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# Strategic Integration Of Electric Vehicles: An Australian Analysis

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**Abstract**

This paper presents the challenges and opportunities of strategic electric vehicle (EV) grid integration with a particular focus on its status and outlook in Australia. EVs are a critical part of many countries net zero commitments because electrification is a key piece in the puzzle to decarbonise the transport sector. Approaches are needed to ensure EVs and their charging practices can be incorporated within the electricity grid cost-effectively, while increasing system reliability and stability, supporting transport decarbonisation, and ensuring other societal benefits. Australia is a large country with a relatively small population which poses challenges for both EV charging and electricity distribution infrastructure provision. However, other market characteristics (such as high solar PV adoption among households) and the rapidly decarbonising grid make Australia an useful case study. Especially for how challenges over range, grid integration, and lack of domestic EV production is leading to new innovations that could inform steps towards more rapid EV adoption in other jurisdictions. This paper will discuss the challenges and opportunities of electric vehicle (EV) uptake in Australia based on a national consultation and workshop series involving stakeholders from the energy and transport sectors.



*Keywords:* Electric vehicles; Grid integration; Sustainable transport; Australia; Case study.

## 1. Introduction

With a high reliance on fossil fuels, transport is responsible for 37% of carbon dioxide emissions globally (International Energy Agency, 2022). Transport plays a critical role in helping society function, from the transportation of goods and services to aiding the pursuit of leisure, education, and work activities. However, with a high reliance

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on fossil fuels it is responsible for 37% of carbon dioxide emissions. Electrifying the sector is therefore a key piece in the puzzle to decarbonise this part of the global economy and reduce our reliance on fossil fuels.

Transport is Australia's second largest source of carbon emissions (19%) with over half of these emissions from passenger vehicles and steady increases until the start of the COVID pandemic (Australian Government, 2022). As a large country with a relatively small population concentrated in coastal cities, Australia faces both generic and specific challenges to EV adoption and grid integration posed by its geography, population, and demographics. Despite the challenges, EV adoption and public charging deployment has been growing in Australia but it has been lagging behind other countries similar in terms of population, economy, or standard of living (Dwyer et al., 2021). Sales of EVs in Australia increased 65% in 2022 on the previous year, but still only represents 3% of all vehicle sales (Electric Vehicle Council, 2022).

To integrate EVs effectively means developing approaches to ensure EVs and their charging practices can be incorporated within the electricity grid cost-effectively, while increasing system reliability and stability, supporting transport decarbonisation, and ensuring other societal benefits. The integration of EVs with Australia's extensive but ageing electricity network poses major challenges for decarbonising transport, while the highest high levels of solar PV adoption in the world and the rapidly decarbonising grid presents opportunities. This makes Australia a useful case study for how challenges over range, grid integration, and lack of domestic EV production is leading to new innovations that could inform steps towards more rapid EV adoption in other jurisdictions. This analysis can lead to informative lessons for the delivery of more resilient national transport and energy systems (Hargroves and James, 2021).

## 2. Methodology

There were four main stages that comprised the methodology for exploring the strategic integration of EVs, as shown in Figure 1. This approach would ensure the focus on the growing Australian uptake of renewable energy and electrified transport provides unique opportunities for mutually beneficial strategies.


Figure 1: Approach to assessing Australian status of strategic EV integration

The aim of the literature review was to understand the current state of Vehicle to Grid ('V2G') and Managed Charging ('MC') nationally and internationally, while assessing the factors that would affect its adoption. The review on V2G and MC covered academic and grey literature sources and was narrowed to those publications since 2010. The results were organised under the following three main themes and ten sub themes:

1. Costs and Benefits, Regulations and Policy
    a. The costs and benefits of different types of V2G and MC
    b. V2G and MC costs, benefits, and value streams
    c. V2G and MC regulatory and policy aspects
2. Technical Challenges and Standards
    a. V2G and MC implementation
    b. Degradation of EV battery lifetime
    c. Energy losses and infrastructure upgrades
    d. V2G and MC services for grid support
    e. EV related standards and grid codes
3. Practice Review
    a. Australian V2G and MC trials and research
    b. International V2G and MC trials and research

The aim of the National Consultation was to engage key stakeholders to better understand the issues affecting V2G and MC adoption and its impact on the electricity grid. It would also help inform the development and design of a future V2G and MC demonstration project that would be implemented in the Australian context.

This phase of the research involved convening a Steering Group and Industry Reference Group (IRG) to provide feedback and guidance during the project. Members of this group were drawn from the energy, transport, and EV sectors. Relevant industry associations and government representatives were also invited to join.

An initial assessment of key stakeholder groups was developed using stakeholder mapping. This was undertaken to target engagement at those who could help inform the research and be interested to participate in later stages. Table 1 describes the identified stakeholder groups.

Table 1: Stakeholder group descriptions

| Stakeholder group | Description |
|---|---|
| Host | Provides the site, hosts the charge points, captures some/all of the revenue. |
| Electricity Network Service Provider | Responsible for distribution or transmission of electricity. |
| Energy Retailer | Retails energy but may also offer EV and/or charging bundles. |
| Charge Point Operator | Manages charge point installation, operation, maintenance etc. |
| Electric Vehicle Supply Equipment (manufacturer) | Manufactures charging equipment |
| EVSE vendor | Specify, sell, supply, arrange installation of charging equipment |
| Auto OEM | Manufacturers and sells EV auto vehicles |
| Software/platform provider | Software and platforms for managing access, payments, fleet, etc. |
| Markets and Regulation | Other types of national/NEM body responsible for markets or regulations relevant for EVs |
| State Government | State governments with targets/obligations for transport decarbonisation |
| Local Government | Number of councils and their joint/regional organisations seeking to lead on EVs / obligations for transport decarbonisation |
| Peak body | Represents industry on topics relevant for EVs. |
| Research | Undertaking research on V2G and MC |

Consulting with these key stakeholders enabled the researchers to identify the most important aspects that are needed for building confidence in V2G and MC. This consultation involved seventeen semi-structured interviews with individuals drawn from these groups. A number of these had been involved in current and past EV grid integration trials in Australia, which also assisted with identifying future research priorities for future trials.

A series of workshops were also held and was attended by participants selected from the stakeholder groups. These workshops sought to present and validate emerging findings from the literature review and the development of key research questions that would be tested in a future demonstration project. The interactive workshops were held online due to the attendees being drawn from different states across Australia and COVID-19 restrictions at the time.

The analysis phase involved coding of the findings from the literature review and applying to the workshop outputs. In addition, research questions for a demonstration project were also defined and refined as part of this phase.

## 3. Results and Discussion

The results of the literature review, national consultation, and workshop series found the following challenges facing EV integration:

1. Policy, regulations, and standards that aren't fit for purpose.
2. Ambiguous costs and benefits.
3. Uncertainty of consumer attitudes, behaviour, and acceptance of different charging practices.

4. Technical challenges that included visibility on the distribution grid, network congestion from increased peak demand, balancing supply and demand, voltage & frequency issues, EV battery degradation, and cybersecurity.

However, these challenges were found to be balanced by the following opportunities:
1. Reduced emissions by supporting higher levels of renewable energy on the grid.
2. Multiple values streams can be unlocked.
3. Reduced costs for EV users, energy consumers, fleet operators, and network businesses.
4. Mitigated electricity network issues from additional load and increasing renewable capacity.

Analyses of the Australian case can lead to informative lessons for the delivery of more resilient future national transport and energy systems.

## 4. Conclusion

The literature review, interviews, and workshops revealed seven key conclusions.

Firstly, there has been an over focus in trials on early user groups i.e. early adopters are likely to behave differently from the majority of users. Due to the early-stage nature of the EV market in Australia, most trials have included participants with a higher propensity for risk and whom have a greater attraction to newer, more expensive technology products or services. This is difficult to avoid but future trials will inevitably see more mass-market customers become participants as the EV market grows and prices fall. However, further consideration should be given to how the views of these customers - who are critical for understanding how EV grid integration will work at scale – can be elicited in the short term. Fleet vehicle users who wouldn't be ready to buy an EV but might need to use one available in the depot could be a good proxy for better understanding customer attitudes for the mass market.

Secondly, there was found to be a need for projects that can unlock scalability/replicability. Focussing on small customer niches could be seen as leading to research findings with limited applicability at scale, or with limited potential for replication. However, some specific customer groups may be small but with promise to lead to lessons that can unlock other, larger segments of the market. This bootstrapping approach could be successful, but a deep understanding of the market trends and customer behaviour and attitudes will be needed.

Thirdly, the immaturity of V2G brings risks to trials for bidirectional charging (V2H, V2B) but this could be worth exploring if the risks can be managed. The ActewAGL and AGL trials both sought to prove the ability for EVs to generate revenue from providing grid services. However, they faced operational, regulatory, and supply chain issues that demonstrated the challenges of V2G in a market that isn't ready for it yet. With many unanswered questions for integrating EVs in the grid through managed charging approaches, exploring V2G in a trial in the short term (next 2-3 years) is likely to yield limited benefits given the risks. However, there could be a case for exploring Vehicle-to-Home/Vehicle-to-Building if the risks around the regulations, standards, and supply chains can be managed. Further V2G trials in Australia will be needed but these must involve the CCS charging standards and cannot be expected until post-2025/2026 following the necessary certification and approvals.

Another conclusion was that an approach was needed that integrates the behavioural aspects and price signals, along with energy system and network impacts. Despite the previous EV grid integration trials and some promising early results, there is still further research needed to generate more data on how EV users respond to price signals and tariff structures to shape their charging behaviour, and the resultant impacts on the network and energy system.
Additionally, the benefits and costs to customers/businesses still need to be understood for specific use cases. Past trials have investigated the costs and benefits for those in the EV and grid value chain but there is still limited understanding of this for a wide variety of customer use cases and contexts. How different business models can re-distribute the risks and drive benefits for consumers, businesses, communities, and the grid still requires a deeper understanding.

A fifth conclusion was that there is a need to look to leverage existing projects or capital works/asset investment in order to accelerate the path to replicability and scalability. Accelerating the pathway to scale will require a strategic selection of customer use cases to explore. Choosing project partners who are already progressed with integrating EVs in their homes, businesses, depots, government jurisdictions, and grids can accelerate the rate at which trials can be deployed and scale can be achieved.

The sixth finding was that bidirectional charging is still at a very early stage in Australia. The only vehicles

currently available in Australia that can support it are the Nissan Leaf BEV and Mitsubishi's Outlander and Eclipse Cross PHEV, which use the CHAdeMO charging standard. However, the majority of EVs sold in Australia and globally use the Combined Charging System (CCS) standard, which does not currently support bidirectional charging (and isn't expected to until 2025/2026). To data there has only been one trial testing V2G in Australia, the ActewAGL Realising Electric Vehicles-to-grid Services (REVS) project, funded by ARENA (2020-2023). Using 51 Nissan Leafs connected to bidirectional chargers, the project sought to demonstrate the ability to deliver ancillary services to the grid using EVs while paving the way for increased adoption of V2G. The project is still finalising at the time of writing but its goal to deliver revenue from FCAS at fleet scale has proved elusive. However, it has been crucial in understanding the realities of implementing V2G in the current market, while building capacity and fostering collaboration along the EV and electricity value chain.

Finally, other EV trials undertaken in Australia over the last decade have mostly been led by energy utilities (network businesses or energy retailers) and have been narrowly focussed on consumer experience and grid integration through Time-of-Use Tariffs and managed charging. V2G trials have began in earnest (with one project completed and one due to start) but this type of trial likely to see a pause until the CCS-2 (Combined Charging Standard) is implemented from 2025/2026 at the earliest.

In summary, despite the many challenges are posed by the complex interactions at the convergence of the transport and energy systems, the many opportunities of V2G and MC will lead to continued interest in strategically integrating EVs from researchers, industry, government, EV owners, and the general public.

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