EV Owner Demographics and Behaviours

Results of EVenergi's relevant surveys

Prepared by Evenergi

OCTOBER 2023

Table of contents

Glossary

Table 1: Glossary of terms	
AMI	Advanced metering infrastructure
BEV	Battery electric vehicle
DER	Distributed energy resources
DMIRS	Department of Mines, Industry Regulation and Safety
DNSP	Distribution network service provider
DOE	Dynamic operating envelope
EPWA	Energy Policy WA
EV	Electric vehicle
HEMS	Home energy management system
NEM	National electricity market
OCPP	Open charge point protocol
PHEV	Plug-in hybrid electric vehicle
PV	Photovoltaic (as it relates to solar panels)
TOU	Time of use tariffs
V2G	Vehicle-to-grid
VPP	Virtual power plant
WA	Western Australia
WEM	Wholesale electricity market

1 Overview of trends in EV ownership

The focus of this paper is on two studies conducted by EVenergi providing insights into the demographics and charging behaviours of EV owners and potential owners:

1. A survey of 1,253 Western Australians including 461 EV owners and 792 potential owners, between 6 May 2023 and 6 June 2023 - selected for its currency on demographics and opinions;

2. A survey of 129 EV owners within the Ausgrid area conducted in November 2019 and February 2020 - selected for its alignment with Ausgrid's actual customer base.

EVenergi has also reviewed over 100 Australian and international studies on EV ownership trends and charging behaviours, some of which are also referred to in our commentary.

Key Findings

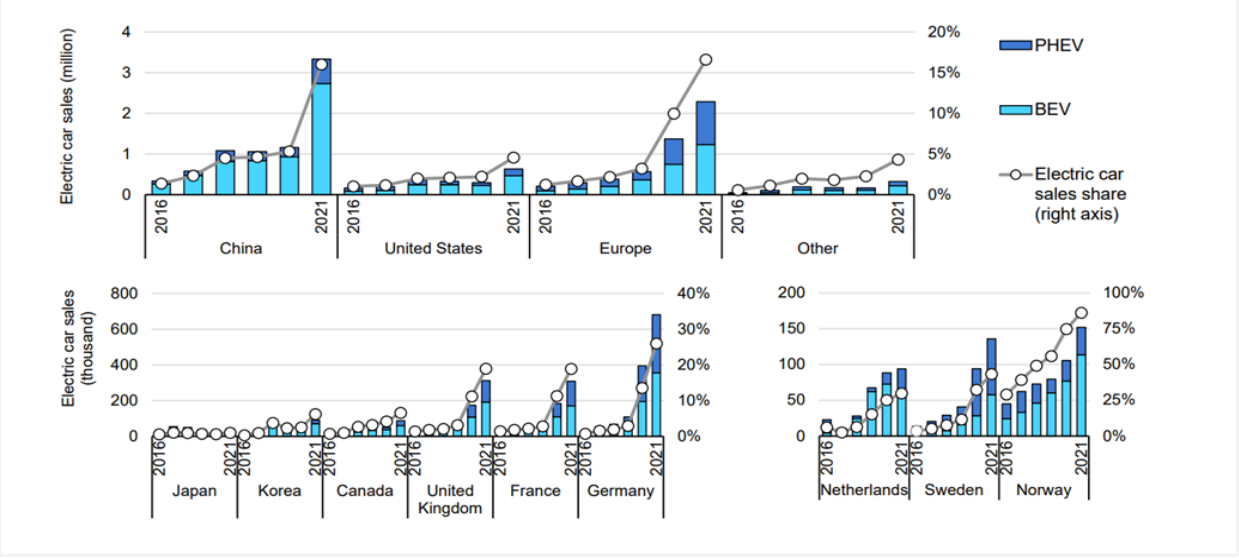
- EV owners in Australia generally fit the early adopter profile that has been seen globally - they are predominantly male, 45-54 years of age, living in houses, full-time or retired, and have a high household income.
- Australian EV owners, like other global EV owners, overwhelmingly reported that they charge at home (70-85%), with some charging at public charging stations (10-20%), and the remaining respondents charging at their workplace (6-10%).
- Australian EV owners have a relatively high adoption of dedicated Level 2 chargers (55%) versus a basic cable charger (41%) compared to other global studies, the likelihood of which increases with income levels.
- Australian EV owners have a relatively high proportion (40-55%) that focus their charging during the day, which is strongly linked to solar PV ownership. The remainder of charging was predominantly done overnight with only a relatively small proportion of charging completed during the peak grid period.
- Time of use (TOU) tariff users are more likely to charge outside peak periods compared to those under a flat rate.

2 Global and Australian EV behaviours

2.1 EV uptake and early adopters

The global electric car stock has been increasing rapidly over the past 10 years. There were over 26 million electric cars in 2022, compared to just 10 million in 2020 [7]. The rate of EV adoption across each country radically differs, as shown in Figure 1. Norway has long been the world leader in EV uptake. In 2022, 79.3% of all new passenger vehicles sold were EVs, according to the Norwegian Road Federation [8]. Other large EV markets include Germany, China, and the United States (particularly California).

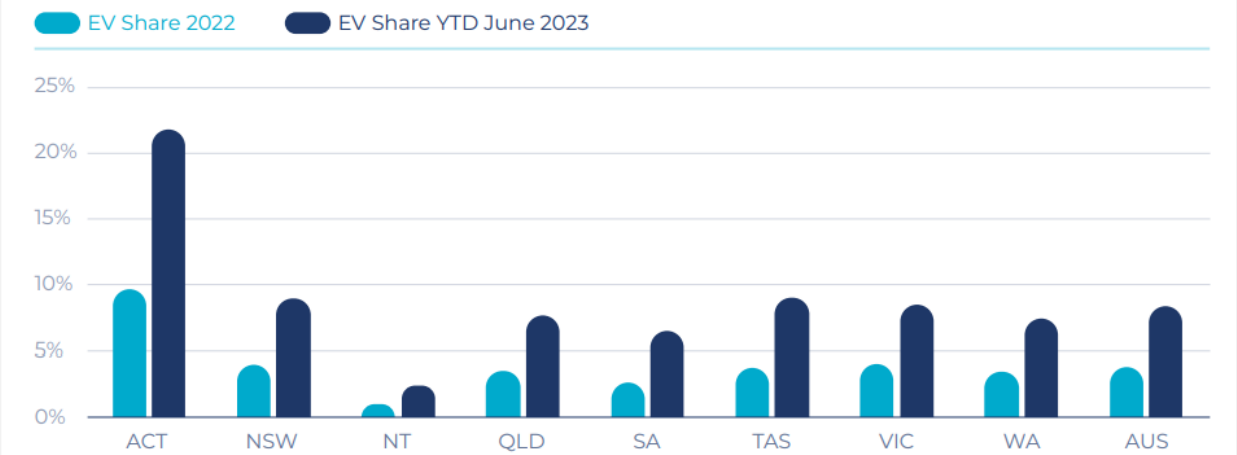
Figure 1: Electric car registrations and sales share of the largest EV markets *(Source:* [9]*)*



Australia has had a low adoption rate compared to these countries at 3.8% of new vehicle sales in 2022 [10], as shown in Figure 2.

Australian EV uptake is, however, growing rapidly, already lifting to 8% of new sales in April 2023 [11]. With the recent introduction of state and federal EV targets and plans like the National EV Strategy [12], the State Electric Vehicle plans, and the ongoing consultation on national fuel efficiency standards [13], EV manufacturers are expected to have more certainty and therefore bring more EV models to Australia, further increasing uptake.

Figure 2: New EV sales share in Australia by state as at July 2023 *(Source:* [10]*)*



Despite the rapid uptake of EVs, they still account for a relatively small proportion of the overall vehicle market. Consequently, the bulk of research conducted on EV behaviours primarily represents the patterns and practices of early adopters or owners belonging to the early majority.

Early adopters are defined as the first consumers of new technologies, and they typically have distinct demographics and motivations for using the new technology compared to the general population. Globally EV early adopters tend to be predominantly highly educated, affluent, male, and often retired [14]. A similar demographic trend can be observed in studies of current EV owners in Australia [15]–[17], implying that the Australian research predominantly captures the behaviours of early adopters, rather than the broader population.

This demographic concentration highlights a crucial point to consider how the trends and demographics captured in this report will change over time as EVs spread into the mainstream population

---

Current EV owners in Australia are early adopters and therefore any user behaviour trends may change as EV technology reaches the mainstream.

2.2 Charging locations for private vehicles

Across many mature markets, EV owners charge predominantly at home [18], [19] with the rest charging at the workplace, destinations, and public fast chargers. This is true of European studies. In Norway, 95% of charging sessions are completed at home [18], in Austria, 88% [19] as well as the US (55%) [19], while China had 38% of charging sessions completed at home, followed by 31% at work [19].

Studies in Australia support this finding. A Queensland survey of EV owners in 2021 (n = 104) found that almost 60% charge at home at least 3 times a week, with 85% of the participants using public chargers 'at least occasionally', and 91% able to charge their cars at work [17]. Similarly, 80% of Australian EV owners in a 2022 study (n = 741) reported charging at home at least twice per week [20] (drivers were mainly from New South Wales, Victoria, and Queensland). From the literature, it is currently unclear whether WA EV drivers will also predominantly charge at home as there has been insufficient research carried out, but it seems likely that they will follow Australian trends.

Australian and global drivers will prioritise charging at home when possible.

2.3 Residential charging infrastructure

EV owners have access to two main options to charge their vehicle at home:

1. Level 1 charging: where the EV is plugged into a portable charger via a standard residential wall plug
2. Level 2 charging: where the EV uses a fixed EV charger that requires dedicated wiring and must be installed by a licensed electrician.

Level 1 charging is the lowest cost option as no additional charging infrastructure is required. Because of this, however, it can only offer slow charge rates around 2.4 kW if using single phase power, which would take circa 27 hours to fully charge a modern passenger EV with a 65kWh battery. This leaves no room for managing the charging time to avoid grid peaks or to take advantage of spikes in renewable energy supply.

Some owners therefore opt for installing dedicated Level 2 charging infrastructure at their residence that provides faster charge rates (between 7 kW single phase, up to 22kW if they use 3-phase power) which can fully charge a modern passenger EV in the overnight off-peak window. The charger is sometimes bundled in the purchase price of the EV but is more often an additional cost between $2,000 - $3,500 including installation.

Many, but not all, of the Level 2 chargers are considered 'smart' as they can visualise EV energy consumption, support charge scheduling, and take remote instructions via the open charge point protocol (OCPP). This allows the vehicle's charging to be managed in both the short term by the scheduling feature in a 'set and forget' fashion, controlled by the EV owner, and in the long term remotely by an aggregator via the OCPP to dynamically adapt charging to the availability of cheap power and the needs of the grid.

This allows the EV owner to participate in third party applications like home energy management solutions (HEMS) in the future, where the charging of the EV is done in alignment with total household loads and generation. HEMS devices are expected to become increasingly more prevalent in residential settings as loads become smarter.

This makes encouraging adoption of a Level 2 charger by a high proportion of EV owners an important point for the network managers and governments to consider when thinking about what it could do to enable smart charging behaviours.

Residential/destination Level 2 EV chargers with smart charging capabilities are essential to enable charging which supports a high renewable energy system.

The proportion of EV owners who install dedicated Level 2 chargers varies globally between 40-80%, even in studies with high proportions of home ownership. A Norwegian survey conducted in 2016 (n = 8,000) found that only 37% of private home chargers were dedicated Level 2 chargers [18], while in the 2022 EV Smart Chargepoint Survey in the UK (n = 1,000) [21], the majority of BEV drivers (66%) primarily used a dedicated charge point at home, arguably due to the UK's Office of Zero Emission Vehicles (OZEV) smart charger grant scheme which will be discussed in Section 2.6.2. This seems to be consistent with Australian studies. A survey of 104 EV drivers in 2021 found that 61% of the sample had Level 2 chargers installed [17]. As 87% of the drivers resided in their own dwellings and therefore had the opportunity to install chargers, it is clear there is a subset of the population who are not sufficiently incentivised to purchase a dedicated Level 2 charger.

The additional cost to install a Level 2 charger may be a prohibitive factor for future EV owners. In the previously mentioned 2022 UK study, 44% of the BEV and PHEV owners who did not have a dedicated chargepoint at home (n = 287) listed the price of the charger as a prohibitive factor [21]. Additionally, of the EV owners with a Level 2 charger, many received it for free when they purchased the vehicle (31%) or participated in the government grant scheme to purchase it (75%).

Without incentives, it's unclear whether future EV owners will opt for Level 1 or Level 2 chargers once the mainstream population starts purchasing EVs.

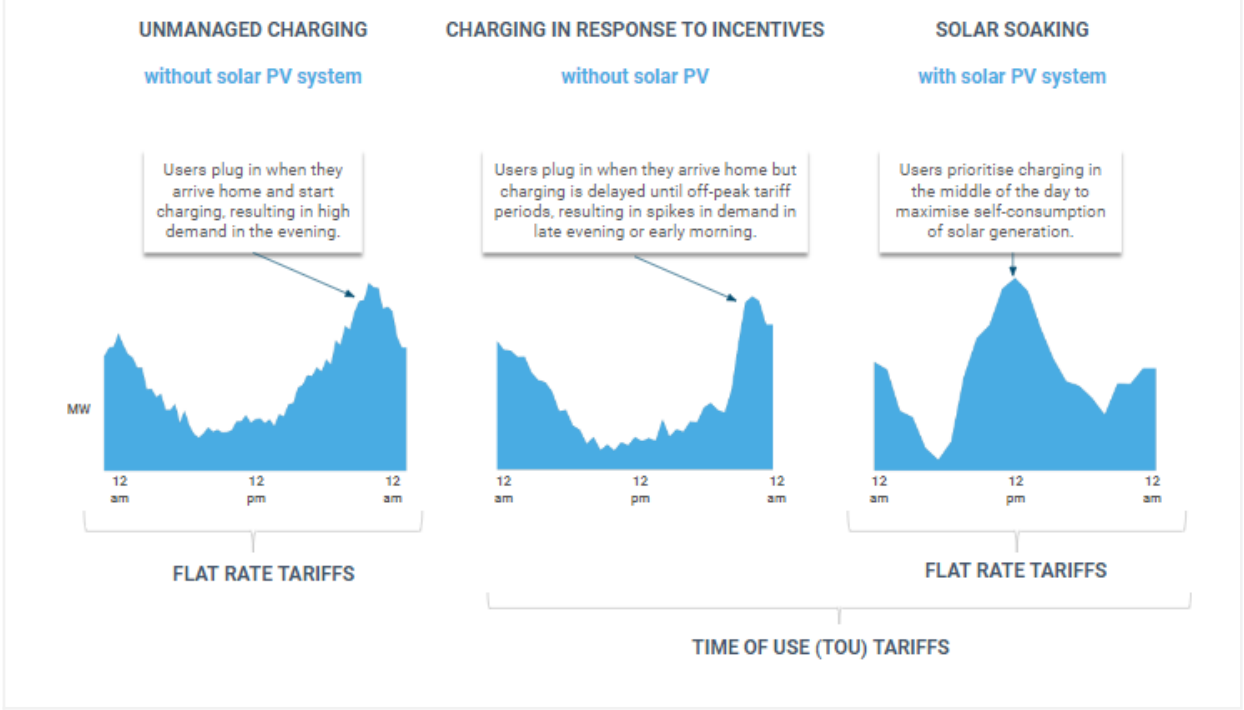
2.4 Charging profiles

There has long been a concern that electric vehicles will exacerbate existing peak demand periods in the evening once EV ownership becomes common place. Three daily charging behaviours have emerged in the literature:

1) Unmanaged charging, where EV owners arrive home after work, plug in and immediately start charging around 5-6 PM,
2) Delaying charging until late at night or early morning, usually in response to some form of incentive like a time of use (TOU) tariff, and
3) Solar soaking, where EVs charge to maximise consumption during times of high solar generation.

These three core profiles are summarised in Figure 4.

Figure 4: Dominant EV charging profiles found globally for passenger vehicles



Australians to date have been found to be more likely to follow options 2 and 3 and more detail is provided on this in a later view of the surveys.

2.5 Australian EV behaviour research & smart charging incentives

There have been a few surveys of Australian EV owners' behaviours to date. Table 3 provides an overview of influential Australian studies and trials conducted on EV owners. The surveys present two prevailing charging patterns: predominantly charging during the day [30], predominantly charging overnight [15], [27], and sometimes both [31].

Importantly, several of these studies (notably AGL and Origin) investigated Australian perspectives on charging behaviour policies like TOU tariffs and external charge control via smart chargers through trials. Participants responded strongly to both of these signal types (as measured by empirical data) and seemed to be largely open to these policies.

Australian EV early adopters are either predominantly charging overnight or during the day. They are much more likely to charge during the day than seen in other countries.

Table 3: Summary of Australian EV charging behaviour studies and trials					
Category	Group	Region	Date range	Sample Size	Findings
Behavioural survey	Griffith University	QLD	2020	348	EV charging mostly occurred overnight from 9 PM - 6 AM (65%), followed by during the afternoon between midday to 6 PM (16%), and finally from 6 AM to midday (11%) [15].
Behavioural survey*	University of Queensland	QLD	2021-2022	239	Drivers were predominantly charging in the middle of the day. The report concludes that EV owners are likely self-managing their charging times to take advantage of off-peak rates for TOU tariffs [30].
Behavioural survey*	Ergon Energy and Energex	QLD	2020-2021	167	Peak home charging occurred at 1 AM in response to TOU tariffs, but daytime charging was also seen (77% of participants had solar PV). 75% indicated that they charged under a flat-rate tariff. The authors note that despite the small amounts of the cohort on a TOU tariff, they had a disproportionately large impact on the total charging profile. Far less charging was done at home than expected (62% of total charging energy) [26]
Behavioural survey	Electric Vehicle Council	AUS wide	2022	741	Only 15% of owners routinely charged during the evening peak periods, EV owners with solar predominantly charged during the day with shorter charge sessions around midnight, while owners without solar mostly charged overnight between 1-2 AM [20].
TOU and Smart charger control trial*	AGL	AUS wide	2021	100	A large proportion of the non-controlled TOU population self-managed their charging to off-peak periods. Customers under a fixed-time charge schedule (constructed to avoid charging during peak demand periods and during TOU tariff rate changes around 11 PM) successfully changed the charging profiles compared to the non-controlled profile with low opt-out rates [16], [27].
TOU and Smart charger control trial*	Origin Energy	AUS wide	2022	150	Baseline charging included both overnight charging and sunshine charging. Trial participants responded strongly to a reward of 10 c/kWh for charging outside of peak periods, where the proportion of participants charging outside of peak periods increased from 70% to 90%. Participants mostly shifted from peak periods to overnight charging. Participants also tested external control between 3 PM and 9 PM with a fixed 25c per day reward. The study found that charging during peak demand periods could be further reduced, and this demand was shifted mostly to early morning periods. [31]

** Study used empirically measured data rather than self-reported*

3 EV ownership demographics and behaviours

3.1 Demographics

EV owners in EVenergi's two surveys are predominantly male, middle age to early retirement, living in houses, employed full time or retired, and have a high household income. This is consistent with the profile of early EV adopters found in the global literature (described in previous sections), and Australia studies of current EV owners in Australia [15]–[17].

Figure 5: Demographics of EV Owners Within Ausgrid Jurisdiction

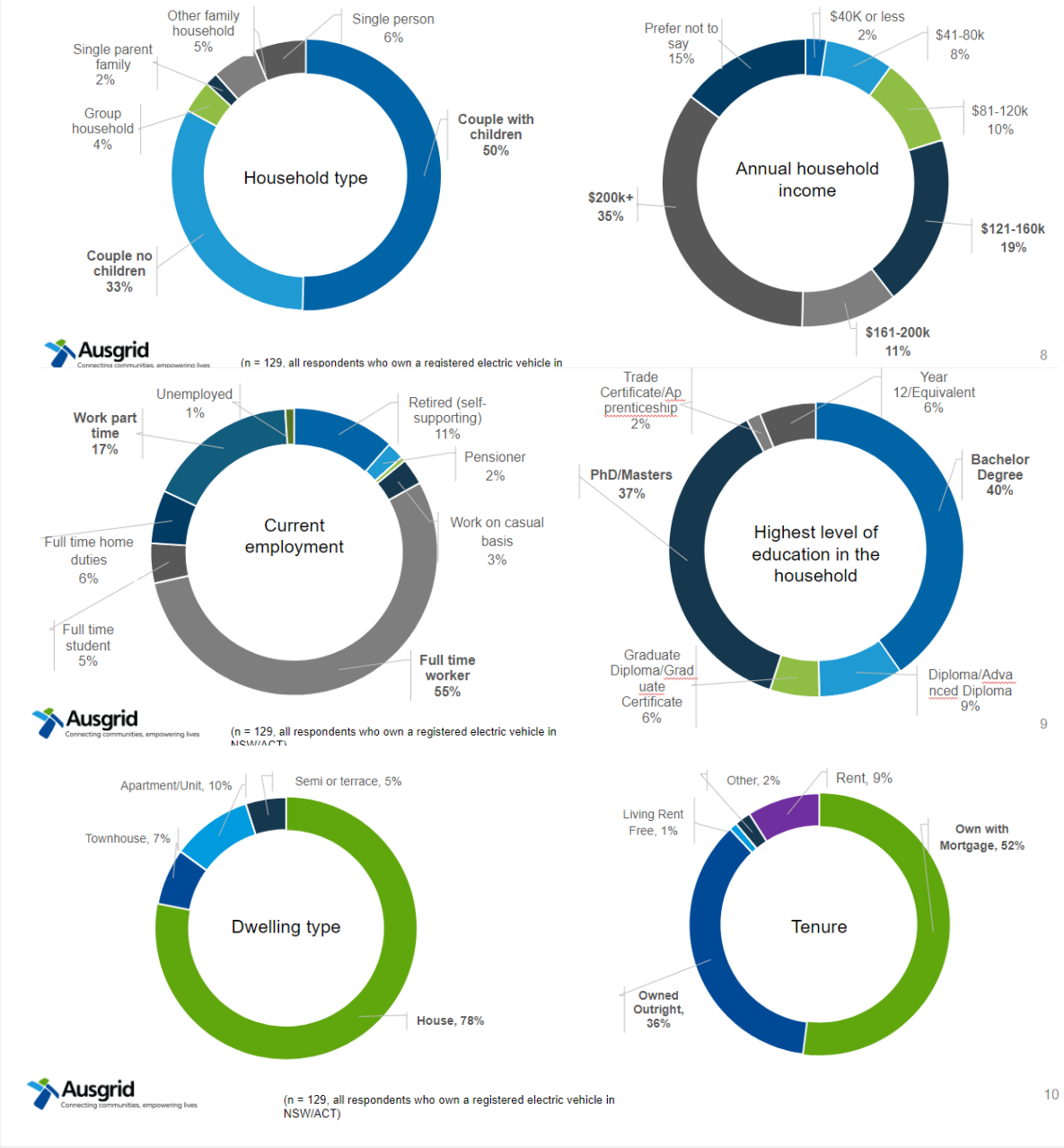
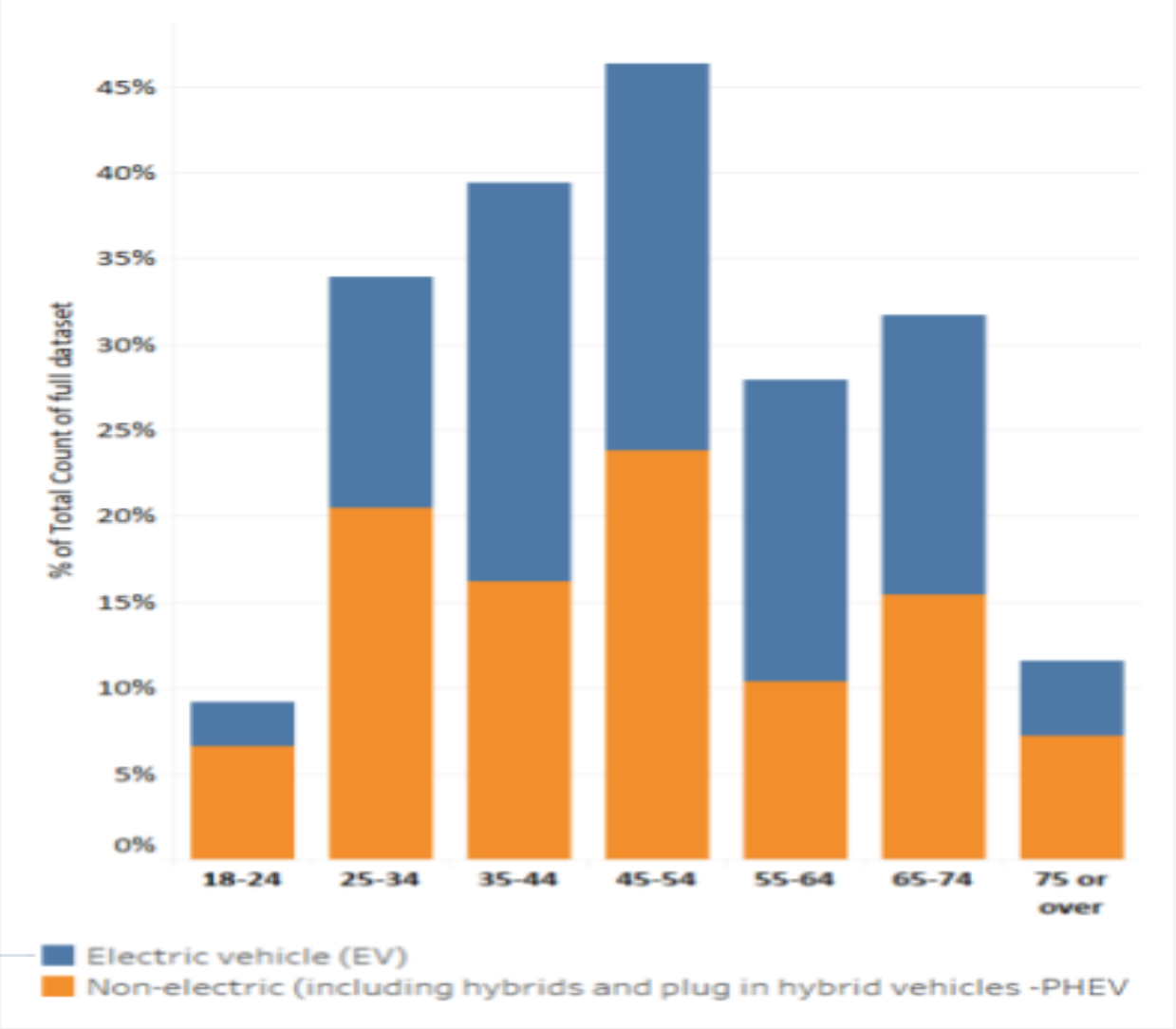


Table 4: Survey demographics from recent WA survey			
Parameter	**EV owners**	**Non-owners**	**Summary insight**
Age group	Predominantly 25 to 74	25 to 74 (with some notable numbers in the 18 - 24 and >75 age groups as well)	25 to 74 age group is the predominant category for both EV owners and non-owners
Gender	~83% of EV owners surveyed are men	~54% of non-owners are men	EV owners are more likely to be men while the distribution is more even for non-owners
Dwelling characteristics	Predominantly houses	Predominantly houses	There is a clear dominance of house dwellers among both EV owners and non-owners
Occupational status	Largest share are full-time workers (65%) and retirees (21%)	Again, largest share are full-time workers (61%) and retirees (11%)	The high percentage of full-time workers and retirees aligns with previous research on EV early adoption, often associating these groups with increased financial capacity and environmental consciousness.
Income levels	A large share (58%) belong to the higher income groups - $100k-$150k (30%), $150k-$200k (14%), and >$200k (14%)	A large share (60%) belong to the low to medium income groups - $40k-$60k (24%), $60k-80k (22%), and $80k-$100k (14%)	There is a positive correlation between higher income levels and EV ownership.

Age distribution

The majority of EV owners tend to be between 34 to 74 years old, with equal proportions (23%) in the 35-44 and 45-54 years brackets. The age groups of 55-64 and 65-74 years are also well-represented at 18% and 16% respectively. Fewer EV owners fall into the 25-34 years (13%), 75 years or over (4%), and 18-24 years (3%) categories. On the other hand, non-EV ownership appears more evenly spread across all age groups, with less mid-age concentration compared to EV owners.

Figure 6: Age Breakdown of Participants in WA Study



Gender distribution - WA Study

Table 5: Breakdown of Gender from WA Study

Car type	Female	Male	Non-binary / third gender	Prefer not to answer
Electric vehicle (EV)	6%	31%	0%	0%
Non-electric (including hybrids and plug in hybrid vehicles -PHEV	29%	34%	0%	0%

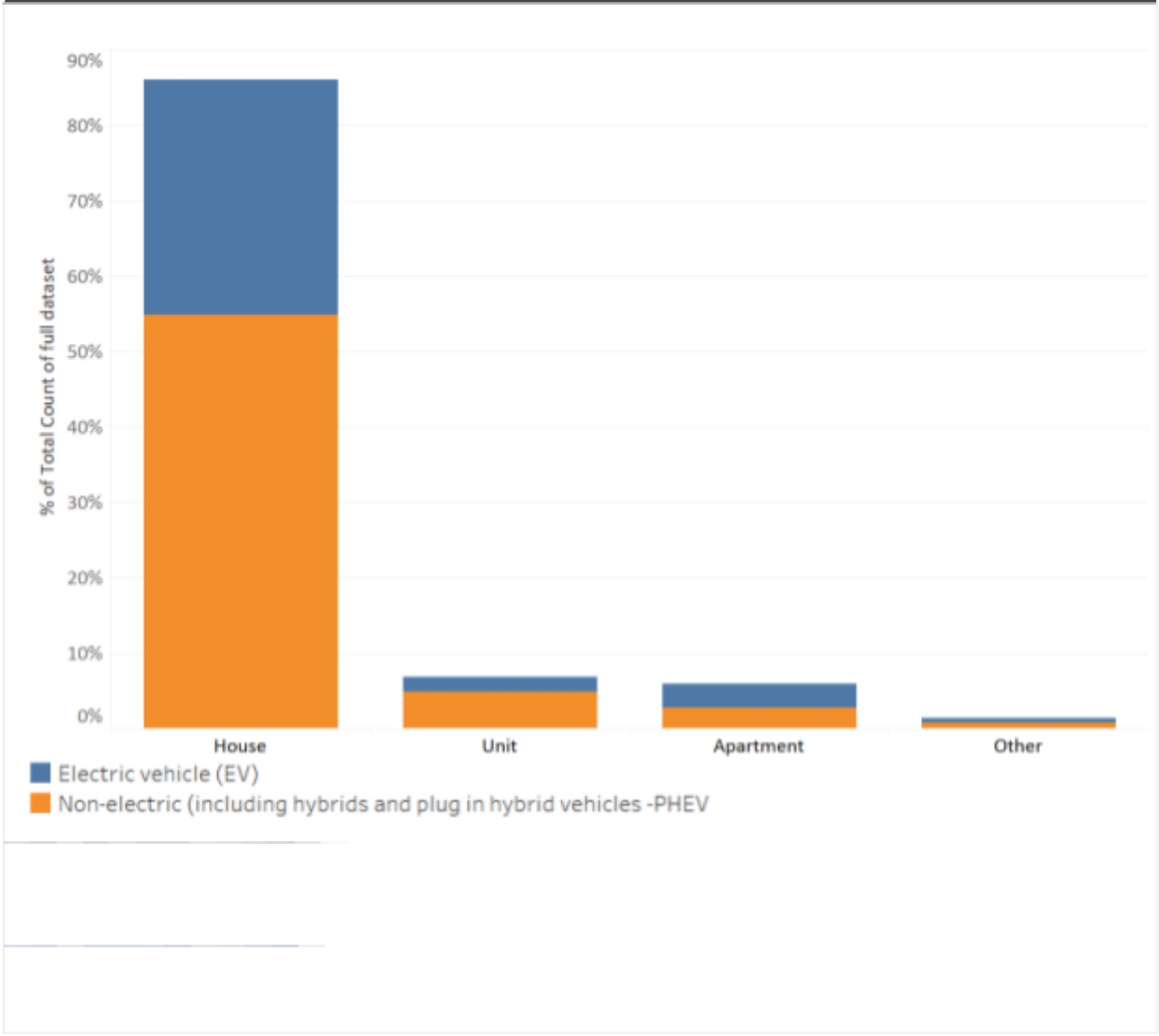
Male respondents are significantly more likely to own an EV, with 31% of men reporting EV ownership versus 6% of women. This gender discrepancy is less prominent in non-EV ownership, with 34% of men and 29% of women respectively. No data is available for non-binary, third-gender individuals or those who opted not to disclose their gender.

These findings underline a notable gender imbalance in EV adoption, which merits further exploration into potential reasons such as socio-economic factors or differing perceptions of EVs. Addressing these disparities could potentially widen the market appeal and speed up the uptake of EVs.

Dwelling characteristics

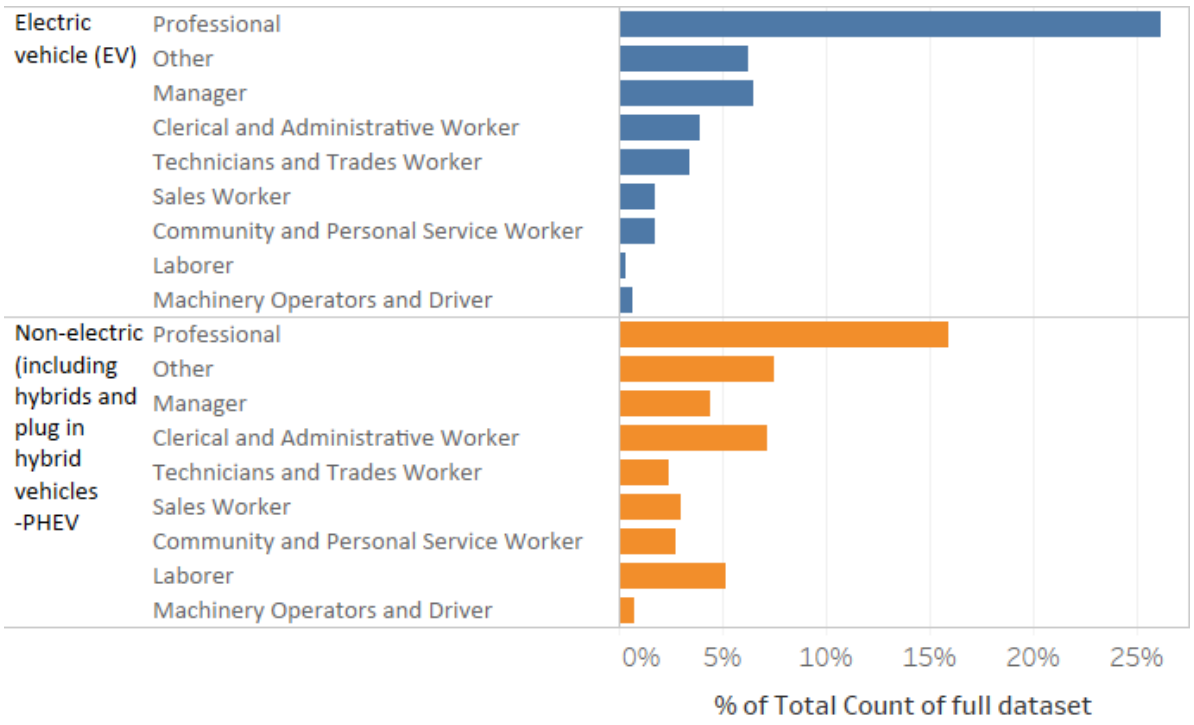
There is a clear dominance of house dwellers in Australia with the WA survey putting this at over 80% of the group. Both the Ausgrid results shown in Figure 5 above and the WA Study shown in Figure 7 below indicate that more than 75% of EV owners live in detached homes

Figure 7: Home Ownership Breakdown in WA Study



Occupation

Figure 8: Occupation Breakdown of Participants in WA Study



Within professional occupations, a significant inclination towards EV ownership is evident. Among EV owners, 26% belong to this professional category, compared to a smaller proportion, 16%, of non-EV owners who are professionals. This gap could be attributed to a range of factors, such as greater income levels or increased environmental awareness among professionals.

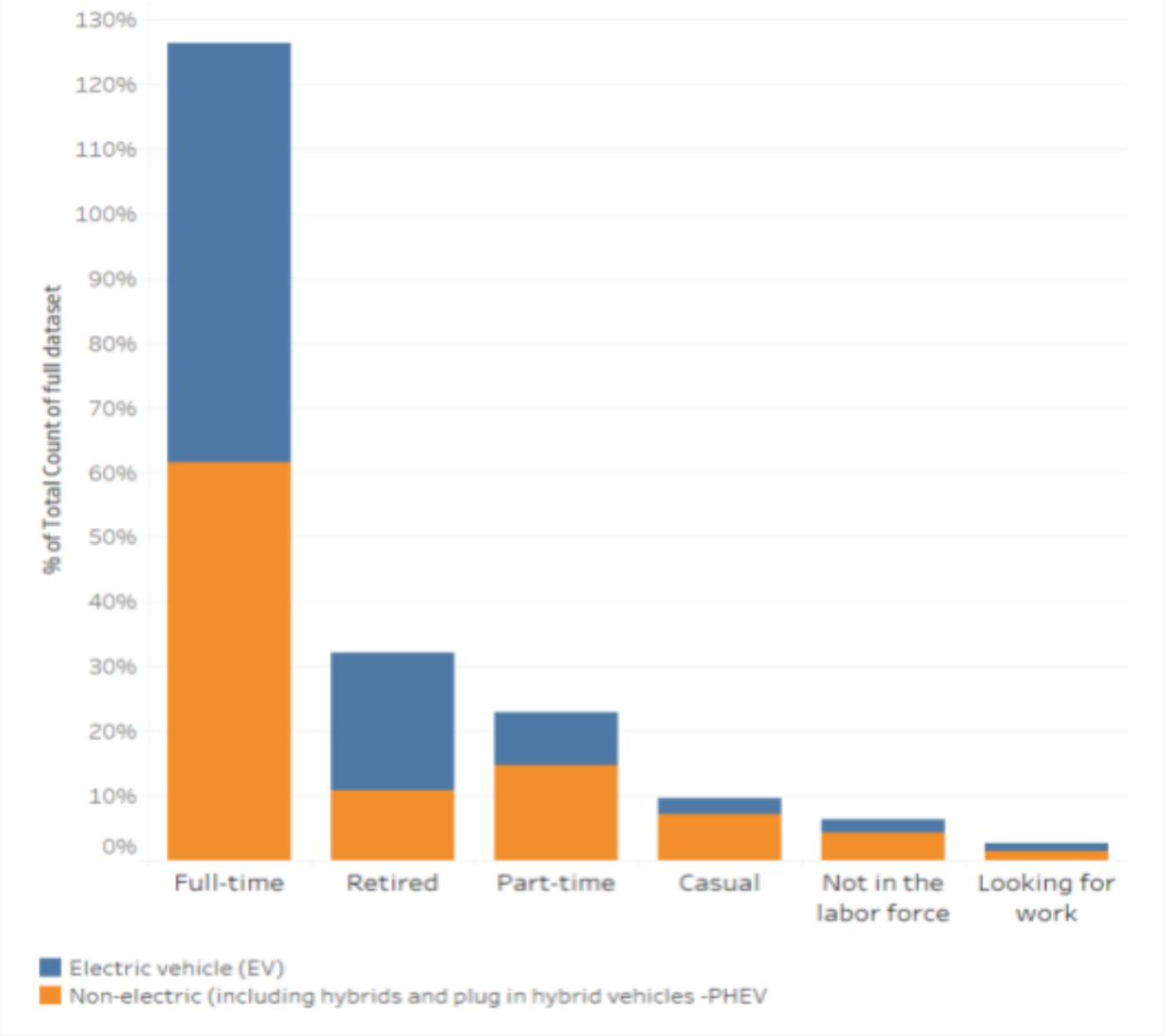
When examining labourer groups, a striking difference emerges, with 5% owning non-EVs, yet no reported EV ownership. This could be attributed to the lack of EV utes currently in the market, but given overseas ute models tend to be higher specced, higher priced options, there may be an underlying trend that labourers and the postcodes these people tend to reside in will have a slower uptake rate to EVs than those more populated by professionals.

Employment

Both studies show a similar trend of circa 60% of EV owners being full time workers, which is hardly surprising as this would be the group most commonly buying new cars in the price range EVs currently exist.

What was more interesting was that retirees accounted for 21% of EV owners in WA and 13% in NSW. This indicates that there is a material proportion of pensioners that have the money and a favourable view of EV technology.

Figure 9: Employment Status of Participants in WA Study

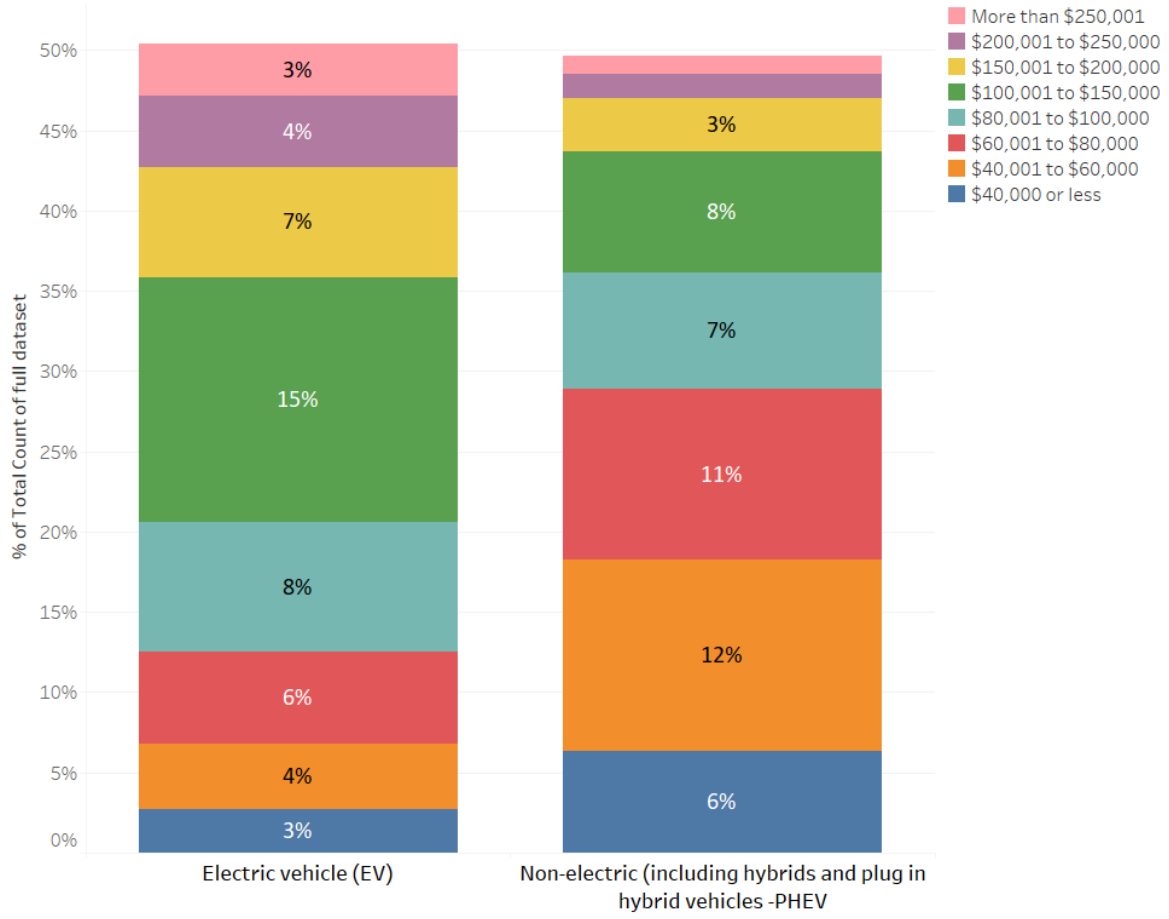


Income

Both studies also concur that EV owners tend to fall in higher income brackets. Specifically, a majority of EV owners earn above $100,000 per annum, with the most common bracket in Sydney being over $200k per annum at 35% of the study group as shown in Figure 5.

This difference could simply be a factor of generally higher incomes in Sydney than other locations around Australia. The common trend is though that relatively high income earners are more likely to own EVs at this point.

Figure 10: Income of Participants in WA Study



3.2 EV usage and trip purposes

A large share of the trips by both EV owners and non-owners are seen to be of less than 30 min. duration, with circa 60% of drivers reporting this to be the case. Trips over an hour were far less common across both studies, with 12% and 10% respectively reporting this to be the most common trip duration in WA and similarly distances of less than 20 kms were commonly observed in Sydney.

The main trip purposes for which EVs are used by the respondents, as shown in Figure 11 (WA) and Figure 13 (Sydney). Commuting to work (39%), social and recreational trips (24%) and work-related business trips (12%).

The fact that the largest trip usage is commuting indicates that there are likely cars parked at workplaces or public transport park-and-ride locations which have the opportunity to charge during the day.

EV owners primarily complete trips under 30 minutes and use their EVs to commute to work or perform work-related business, and travel for social and recreational reasons

Figure 11: Primary EV trip purposes - WA

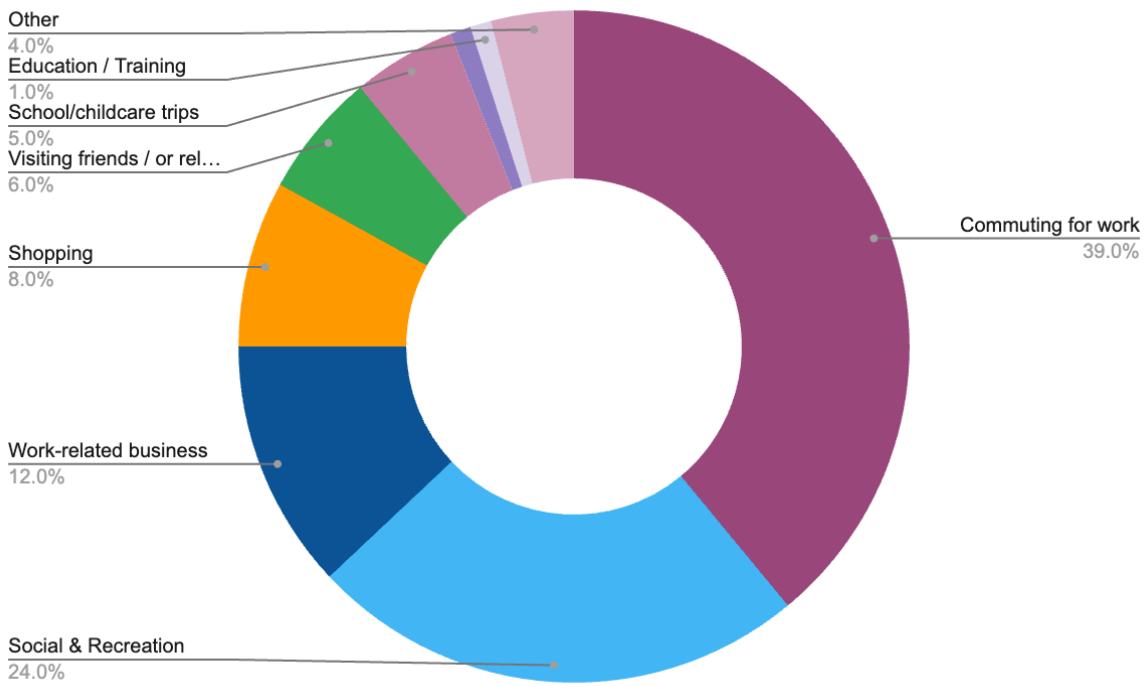


Figure 12: EV Usage - Ausgrid

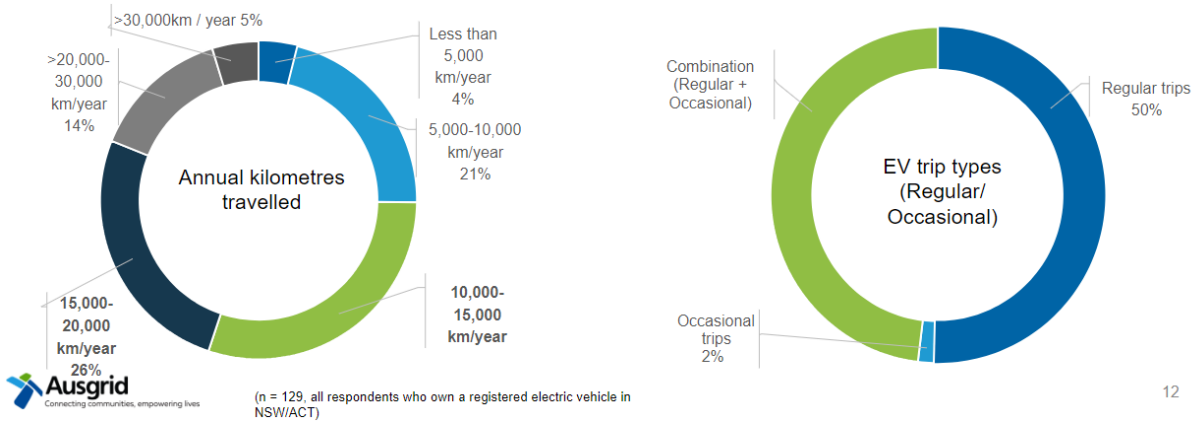
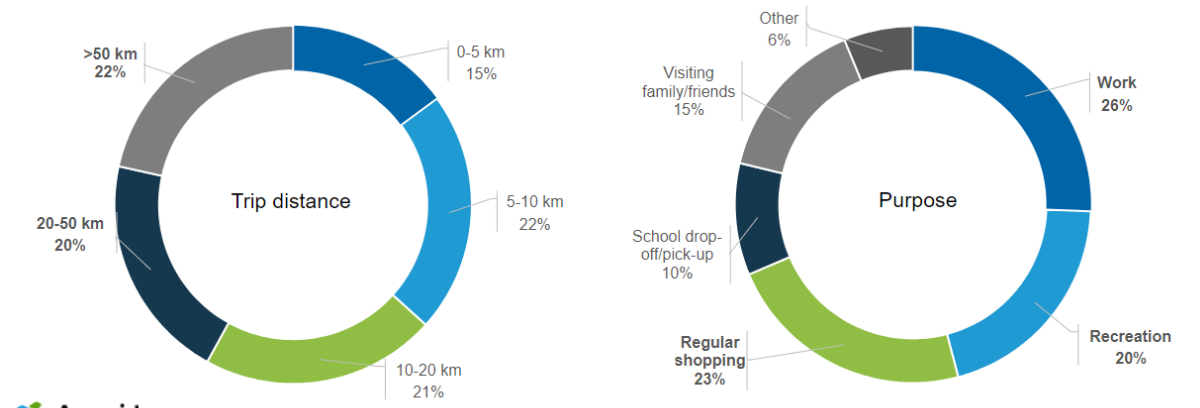
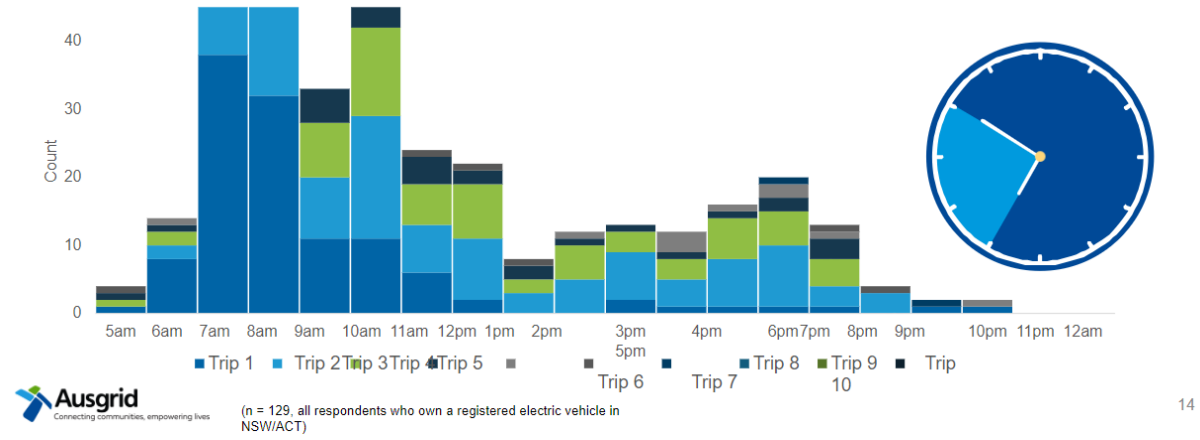


Figure 13: Regular Trip Duration and Timing - Ausgrid





3.3 Charging behaviour

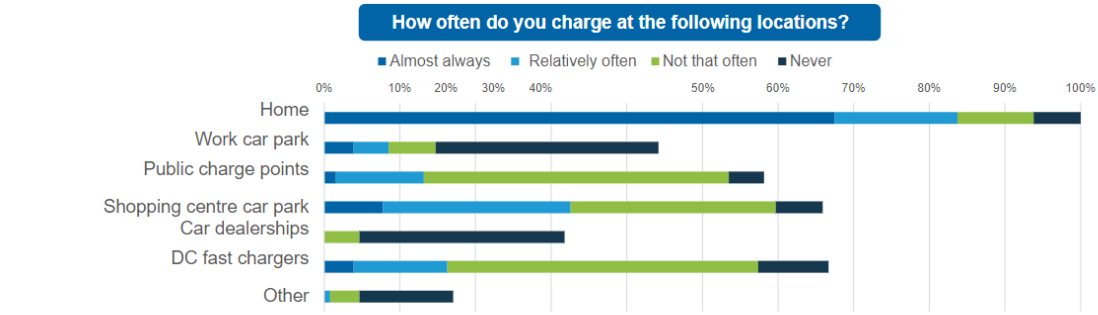
Key parameters that were assessed to understand the charging behaviour of EV owners included charging times, charging locations, types of chargers, and charging frequency. Notable insights from this assessment are summarised below.

Charging locations

EV owners overwhelmingly reported that they charged at home (84% in WA and 83% in Sydney), with some charging at public charging stations (10%), and the remaining respondents charging at their workplace (6%). This is consistent with global findings and slightly higher than other Australian surveys previously discussed (60-80% [17], [20]).

EV owners overwhelmingly charge at home, with a small amount of charging at public charging stations and workplaces.

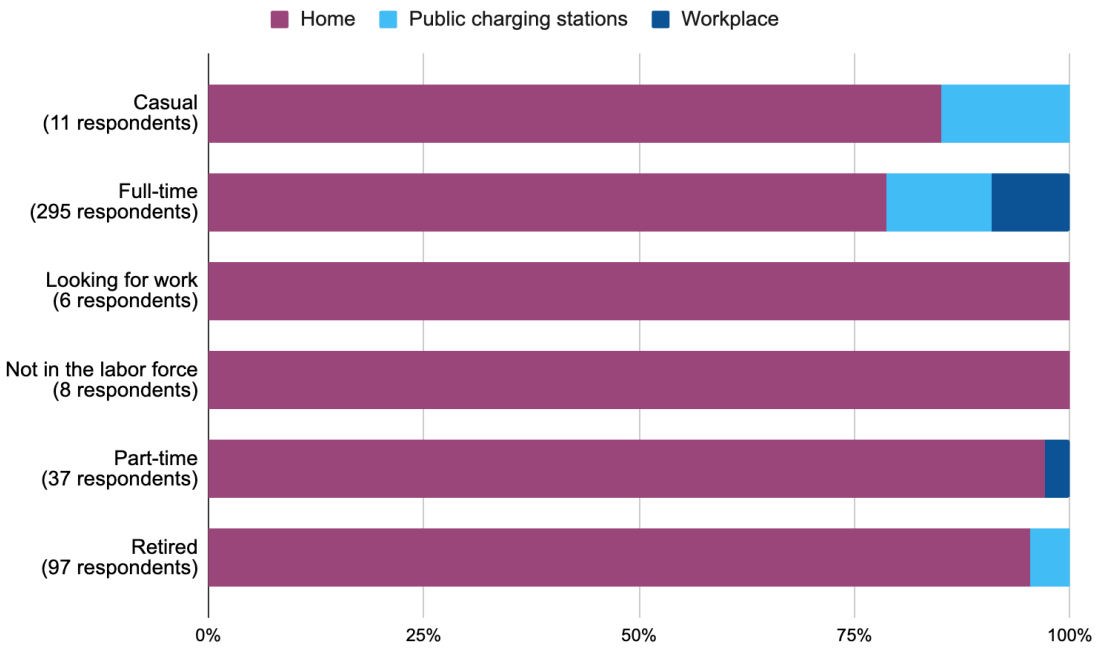
Figure 14: Charging Locations - Sydney Study



Home charging is the most dominant across all employment categories, as shown in Figure 15. This is true even for full-time workers, possibly indicating insufficient amounts of charging infrastructure at workplaces, or that home charging is the most convenient.

There is a disconnect that the most common trip type is commuting while the least common charging location is at the workplace. This indicates that there are many EVs parked in workplace carparks and park-and-ride locations during the day, and that there is an opportunity to install chargers at those locations to maximise EV charging consuming solar generation.

Figure 15: Impact of type of employment on charging location



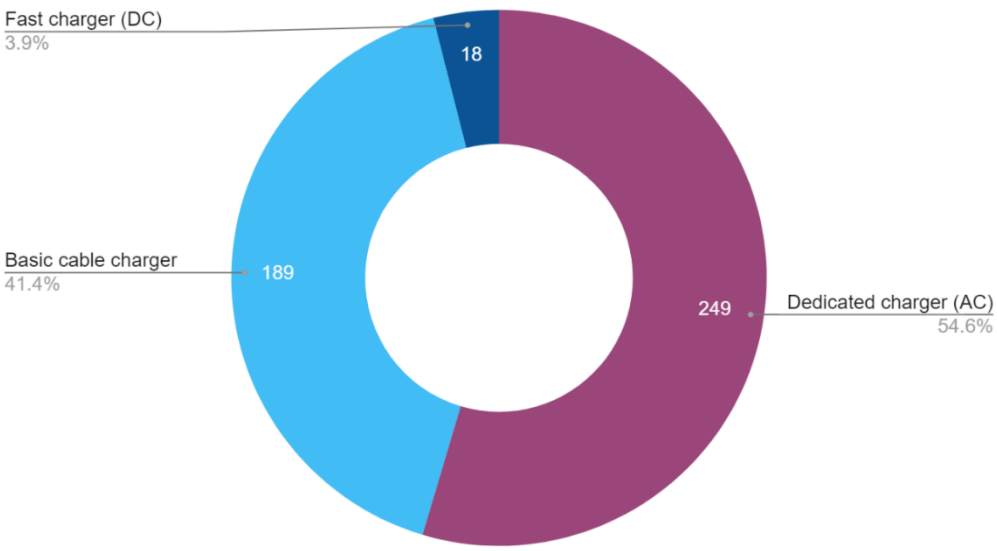
Charger types

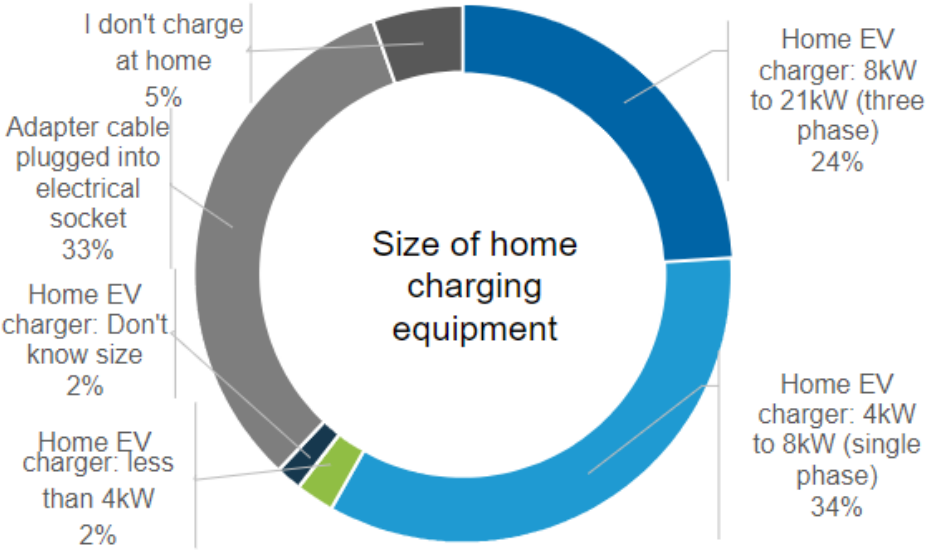
The survey revealed a significant prevalence of dedicated Level 2 chargers, with around 55% of EV owners in WA and 80% in Sydney reporting using dedicated chargers, as shown in Figure 16. This is consistent with global statistics of 40-80%, and Australian studies (61%, [17]).

Since a large share of EV owners are home charging, this means that a lot of the homes have Level 2 charger installations. This is a positive sign for the implementation of future smart energy management initiatives, however, it is important to note that not all dedicated chargers are 'smart', in particular early generation Tesla chargers given such a large proportion of all EVs in Australia are Teslas.

At the same time, there are quite a few owners (~41% of respondents) using basic cable chargers who could potentially move to smart chargers in the future, if adequate incentives are in place coupled with awareness of their benefits.

Figure 16: Charger types



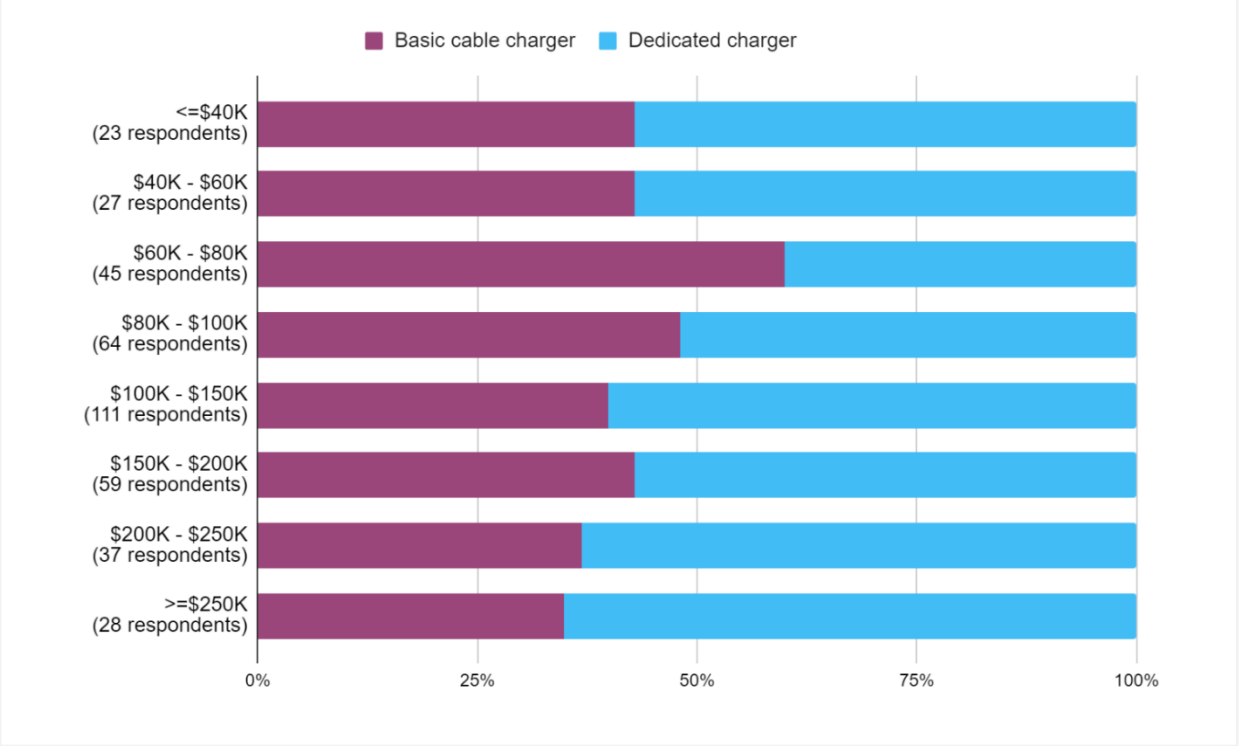


Full-time employees in the middle to higher income range ($80,000 to $250,000) have the highest share of ownership of dedicated Level 2 chargers. The installation of Level 2 chargers seems to be somewhat correlated to the EV owner's annual income, as per Figure 17, with high income earners more likely to have a dedicated charger than lower income earners. However, the proportion of Level 2 ownership does not vary significantly over income brackets suggesting cost is not an insurmountable barrier to smart charger ownership. This trend aligns with global literature [21].

The fact that it is likely most of the EV owners have Tesla's may also influence the ratio of EV owners with Level 2 chargers. Before 2020, Tesla bundled their wall charger with the vehicle on purchase however, as the majority of EVs in Australia have been purchased since then this is not likely the main cause. Tesla now offers a relatively cheap wall charger and does not include a Level 1 charger with the car so would still act to sway consumers towards the Level 2 charger option.

More than half of EV owners already use a smart charger to charge (even those at lower income levels).

Figure 17: Income vs dedicated Level 2 charger usage[1]



[1] Please note that this has been normalised to 100% of the participants in that income bracket. There were few respondents in the very high and very low income brackets and therefore these results may be outliers. Please refer to the demographics section or the full report for more information.

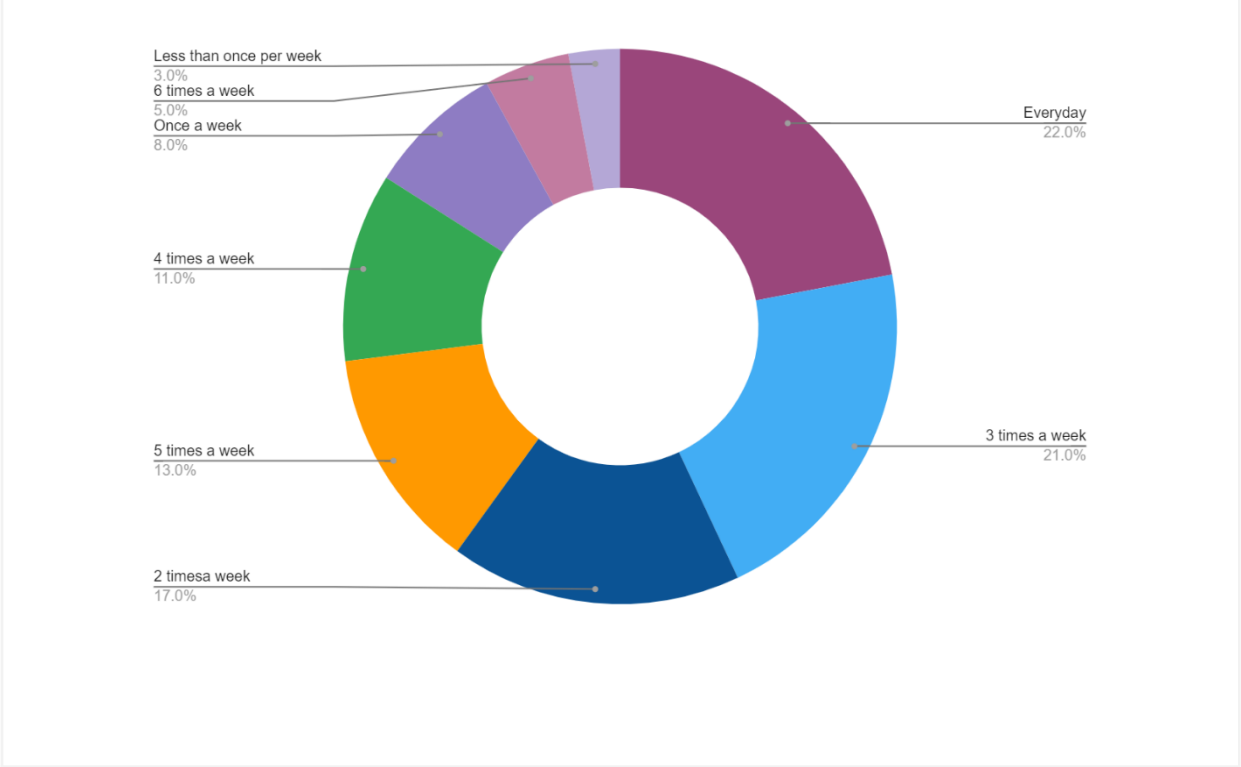
Charging frequency

Frequency of charging is an important indicator of charging behaviour, as it gives insights into not just the level of usage of vehicles (and consequently their energy requirements), but also the propensity of owners to plug-in their vehicles for charging (irrespective of the battery's state of charge).

As shown in Figure 18, the survey reveals a wide distribution of charging frequency, ranging from everyday charging (~22% of respondents) all the way to once or less than once a week. Close to half of the respondents are charging their vehicles 3 or less days a week, indicating that a lot of these owners are not having significant daily usage relative to the vehicle's battery capacity. This is a consistent finding with the global literature, as discussed in the literature review section.

A fifth of EV owners in WA engage in daily EV charging habits, but many are only charging as needed every 2-3 days

Figure 18: Charging frequency

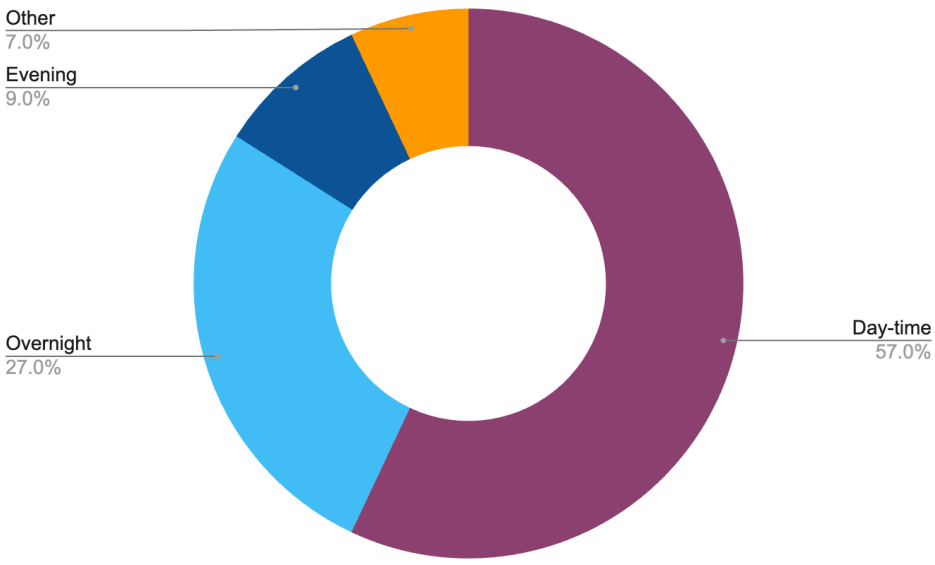


Charging times

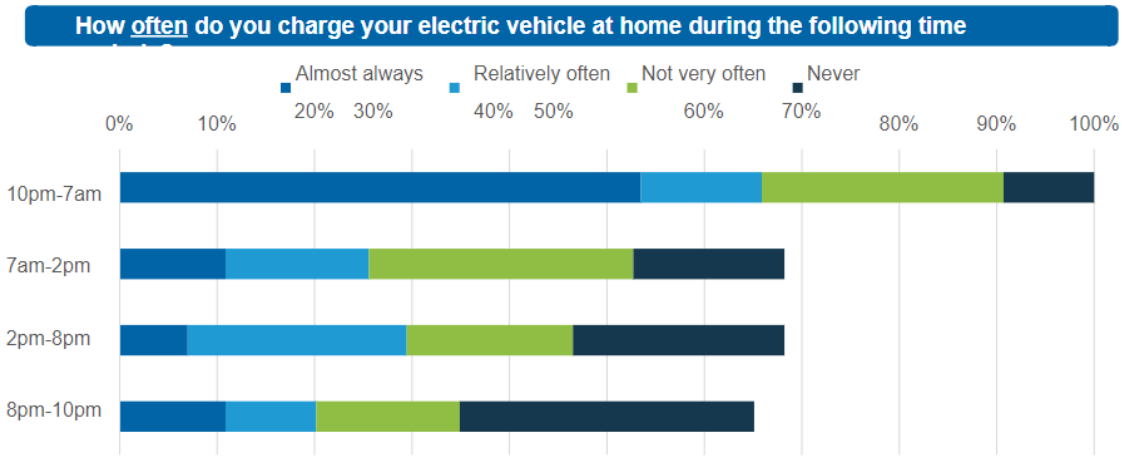
As seen in Figure 19, charging behaviours observed in both studies suggest charging is predominately being done outside of the peak hours.

EV owners on average are predominantly commencing charging during the day (57%) or overnight (27%).

Figure 19: Most common time of commencing EV charging



Where "Other" represents respondents who did not choose a time period, perhaps indicating that they have a diverse mix of charging time behaviour across different time periods.

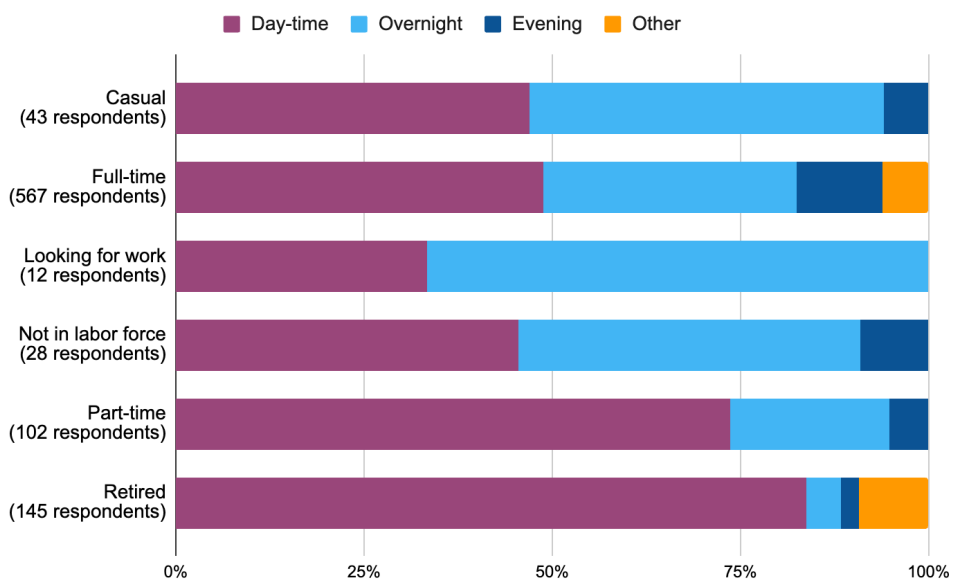


Employment type impact on charging times

Figure 20 shows the charging time distribution for EV owners belonging to different employment type categories. EV owners who are retired or working part-time are far more likely to engage in day-time charging compared to other employment categories and bring up the cohort average as they are overrepresented in this study compared to the general population in WA. This large share of mid-day charging may be attributed to this cohort having the flexibility to charge their EVs at home during the day.

Retired and part time workers are more likely to charge during the day than others, but a notable share of full-time and casual employees are also engaging in day-time charging behaviour.

Figure 20: Type of employment vs. primary charging time period



Where "Other" represents respondents who did not choose a time period, perhaps indicating that they have a diverse mix of charging time behaviour across different time periods.

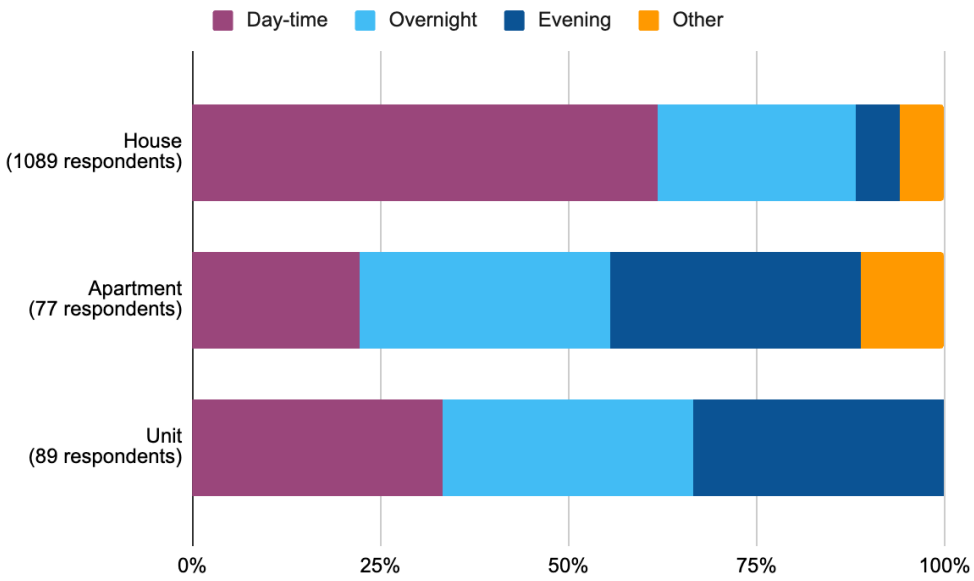
Type of residence

Figure 15 shows the primary charging time period by type of residence. Respondents that live in houses are more likely to charge their EVs during the daytime (between 9 AM and 3 PM) compared to those living in apartments or units. This may be as because a larger share of EV owners living in houses have solar PV ownership compared to those living in apartments and units, and a significant number of them also have the flexibility to adjust their EV charging time to the daytime to take advantage of solar generation (such as retirees and full-time workers working from home).

EV owners residing in houses are far more likely to start charging during the day than those in apartments and units.

In 2021, most people in WA lived in separate houses (79.7%) compared to flats or apartments (6.5%) [50] so this finding is encouraging. If growth in apartments and flat dwellings follows historical trends (from 5.7% in 2016 to 6.5% in 2021), the number of people in apartment and flat dwellings will further increase and therefore options for these EV owners to either charge during the day, or shift charging to overnight from the evening period should be explored. These might be options for on-street charging, workplace charging, or requirements in new apartment buildings for designated EV charging points.

Figure 15: Type of residence vs. primary charging time period



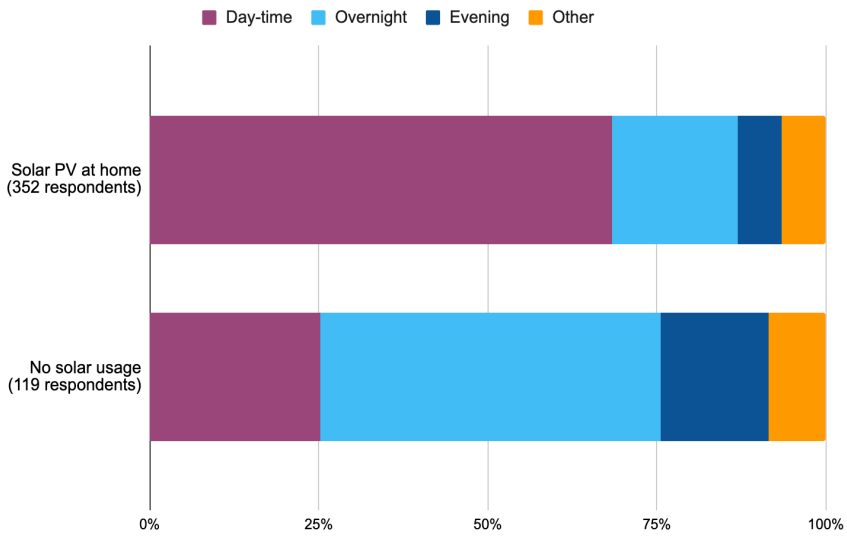
Where "Other" represents respondents who did not choose a time period, perhaps indicating that they have a diverse mix of charging time behaviour across different time periods.

Solar PV use

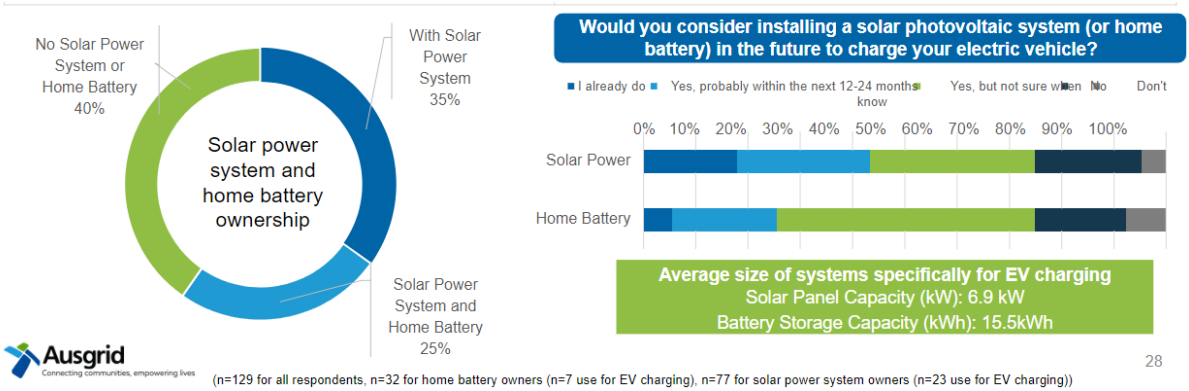
The presence of solar power at home has a notable impact on charging time behaviour, as close to 68% of respondents in the WA Study with solar power primarily charge their EVs during the day-time, while overnight charging has the largest share (50%) for EV owners without solar power. Interesting, 25% of the respondents who do not have solar are still beginning their charging during the daytime. This may be due to environmental concerns or a TOU tariff.

Solar PV owners are more likely to prefer daytime charging. TOU tariff adoption is expected to drive a similar pattern if the tariff range has a solar super off peak rate included.

Figure 16: Solar PV use vs charging time



Where "Other" represents respondents who did not choose a time period, perhaps indicating that they have a diverse mix of charging time behaviour across different time periods.



(n=129 for all respondents, n=32 for home battery owners (n=7 use for EV charging), n=77 for solar power system owners (n=23 use for EV charging))

Bibliography

[1] Department of Water and Environmental Regulation, 'Western Australian Climate Policy', Perth, Nov. 2020. Accessed: Jul. 18, 2023. [Online]. Available: https://www.wa.gov.au/system/files/2020-12/Western_Australian_Climate_Policy.pdf

[2] Department of Water and Environmental Regulation, 'State Electric Vehicle Strategy for Western Australia', Government of Western Australia, Perth, Nov. 2020. Accessed: Jul. 17, 2023. [Online]. Available: https://www.wa.gov.au/system/files/2020-11/State_Electric_Vehicle_Strategy_for_Western_Australia_0.pdf

[3] Energy Transformation Taskforce, 'Distributed Energy Resources Roadmap', Perth, Dec. 2019. Accessed: Jul. 18, 2023. [Online]. Available: https://www.wa.gov.au/system/files/2020-04/DER_Roadmap.pdf

[4] Energy Transformation Taskforce, 'Electric Vehicle Action Plan: Preparing Western Australia's electricity system for EVs', Aug. 2021.

[5] DAVID CARROLL, 'Rooftop solar powers WA to renewable energy record', pv magazine Australia. Accessed: Aug. 24, 2023. [Online]. Available: https://www.pv-magazine-australia.com/2022/11/18/rooftop-solar-powers-wa-to-renewable-energy-record/

[6] Electric Vehicle Council, 'State of Electric Vehicles 2022'. Accessed: Jun. 09, 2023. [Online]. Available: https://electricvehiclecouncil.com.au/wp-content/uploads/2022/10/State-of-EVs-October-2022.pdf?utm_medium=email&_hsmi=229569868&_hsenc=p2ANqtz-9ohg4BHqHTThjUrdcx3kTumy7ruNQL6yEkuW7eyBv3jo9Mpsv0hffbcvpB8THZBfmVL8A2hZ3t1SQBdkkumSwyHpiKbg&utm_content=229569868&utm_source=hs_automation

[7] International Energy Agency, *Global EV Outlook 2023: Catching up with Climate Ambitions*. in Global EV Outlook. OECD, 2023. doi: 10.1787/cbe724e8-en.

[8] Norsk Elbilforening, 'Norway celebrates another record-breaking year for electric vehicles'. [Online]. Available: https://elbil.no/norway-celebrates-another-record-breaking-year-for-electric-vehicles/

[9] IEA, 'Global Electric Vehicle Outlook 2022', May 2022. [Online]. Available: https://iea.blob.core.windows.net/assets/ad8fb04c-4f75-42fc-973a-6e54c8a4449a/GlobalElectricVehicleOutlook2022.pdf

[10] Electric Vehicle Council, 'State of Electric Vehicles', Electric Vehicle Council, Jul. 2023. Accessed: Aug. 21, 2023. [Online]. Available: https://electricvehiclecouncil.com.au/wp-content/uploads/2023/07/State-of-EVs_July-2023_.pdf

[11] Riz Akhtar, 'Australia's EV sales hit record 8% in April, as Tesla nearly snatches top spots', The Driven. Accessed: Jul. 17, 2023. [Online]. Available: https://thedriven.io/2023/05/03/australias-ev-sales-hit-record-8-in-april-as-tesla-nearly-snatches-top-spots/

[12] Department of Climate Change, Energy, the Environment and Water (DCCEEW), 'The National Electric Vehicle Strategy', Australian Government, Canberra, 2023. Accessed: Jul. 17, 2023. [Online]. Available: https://www.dcceew.gov.au/energy/transport/national-electric-vehicle-strategy

[13] T. Department of Infrastructure, 'Fuel Efficiency Standard—Cleaner and Cheaper-to-run Cars for Australia', Department of Infrastructure, Transport, Regional Development, Communications and the Arts. Accessed: Jul. 17, 2023. [Online]. Available:

https://www.infrastructure.gov.au/have-your-say/fuel-efficiency-standard-cleaner-and-cheaper-run-cars-australia
[14] Ricardo Strategic Consulting, 'EV Consumer Behaviour', Fuels Institute, Electric Vehicle Council, MI, USA, Jun. 2021. Accessed: Jul. 17, 2023. [Online]. Available: https://www.transportationenergy.org/wp-content/uploads/2022/11/21FI_-EVC_ConsumerBehaviorReport_V07-FINAL.pdf
[15] A. Mortimore, S. Ratnasiri, and M. S. Iftekhar, 'Who is buying electric vehicles in Australia? A study of early adopters in Queensland, Discussion Paper Series'. 2021. [Online]. Available: https://www.griffith.edu.au/__data/assets/pdf_file/0031/1379713/Who-is-buying-electric-vehicles-in-Australia.pdf
[16] AGL, 'AGL EV orchestration trial lessons learnt: Report Two', Sep. 2021. Accessed: Jul. 17, 2023. [Online]. Available: https://arena.gov.au/assets/2021/09/agl-electric-vehicle-orchestration-trial-lessons-learnt-report-2.pdf
[17] P. S. Lavieri and G. J. M. Oliveira, 'Electric Vehicle Charging Consumer Survey Insights Report', e, Sep. 2021. [Online]. Available: https://www.energynetworks.com.au/miscellaneous/electric-vehicle-charging-consumer-survey-report/
[18] E. Figenbaum and M. Kolbenstvedt, 'Learning from Norwegian Battery Electric and Plug-in Hybrid Vehicle users: Results from a survey of vehicle owners', 2016. [Online]. Available: https://www.toi.no/getfile.php/1343167-1467632310/Publikasjoner/T%C3%98I%20rapporter/2016/1492-2016/Summary.pdf
[19] B.C.G., 'What Electric Vehicle Owners Really Want from Charging Networks'. [Online]. Available: https://www.bcg.com/publications/2023/what-ev-drivers-expect-from-charging-stations-for-electric-cars
[20] Electric Vehicle Council, 'Insights into electric vehicle ownership: A survey of Tesla Owners Club Australia members in partnership with the Electric Vehicle Council.', Electric Vehicle Council, Sep. 2022. Accessed: Jul. 17, 2023. [Online]. Available: https://electricvehiclecouncil.com.au/wp-content/uploads/2022/09/EVownerinsights.pdf
[21] Department for Business, Energy and Industrial Strategy, 'Electric Vehicle Smart Chargepoint Survey 2022, Findings Report', Jan. 2023. [Online]. Available: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1129104/electric-vehicle-smart-charging-survey-2022.pdf
[22] F. Schmalfuss, 'User responses to a smart charging system in Germany: Battery electric vehicle driver motivation, attitudes and acceptance', *Energy Research & Social Science*, vol. 9, pp. 60–71, 2015.
[23] C. Corchero García, 'European electric vehicle fleet: driving and charging behaviors. in X Congreso de la Asociación Española para la Economía Energética'. 2015. [Online]. Available: https://core.ac.uk/download/pdf/41778899.pdf
[24] M. A. Nicholas, G. Tal, and T. S. Turrentine, 'Advanced Plug-in Electric Vehicle Travel and Charging Behavior Interim Report', 2017, Accessed: Jun. 19, 2023. [Online]. Available: https://escholarship.org/uc/item/9c28789j
[25] W. P. Distribution, 'Summary of the findings of the Electric Nation smart charging trial'. 2019. [Online]. Available:

https://electricnation.org.uk/wp-content/uploads/2019/07/Electric-Nation-Trial-Summary-A4.pdf
[26] Ergon and Energex, 'EV SmartCharge Queensland insights report'. 2023. [Online]. Available: https://www.energex.com.au/__data/assets/pdf_file/0004/1059331/EV-SmartCharge-Queensland-Insights-Report.pdf
[27] AGL, 'AGL EV orchestration trial lessons learnt: Report Four', AGL, Sep. 2022. [Online]. Available: https://arena.gov.au/assets/2022/09/agl-ev-orchestration-trial-lessons-learnt-report-4.pdf
[28] Synergy, 'Electric Vehicle Add On', Accessed. [Online]. Available: https://www.synergy.net.au/Your-home/Energy-plans/Electric-Vehicle-Add-On
[29] E. Delmonte, 'What do consumers think of smart charging? Perceptions among actual and potential plug-in electric vehicle adopters in the United Kingdom', *Energy Research & Social Science*, vol. 60, p. 101318, 2020.
[30] T. Phillip, K. Lim, and J. Whitehead, 'Driving and charging an EV in Australia: A real-world analysis', presented at the Ausraliasian Transport Research Forum 2022, Adelaide, Sep. 2022. [Online]. Available: https://arxiv.org/ftp/arxiv/papers/2206/2206.03277.pdf
[31] Origin, 'Origin EV Smart Charging Trial'. May 2022. [Online]. Available: https://arena.gov.au/assets/2022/05/origin-energy-electric-vehicles-smart-charging-trial-lessons-learnt-2.pdf
[32] Australian Electric Vehicle Association, 'World EV Day'. [Online]. Available: https://aeva.asn.au/events/422/
[33] P. I. America, 'Electric Vehicle Association, Sierra Club, and EVHybridNoire. 2023', *National Drive Electric Week*, 2023, [Online]. Available: https://driveelectricweek.org/
[34] E. America, 'Normal Now'. 2023. [Online]. Available: https://normalnow.com/
[35] J. N. Yan, 'See Electrify America's $10 million EV education campaign'. 2022. [Online]. Available: https://adage.com/article/marketing-news-strategy/electrify-americas-10-million-ev-education-campaign/2447411
[36] S. Columbus, 'Growing Demand for Electric Vehicles Through Online Education'. 2023. [Online]. Available: https://smartcolumbus.com/playbook-assets/electric-vehicle-consumer-adoption/growing-demand-for-electric-vehicles-through-online-education
[37] Veloz, 'Electric For All'. 2023. [Online]. Available: https://www.veloz.org/electric-for-all/
[38] Zemo Partnership, 'Smart Charging Consumer Awareness Campaign'. 2023. [Online]. Available: https://www.zemo.org.uk/work-with-us/energy-infrastructure/projects/smart-charging-consumer-awareness-campaign.htm
[39] Endeavour Energy, 'Endeavour Energy Time-of-Use Tariffs Knowledge Review'. Jan. 2023. [Online]. Available: https://ehq-production-australia.s3.ap-southeast-2.amazonaws.com/81b7031b4304c65f5cd92e108bc2abbabbaf7fba/original/1679829930/96c8db6abae8e65c5864a414af0e7867_endeavour_energy_time-of-use_tariffs_knowledge_review_March_2023.pdf
[40] Department for Energy Security and Net Zero, Office for Zero Emission Vehicles, 'Regulations: electric vehicle smart charge points', GOV.UK. Accessed: Jul. 21, 2023. [Online]. Available: https://www.gov.uk/guidance/regulations-electric-vehicle-smart-charge-points

[41] U. K. Government, 'Grant schemes for electric vehicle charging infrastructure'. Aug. 2022. [Online]. Available: https://www.gov.uk/government/collections/government-grants-for-low-emission-vehicles
[42] N. M. L, M. J. Fell, and H. G. M, 'Consumer demand for time of use electricity tariffs: A systematized review of the empirical evidence', *Renewable and Sustainable Energy Reviews*, Dec. 2018, [Online]. Available: https://www.sciencedirect.com/science/article/pii/S1364032118306257
[43] Western Power, 'Advanced metering infrastructure for an intelligent grid'. Accessed: Aug. 22, 2023. [Online]. Available: https://www.westernpower.com.au/our-energy-evolution/grid-technology/advanced-metering-infrastructure-the-best-way-to-meter-electricity/
[44] S. Adams *et al.*, 'Social license to automate: A critical review of emerging approaches to electricity demand management', *Energy Research & Social Science*, vol. 80, p. 102210, Oct. 2021, doi: 10.1016/j.erss.2021.102210.
[45] Energy Consumers Australia, 'Social Licence for Control of Distributed Energy Resources'. Accessed: Aug. 23, 2023. [Online]. Available: https://energyconsumersaustralia.com.au/wp-content/uploads/Social-License-for-DER-Control.pdf
[46] Roy Morgan Research, 'Utility companies have a significant consumer distrust problem'. Accessed: Aug. 23, 2023. [Online]. Available: https://www.roymorgan.com/findings/utility-companies-have-a-significant-consumer-distrust-problem
[47] SA Power Networks, 'Advanced VPP Grid Integration Project: Knowledge Sharing Report', May 2021. [Online]. Available: https://arena.gov.au/assets/2021/05/advanced-vpp-grid-integration-final-report.pdf
[48] ARENA, 'Project EDGE (Energy Demand and Generation Exchange)', Australian Renewable Energy Agency. Accessed: Aug. 23, 2023. [Online]. Available: https://arena.gov.au/projects/project-edge-energy-demand-and-generation-exchange/
[49] FTI Consulting, 'Dynamic Operating Envelope Policy in the National Electricity Market', AER, Jun. 2022. Accessed: Aug. 23, 2023. [Online]. Available: https://www.aer.gov.au/system/files/30062022%20FINAL%20Dynamic%20Operating%20Envelope%20Policy%20in%20the%20National%20Electricity%20Market%2814114150.1%29_0.pdf
[50] Australian Bureau of Statistics, 'Snapshot of Western Australia'. Accessed: Jul. 18, 2023. [Online]. Available: https://www.abs.gov.au/articles/snapshot-wa-2021
[51] Energy Policy Western Australia, 'DER Roadmap: DER orchestration roles and responsibilities information paper'. May 2022. [Online]. Available: https://www.wa.gov.au/system/files/2022-07/DER%20Orchestration%20Roles%20and%20Responsibilities%20information%20Paper.pdf
[52] Project Symphony, 'Project Symphony Lessons Learnt Report 2', Aug. 2022. Accessed: Jul. 18, 2023. [Online]. Available: https://arena.gov.au/assets/2022/08/project-symphony-lessons-learnt-2.pdf
[53] Hon Bill Johnston M.L.A.'s office, 'Summer Readiness energy campaign launches'. Nov. 2022. [Online]. Available: https://www.mediastatements.wa.gov.au/Pages/McGowan/2022/11/Summer-Readiness-energy-campaign-launches.aspx

[54] A. N. University, ‘Realising Electric Vehicle-to-grid Services’. 2023. [Online]. Available: https://bsgip.com/research/realising-electric-vehicles-to-grid-services/
[55] Cenex, ‘Project Sciurus Trial Insights: Findings from 300 Domestic V2G Units in 2020’, May 2021. Accessed: Jul. 21, 2023. [Online]. Available: https://www.cenex.co.uk/app/uploads/2021/05/Sciurus-Trial-Insights.pdf
[56] Department for Energy and Mining South Australia, ‘Technical Regulator Guideline - Technical Standard for Installation of Electric Vehicle Supply Equipment (EVSE)’. Feb. 2022. [Online]. Available: https://www.energymining.sa.gov.au/__data/assets/pdf_file/0020/813512/Technical-Regulator-Guideline-Technical-Standard-for-Installation-of-Electric-Vehicle-Supply-Equipment-EVSE.pdf
[57] WA Government, ‘Charge Up Workplace EV Charging Grants’. Accessed: Aug. 23, 2023. [Online]. Available: https://www.wa.gov.au/organisation/energy-policy-wa/charge-workplace-ev-charging-grants