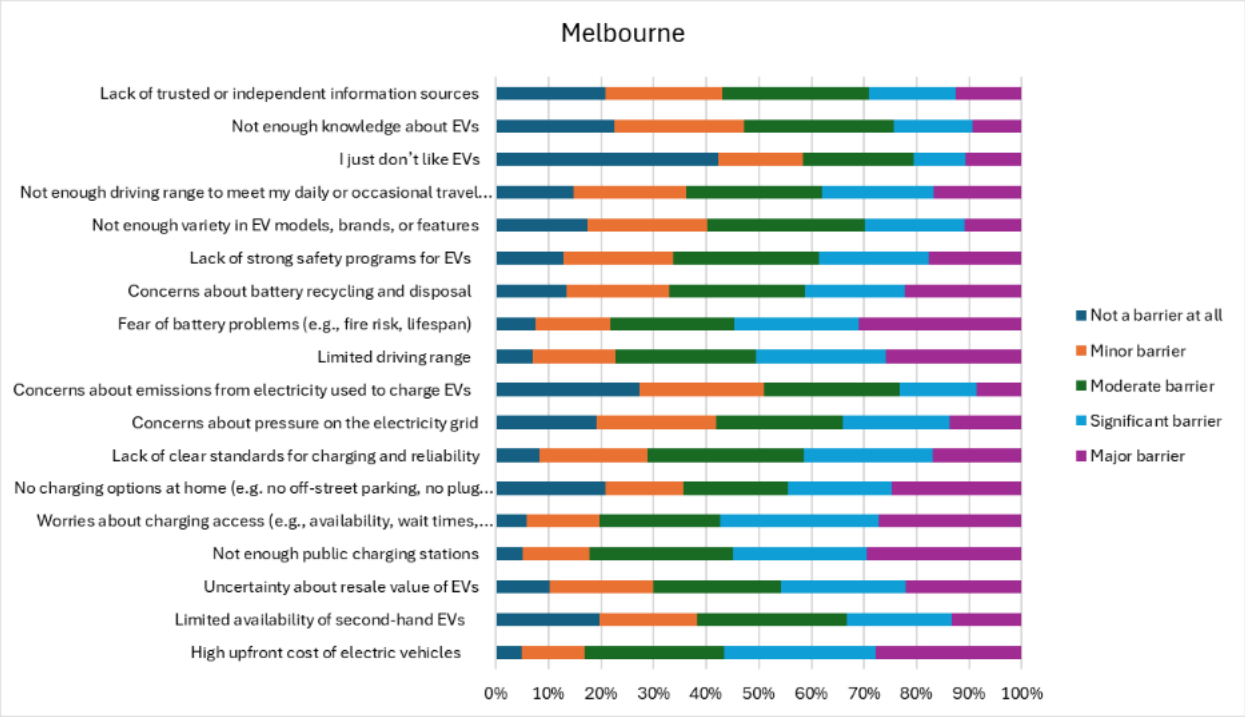
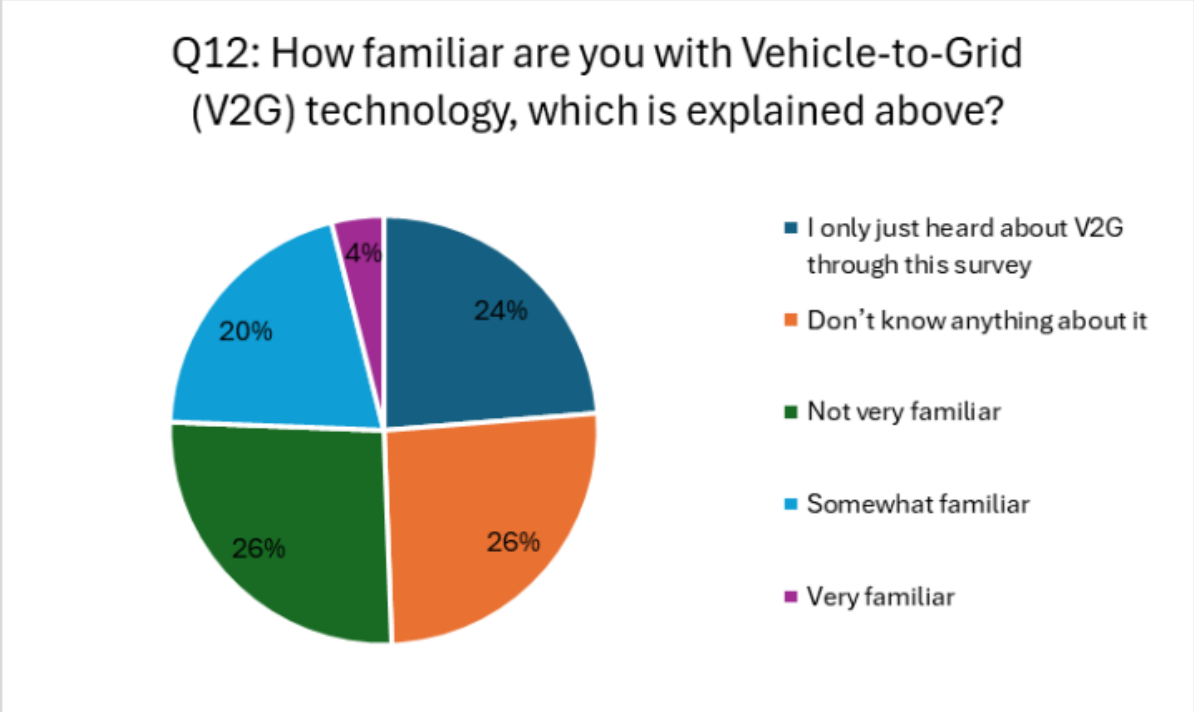
Q7 - How likely are you to purchase an EV in the next 5 years?	**I already have an EV**	**Very likely**	**Somewhat likely**	**Not sure**	**Unlikely**
	5%	19%	25%	21%	13%
Q8 - What is the maximum upfront cost you would be willing to pay for a new electric vehicle (EV), assuming it meets your needs for range, charging, and features?	**I would not consider purchasing an EV regardless of cost**	**I can't afford any EV regardless of cost**	**Under $10,000**	**$10,000-$39,000**	**$40,000-$69,000**
	11%	10%	3%	31%	39%
Q9. If you were to purchase a new vehicle today, how strongly would you consider an EV?	**Definitely**	**Strongly**	**Moderately**	**Slightly**	**Not at all**
	10%	20%	25%	22%	23%
Q10. What would most influence your decision to buy an EV?	**Government incentives (Yes/No)**	**Lower running costs (Yes/No)**	**Environmental impact (Yes/No)**	**Peer influence (Yes/No)**	**Improved technology (range) (Yes/No)**
	49%/51%	67%/33%	38%/62%	5%/95%	48%/52%

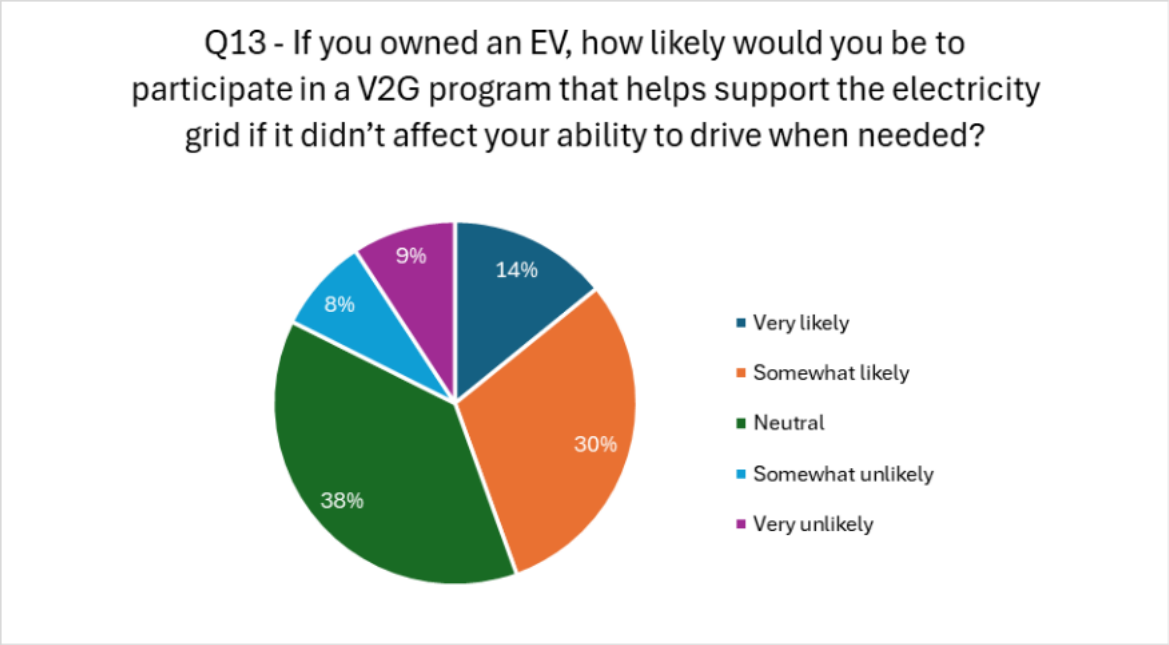
Question 11 results related to drivers and barriers



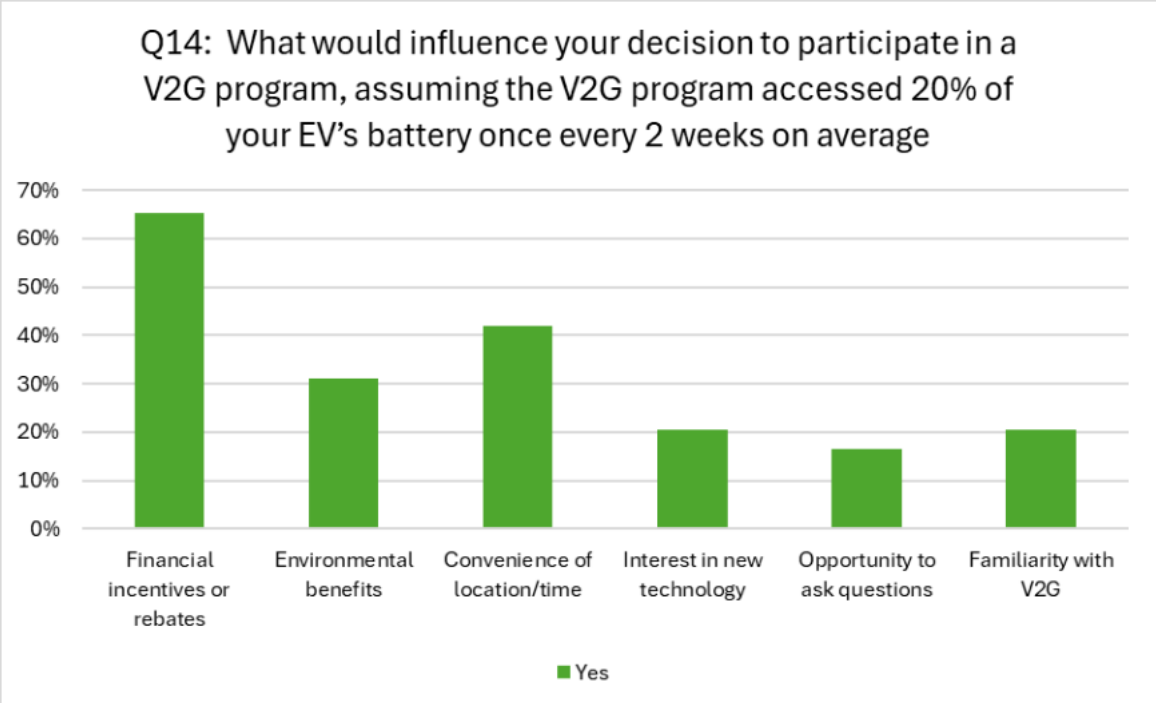
Question 12 results related to V2G familiarity



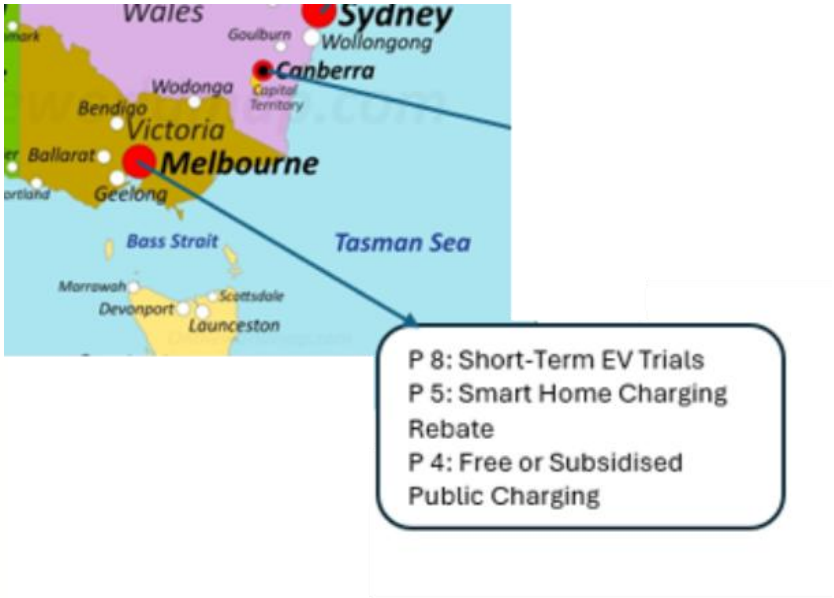
Question 13 results related to V2G program participation



Question 14 results related to factors to influence decision to participate in a V2G program



Questions 16-25 – results related to ranking EV related policy



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