Origin EV Smart Charging Trial

Interim Report

June 2021

Acknowledgement and Disclaimer

This Project received funding from ARENA as part of ARENA's Advancing Renewables Program. The views expressed herein are not necessarily the views of the Australian Government, and the Australian Government does not accept responsibility for any information or advice contained herein.

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1. Executive Summary

EV adoption is expected to increase at a rapid pace both in Australia and globally. EVs can provide numerous operational and monetary benefits to customers as well as enabling the decarbonisation of the transportation and energy sectors. However, as EV adoption increases, EV charging will need to be managed to optimise for energy supply and demand, and grid capacity. EV smart charging can not only aid in managing grid load but can also enable customers to optimise charging based on the lowest cost.

Origin's Smart Charging Trial ("the **trial**") aims to gain insight into EV charging patterns and behaviours of residential and business customers and demonstrate the value created in managing EV charging to respond to signals from the energy markets.

Origin commenced the trial in August 2020 and has so far engaged with both residential and business participants. A total of 103 (70 residential and 33 business) smart chargers have been installed which has provided meaningful baseline charging data.

Our interim progress to date has found the following insights:

- The profile of our participants is skewed to early adopters. Any commercial propositions would need to consider the appropriate customer segment as it is unlikely there will be a one size fits all solution for the management of charging whether it be residential or business.
- Charging data was impacted by COVID-19 lockdowns in various states and at various times. Behaviour is starting to normalise, and this will continue towards later periods of 2021. Even so, charging can be seen to peak towards later afternoon to early evening periods.
- Technology to control a small group of EV chargers can be simple, however the eco-system becomes fragmented and costly at scale. Policies and standards should be explored to address this.

2. Project Overview

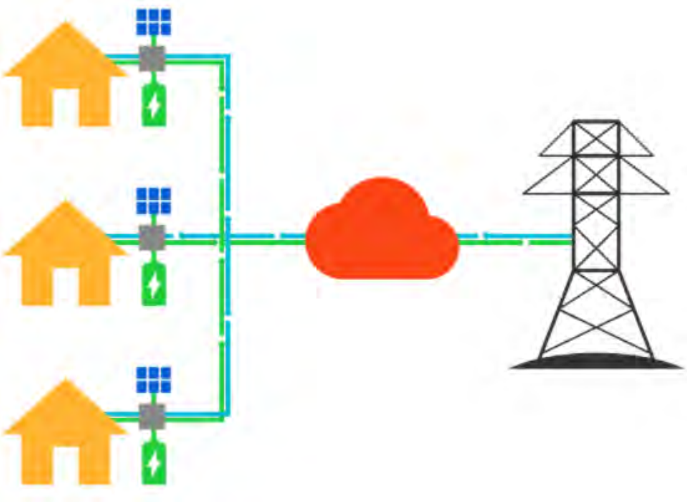
2.1 Smart Charging Trial

Origin's smart charging trial seeks to collect charging and usage data to provide insights into EV charging behaviours and examine responses to smart charging. The trial will provide insights required to inform the design of tariffs and retail propositions for smart charging to encourage the charging of EVs by customers in a way that will be beneficial to both EV owners as well as the electricity system.

The trial commenced in August 2020 and involves:

1. Installing and connecting at least 150 smart chargers onto Origin's Virtual Power Plant *(Figure 1)*.
2. Capturing data on EV charging patterns. Data will be captured during a baseline period of unmanaged charging followed by a period of smart charging with different incentives and price signals.
3. Capturing data on how much energy usage can be shifted through smart charging.
4. Longitudinal study on drivers to explore customer perceptions, motivations and experience in smart charging and driving.

Figure 1: Illustration of connection of EV chargers onto Origin's Virtual Power Plant to facilitate smart charging



Origin's VPP will provide charging instructions to:

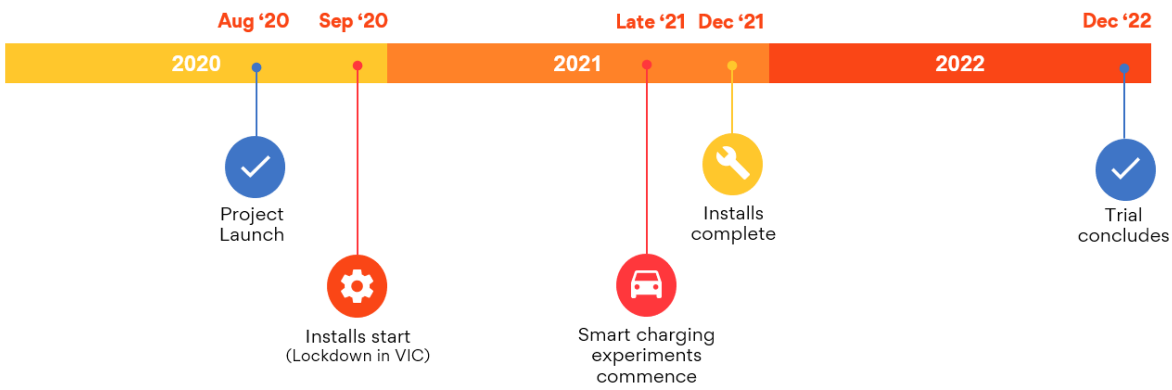
- Maximise consumption of renewables
- Minimise wholesale energy costs
- Manage load to prevent local switchboard and network upgrades
- Comply with user preference for priority charging

3. Progress to Date

The trial was launched in August 2020 and since launch, Origin has been engaging with participants and installing chargers for the participants. The trial was targeting the participation of at least 150 smart chargers (75 residential chargers and 75 fleet chargers) to be enrolled onto Origin's VPP by December 2021. Origin has received strong demand from participants all around Australia. To date, Origin has installed and enrolled 70 residential chargers and 33 fleet chargers, with a strong pipeline for the remaining targeted fleet chargers.

Origin has been collecting baseline information from connected chargers without intervention from the smart charging platform. This information will be used to compare to the charging patterns once incentives and price signals have been introduced.

Figure 2: Project timeline



4. Insights

4.1 Demographics of Participants

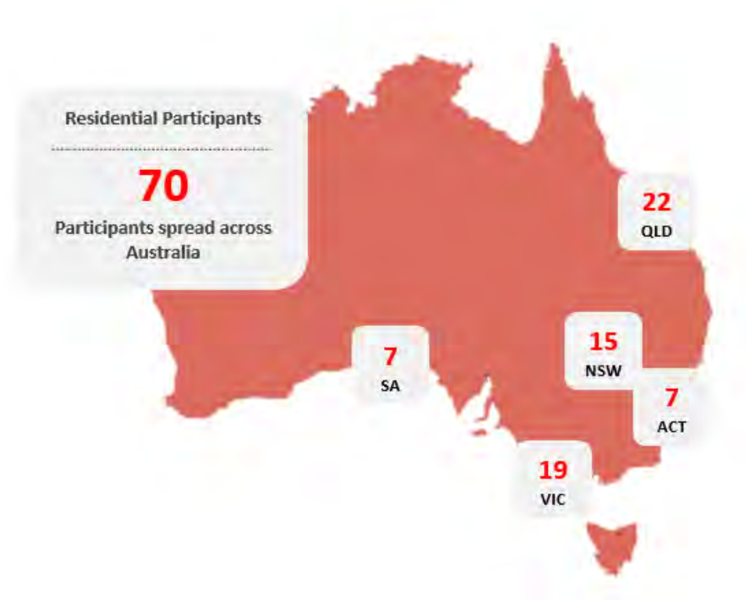
4.1.1 Residential Participants

Origin received expressions of interest from 388 residential participants, which were distributed all around the nation. There was particularly strong demand from QLD, NSW, and VIC, which made up around 75% of the total expression of interest.

70 residential participants *(Figure 3)* were selected to be part of the trial based on eligibility criteria including:

- Dwelling type (e.g., freestanding houses or townhouses).
- Off-street parking to install chargers.
- Being an Origin Energy electricity customer.
- Willingness to participate in surveys, interviews, and experiments over the period of 2 years.

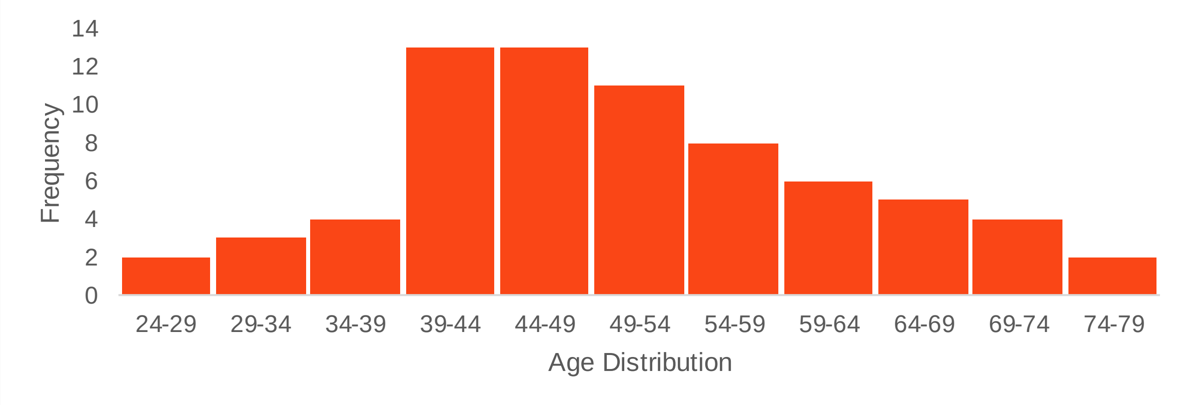
Figure 3: Residential participants split by state



Through surveys and interviews, Origin identified that 89% of participants had Solar PV installed at their premise of which 20% also have a battery.

Trial participants were skewed towards males (3:1 ratio) as a primary contact and age was skewed to over 40s *(Figure 4).*

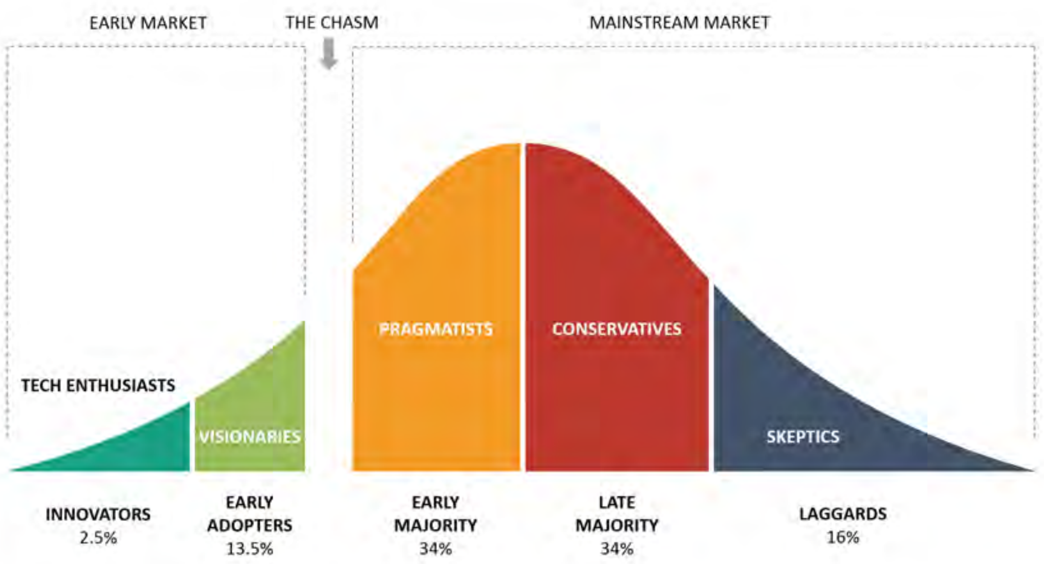
Figure 4: Age distribution of residential participants



Attitudes and motivations of residential participants

Our trial participants sit in the innovator and early adopter categories of the technology adoption lifecycle *(Figure 5)*. It is important to acknowledge this as the data and opinions are skewed towards a highly engaged cohort.

Figure 5: Technology adoption life cycle



Using insights gathered in discussions, interviews, and surveys we have categorised our participants into 3 main personas:

1. **The Tinkerer** – This cohort is highly engaged with energy and are passionate when it comes to analysing data. Participants are open to new concepts and technologies if value can be seen, or additional data can be collected. Origin noted that participants are motivated by optimisation, have a general curiosity for how things work and are very conscious of both energy consumption and cost. Generally, it was found that this group did not want the fastest charging, rather just the technology to control the

charging. For this cohort, range anxiety was not an issue as participants planned ahead in the event of long trips.

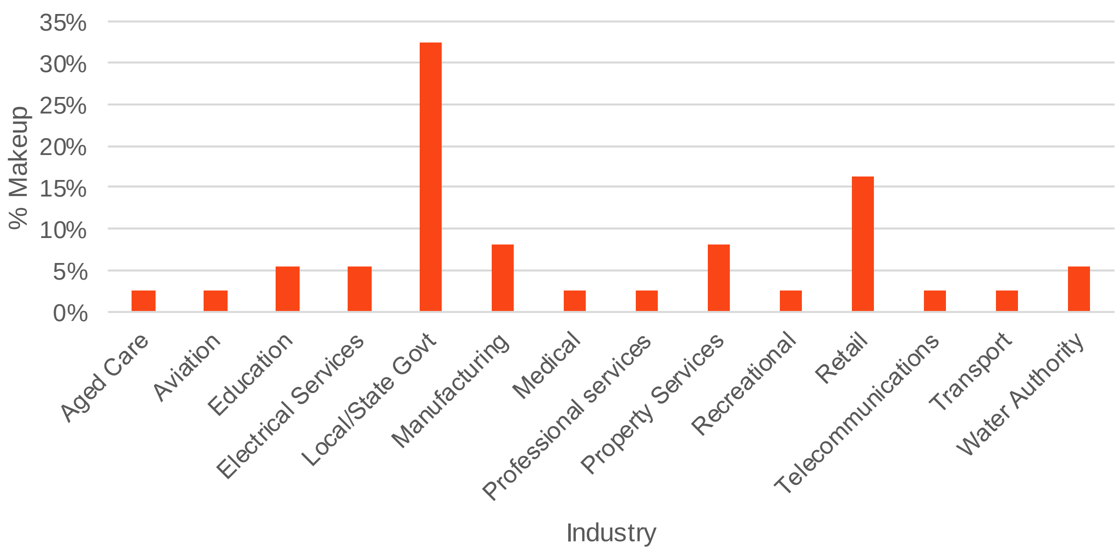
2. **The Evangelist** – This cohort enjoys talking about their EV, especially if the participant is a Tesla driver. Participants tend to not be as knowledgeable around the energy space, however the thrill of experiencing driving an EV has them more engaged in energy. This cohort will be key to unlocking mass market drivers as they spread the good news of EVs.

3. **Gets me from A to B** – This is a broad cohort that reflects the mass market and tend to have little understanding of energy. Participants need guidance and education on EVs, charging and energy. Participants don't typically use their digital app regardless of whether it's for their car or utility. Origin noted that this these participants like the perception of being green and environmentally conscious, but the process needs to be made easy to ensure adoption. Participants see their EV as a mode of transport as opposed to an energy asset that can be managed.

4.1.2 Business Participants

Origin received interest from over 50 large organisations across a wide variety of industries *(Figure 6).* Local and State Government, Retail, Property Services and Manufacturing were key segments which expressed interest in participating in the smart charging trial.

Figure 6: Split of business leads by industry



Business participants were assessed for selection into the trial based on:

- Existing sustainability and EV fleet plans.
- Availability of dedicated parking spaces to install EV chargers.
- A detailed site assessment to understand charging infrastructure requirements.
- Participation of surveys, interviews and experiments over the period of 2 years.

33 fleet chargers have been installed to date across 15 business participants *(Figure 7).*

Figure 7: Split of business participants by state

Attitudes and motivations of business participants

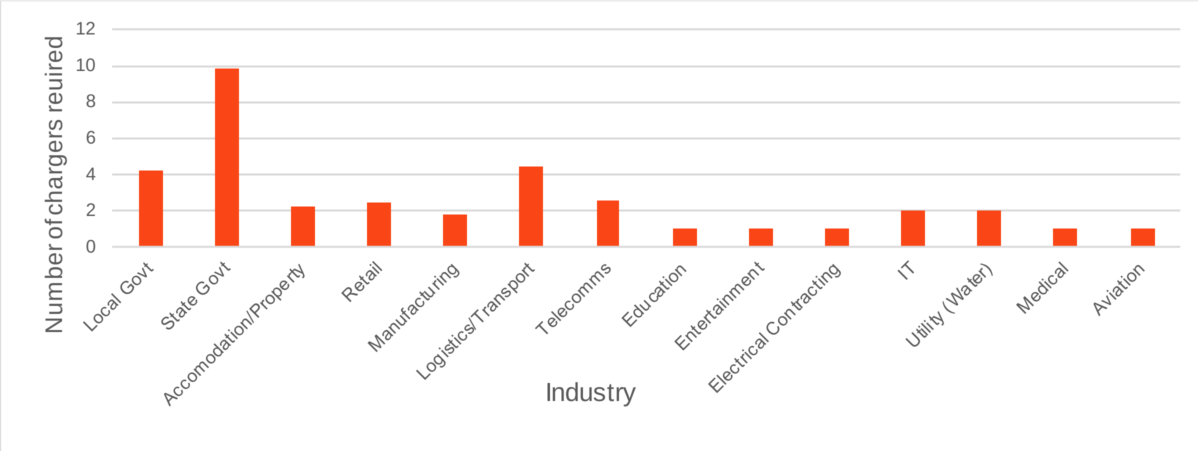
For the majority of business participants in the trial, the uptake of EVs was not driven by economics, but rather linked to a sustainability commitment or a business offering intrinsically linked to sustainability. Transitioning to EVs was seen as *"the right thing to do".*

Many Local/State Government entities are increasingly including EVs as a means of lowering transport related emissions. Many of these entities tend to have progressed beyond a single EV within their fleet and are purchasing multiple EVs and chargers across multiple sites.

Particularly in the retail segment, transitioning to EVs was either brought about by corporate targets to reduce emissions, or as a means of exhibiting the organisations commitment to the environment. It was also noted that in some instances for smaller organisations, sustainability was intrinsically linked to their business offering.

The average number of chargers by industry is a good proxy for the scale to which EV uptake has progressed by industry *(Figure 8).* Whilst many participants are looking at 1-2 chargers as a means of trialling out the technology, a few segments have expanded beyond that to include EVs as a key cornerstone of their future fleet requirements.

Figure 8: Average Number of chargers required by industry



4.2 Learnings from Participant Recruitment Process

4.2.1 Residential Participants

Origin uncovered some key learnings during the residential participant recruitment process. Most notably the following:

1. **Technical aspects and details of residential EV ownership.**

Detailed technical knowledge of the vehicles and EV ownership was very important when serving participants. This required understanding of facets such as maximum charge rates, connector types and speed of charging. This information assists in getting customers comfortable with EVs and the charging experience. For future trials, it is recommended that dedicated training sessions are conducted to better serve participants.

2. **Smart charger being offered for free as part of the trial.**

Origin noted that residential participants tended not to be as responsive in the installation process for the free charger as compared to when they are paying for a product. In some cases, unexpected additional costs even if quite relatively small to the value of the charger being installed, did result in participants pulling out of the trial.

4.2.2 Business Participants

It was noted that participants decision-making process tended to be longer when compared to residential participants, this was due to the multiple stakeholders and approvals required to purchase EVs and install chargers.

Origin noted several key findings relating to business participants:

1. **Technical aspects and details of business EV ownership and operation.**

There was major focus by businesses to ensure the compatibility of chargers and how that related to the EVs they already owned, or how it might impact future choice of EVs. Similarly, to residential participants, Origin noted that educating businesses on the specifics of charging times and charger types was important to participation in the trial

2. **How smart charging would impact fleet operations.**

Business participants were interested to understand how smart charging could help optimise the spend associated with powering their fleet, and whether smart charging could lower demand charges (i.e., by blocking charging during peak demand periods)

Business participants exhibited a level of concern around how the trial's 'charging events' may impact business operations. Questions were also raised about the amount of notice they would receive prior to events occurring and who in the organisation (either fleet managers or drivers) would be best to make decisions on whether to opt-out of smart charging or not. This concern was particularly noticeable in instances where it was a pool vehicle and not dedicated to a particular driver.

3. **Vehicle fit-for-purpose.**

Business participants were also particularly interested in understanding fit-for-purpose vehicles that were available currently in the market, and how this would suit their needs.

It is important to note that feedback from participants who did not progress through the trial cited the economics of EVs a primary reason. Businesses felt that even with reduced emissions and lower maintenance and operating costs, the economic value in obtaining an EV was not justified and instead preferred a PHEV.

Conversations with business participants also uncovered some key themes in relation to key barriers faced in taking up an EV *(Table 1)*.

Table 1: Business participant feedback on barriers to EV uptake

Barrier to EV take up	Customer Feedback
Subsidised infrastructure costs	*"We've been thinking about EVs for a while, this has provided an opportunity to have the discussion internally"*- ***Local Govt*** *"We have global commitments to transition to EVs, subsidised chargers make it more cost-effective manner"* - ***Manufacturing*** *"EVs isn't something we had considered in the past, but if there is a subsidy, we would consider it, as being a good social citizen is important to our business"* – ***Healthcare***
Home charging and reimbursements	*" The EVs would be for our sales rep's who are on the road, we'd need the chargers to be installed at their homes, how would we manage the electricity costs to power the car"* – ***Retail***
EV Costs	*"We have commitments around EVs, but at this point in time, the costs don't justify us taking that step now"* - ***Retail*** *"At this stage we have starting using hybrid vehicles, this will help us in the short-term reach our targets. It's a much more cost-effective option at the moment"* - ***Property Management***

Fit for purpose cars	*We have a global mandate on EVs and right now we have an exemption for Australia as there are no fit for purpose cars"-* ***Logistics*** *"We're interested in EVs, but we took an EV for a couple of weeks and the sales team weren't happy to use them, there wasn't enough boot space"-* ***Manufacturing***
COVID-19 Impact	*"we really want to be part of the trial, but Universities are feeling the pressure due to COVID, we can't justify the spend"-* **Education** *"We have commitments, but COVID has had a significant impact on our business, so we'll need to hold off for 12months" -* ***Aviation***

4.3 Learnings from Installation Process

4.3.1 Key learnings

Key learnings identified during the installation process include:

1. **Physical factors** – Photos from customers were key to gain a better understanding of the site requirements before an installer arrives on site. However, some physical factors were still not visible or not obvious, sometimes resulting in variation costs.

2. **Customer preferences** – The location of an EV charger was an important consideration to participants, particularly those who own multiple cars. It was important to ensure that it was possible to park the EV near the charger if the charging cable was not long enough.

3. **Cost** – Although the charger and a standard installation was at no cost to the participants, some sites required additional variation costs. For business participants, based on the site assessments completed, it was noted that depending on the site type, the cost of installing chargers could vary significantly. This included factors such as cable run from switchboard to charger location, trenching, existing site infrastructure and whether the charger was required to be pole mounted.

4. **Approvals** – The approval processes required for large businesses to purchase EVs and/or install charging infrastructure on site can require multiple stages of review, reflecting the lower number of fleet related charger installations to date.

4.3.2 COVID-19

The occurrence of a pandemic briefly impacted installation of chargers, however the largest impact to the trial was through change in charging behaviour. The exact impact of lockdowns in various states at varying times is difficult to ascertains, but we hypothesise with some confidence that this will have affected participant EV usage behaviour and therefore the baseline charging behaviour data we captured.

4.4 Performance of Hardware and Software Combination

The combination of Schneider hardware and the GreenFlux smart charging software platform are performing in-line with expectations:

- The EV charger configuration process has been relatively straight forward for installers to repeat, following initial training.
- There have been relatively few issues connecting to the smart charging platform.
- This has resulted in successful implementations of smart charging at group and single user levels.

For a cloud-based solution, reliability of connection is important to ensure stable transfer of data, instructions and servicing of hardware. Although rare, Origin has found instabilities with certain areas of the 4G network causing a lack of connectivity, interruptions, and delays in data transfer. This may limit the effectiveness of smart chargers at larger scales. Wi-Fi was considered as an alternative; however, this introduces other complexities as reliability falls onto the customer to ensure the network is maintained and secure *(Table 2)*.

Table 2: Connectivity options considered

Connectivity	Pros	Cons
4G	• Connectivity not impacted by customer • Allows remote diagnostics of connectivity problems	• Relies on telco network coverage i.e., subject to blackspots • Most expensive
Wi-Fi	• Cheapest and easiest option	• Relies on customer's Wi-Fi coverage and security to the garage/carport/driveway • Connectivity breaks if network configuration changes or if customer gets a new router or if customer moves • Cannot remotely fix or diagnose connectivity problems
Ethernet	• Most stable connection once wiring has been implemented	• Relies on customer's home security • Can be expensive due to threading cables from the router to the EV charger • Cannot remotely fix or diagnose connectivity problems • Connectivity breaks if network configuration changes or if customer gets a new router or if customer moves

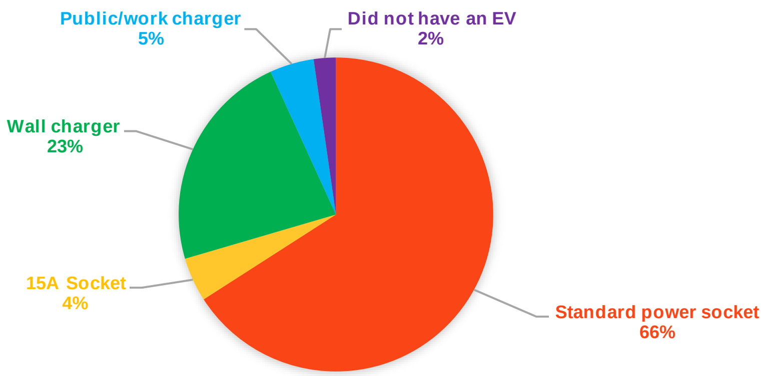
4.5 Baseline Charging Patterns and Behaviours

4.5.1 Residential Participants

Method of charging prior to joining trial

Participants were asked about their method of charging prior to joining the smart charging trial. The majority of participants were comfortable with relying on a standard power point to charge their EV *(Figure 9)*. When asked about their motivations in joining the trial, participants expressed that having intelligence around charging was more valuable than increasing the speed of charging. In fact, many did not want the maximum speed that came with a wall box charger. For example, some participants expressed that they would like to only charge their EV via solar and not draw from the grid at all – requiring speeds to shift dynamically based on their solar generation.

Figure 9: Surveyed method of charging pre COVID-19



Plug-in pattern

Participants appeared to not necessarily plug in everyday, instead opted to plug in every few days suggesting that drivers were comfortable and aware of their energy consumption.

Participants did not necessarily top up every time they parked *(Figure 10)* and preferred to plug in and charge their EV when their battery reached below 50% *(Figure 11)*. This reflects the attitudes with the early adopter cohort where the group is very comfortable with the range and use of their EVs.

Figure 10: Surveyed frequency of EV plug-in

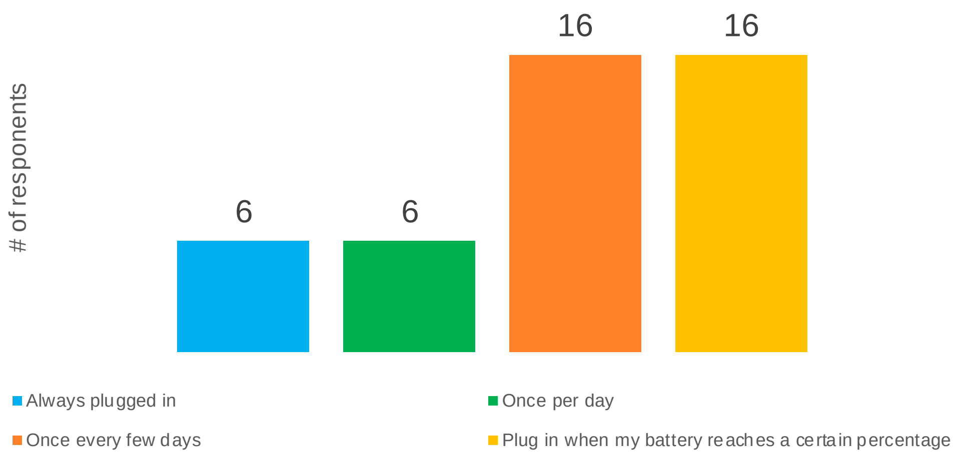
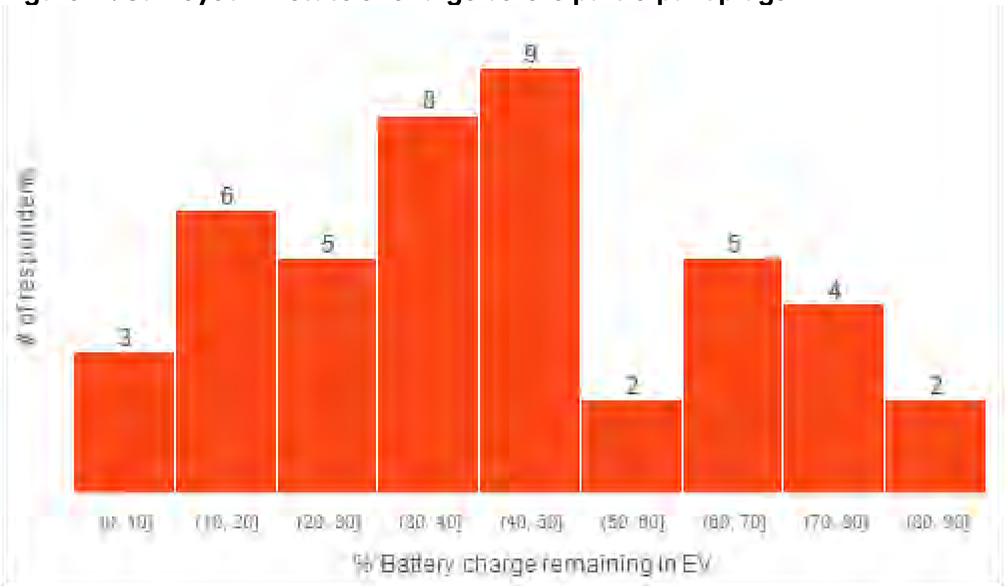
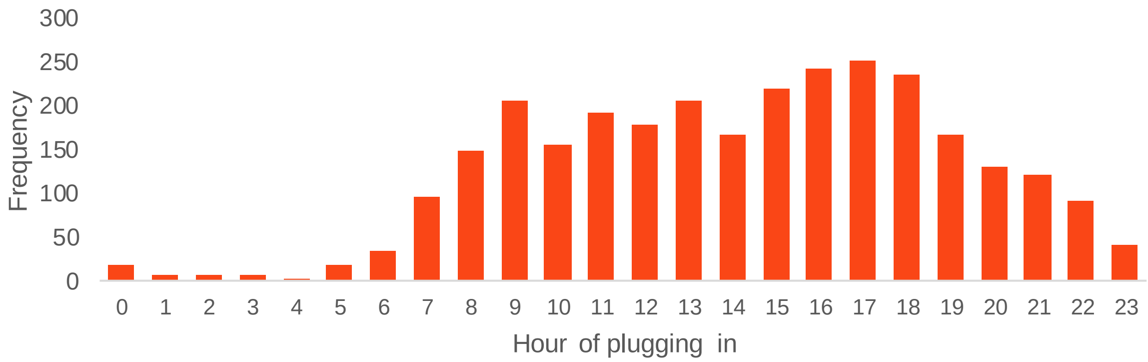


Figure 11: Surveyed EV state of charge before participant plugs in



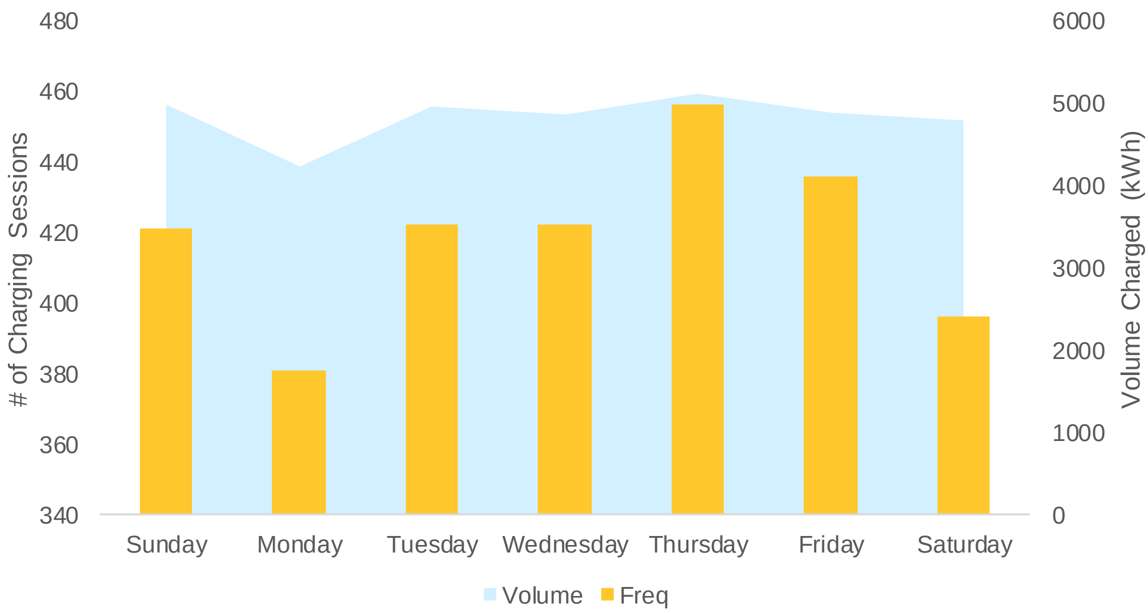
Over a 24-hour period, drivers typically plug in during early morning or afternoon *(Figure 12)*. Due to the pandemic and summer holiday period, these patterns may become more prominent as drivers move towards a typical working week.

Figure 12: Distribution of drivers plugging in between 1 Aug 2020 to 27 April 2021 by hour of day



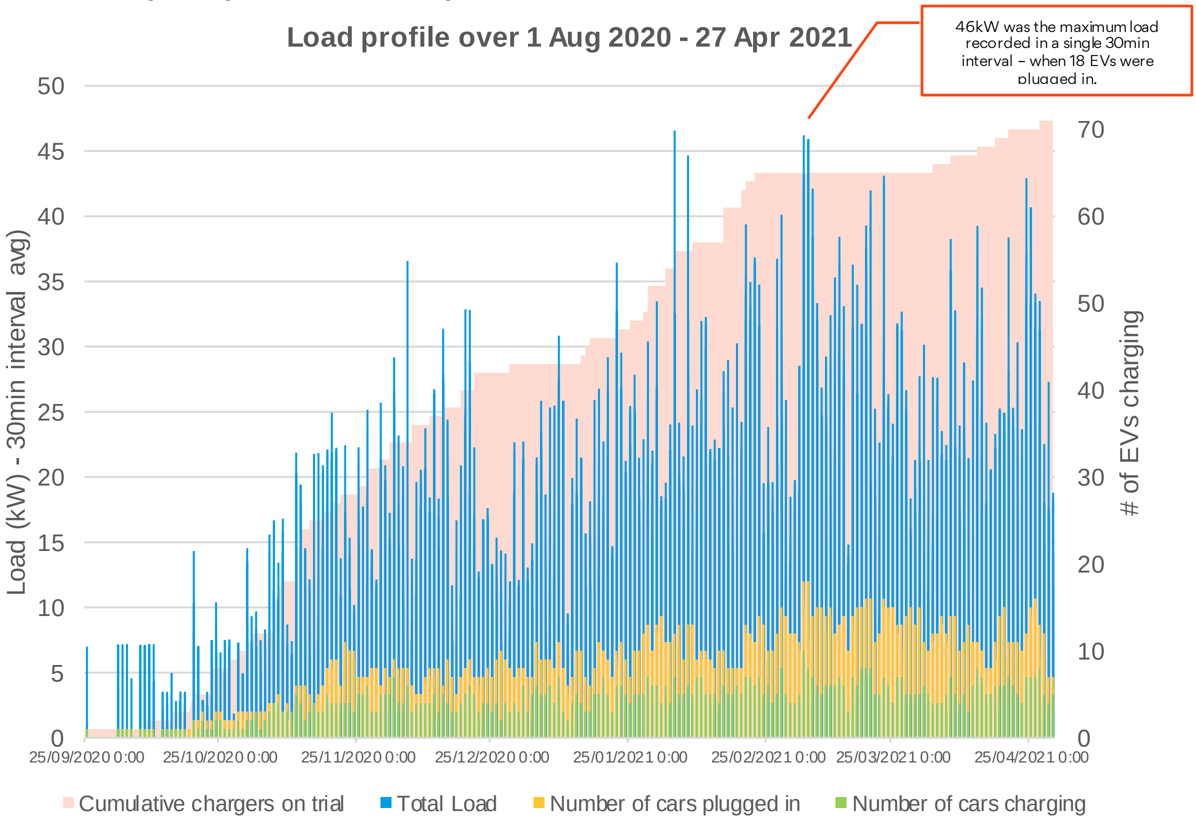
Thursdays appears to be the most popular day to charge an EV, however charging volume per session is on average smaller *(Figure 13)*.

Figure 13: Distribution of drivers plugging in between 1 Aug 2020 to 27 April by day of week



Charging profiles and patterns

Figure 14: Daily load profiles over trial period



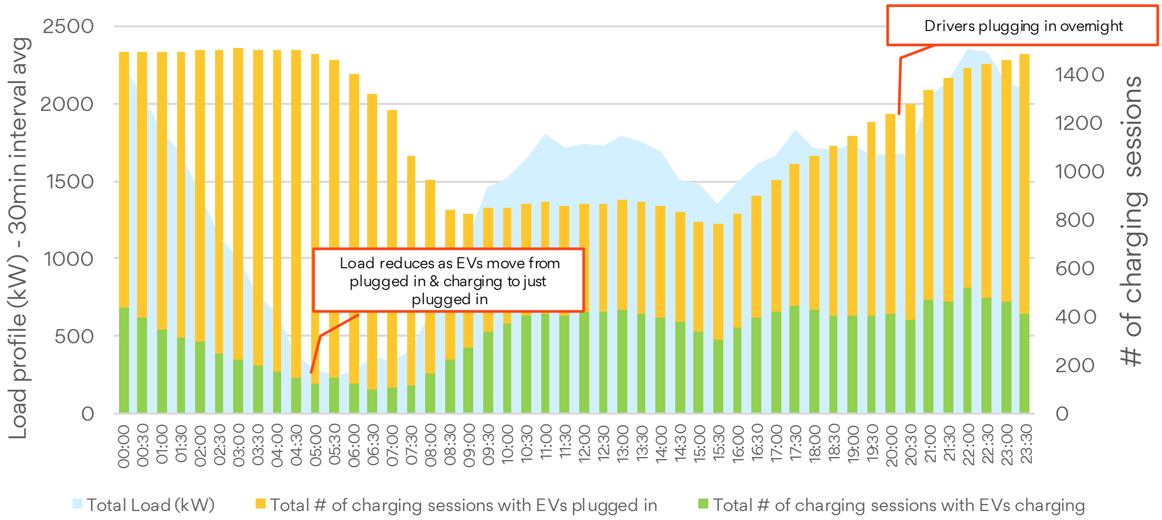
As the number of chargers increased in the trial, total charging load increased which further corresponded to an increase in daily charging load (*Figure 14*). Whilst *Figure 12* indicated the times at which participants plugged in their EVs to the smart charger, it did not indicate whether the EV was actually charging or the amount charge per session. This is important to note as the real load is dependent on various factors such as car charging schedulers, EV battery management and plug out time. This can be seen in *Table 3* which shows that whilst an EV might be plugged into the smart charger, not all of them are charging.

Table 3: Breakdown of Charging Behaviours

30 min interval with average loads >40kW			
Meter Timestamp (Local time)	**Total Load (kW) - Average for 30min interval**	**Number of EVs plugged in**	**Number of EVs charging**
4/02/2021 13:30	46.6	10	7
7/02/2021 11:30	44.7	7	6
7/02/2021 13:00	41.8	8	6
28/02/2021 15:30	40.1	15	8
5/03/2021 19:00	42.1	14	7
5/03/2021 22:00	43.2	16	8
5/03/2021 22:30	40.5	17	8

5/03/2021 23:00	40.1	17	8
5/03/2021 23:30	46.2	18	10
6/03/2021 0:00	45.8	18	7
6/03/2021 0:30	45.9	18	8
7/03/2021 21:30	42.1	13	7
20/03/2021 0:00	40.9	16	8
20/03/2021 0:30	42.0	16	7
23/03/2021 22:00	43.1	14	7
23/03/2021 22:30	42.3	14	7
24/04/2021 13:30	42.9	10	7
25/04/2021 0:00	40.6	13	6
25/04/2021 0:30	40.7	13	6

Figure 15: Daily loads summarised by hour of day over a 24-hour period



Note:

- Loads are 30-minute averages
- Charging is defined as any load greater than 0kW
- Plugged in is defined as any interval where a meter value has been registered

Figure 15 provides a cumulative view of *Figure 12* where the total effect of drivers plugging in and charging can be seen. There are 3 peaks from a load perspective, midday, evening and midnight. This is surprising as it suggests that participants are already somewhat managing their load to optimise for solar.

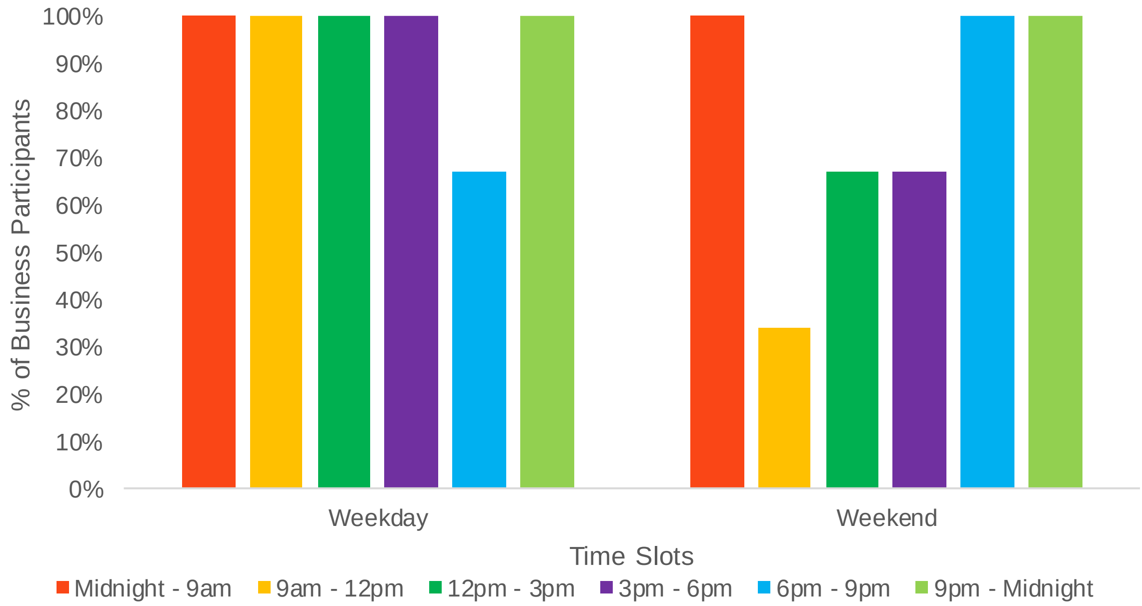
By aggregating load by 30-minute intervals in a 24-hour period, we can observe what a typical daily profile may look like. To give context of the volume of charging sessions, we have shown the total number of charging sessions.

4.5.2 Business Participants

The survey highlighted for business participants that although the majority travelled between 200-300km per week, less than one full charge for many of today's EV models, chargers were predominantly plugged-in at all times while the car was not in operation.

It was also interesting to note that the charging habits by time of day didn't seem to follow any obvious pattern, potentially reflective of the data from a mix of organisations in a number of industries which use their fleet in a manner tailored to their business' needs. For example, 100% of business participants indicated that they would charge from midnight to 9am both on weekdays and weekends *(Figure 16)*. However, only 34% of business participants indicated that they would charge from 9am to 12pm on weekends, compared to 100% on weekdays.

Figure 16: Surveyed typical charge times for business participants



Note: data is used to provide context

Even with the inclusion of on-site charging infrastructure, many participants still desired access to public charging to supplement their charging requirements.

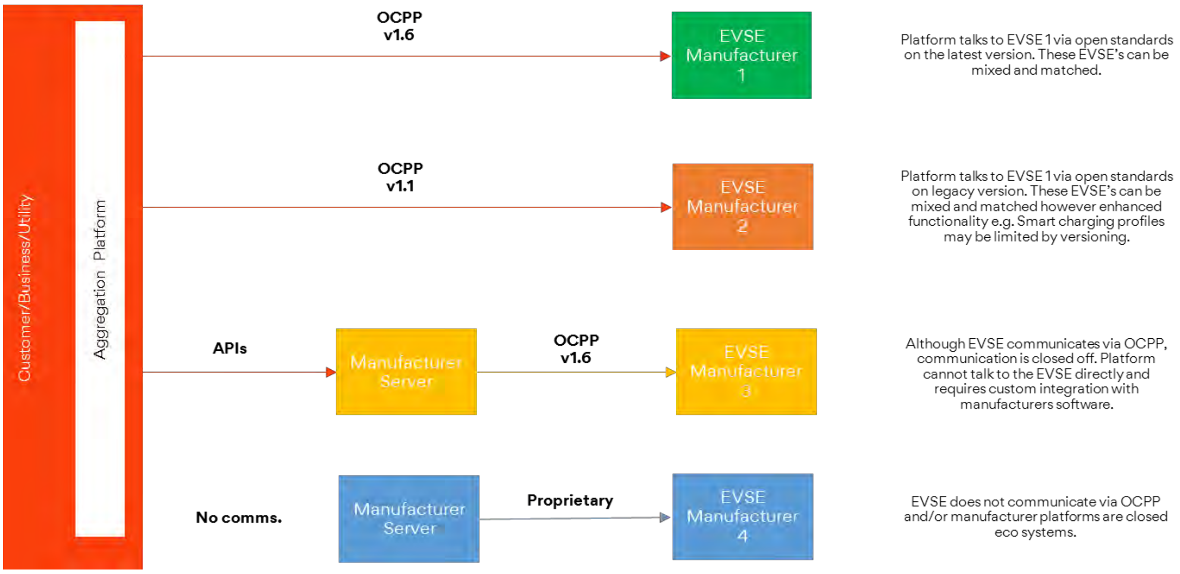
5. Market Observations

5.1 Standards of Communication

In an ideal world, sending and receiving data to the EV charger occurs in a simple and universal way. As part of the assessment of hardware providers, Origin identified a number of factors that may prevent utilities/businesses/customers from using chargers from different manufacturers in a coordinated manner.

a) Open Charge Point Protocol (OCPP) versions – Mixing and matching hardware and software across different OCPP versions will introduce additional maintenance across the ecosystem of charger and software platforms. This may drive the need for feature tracking to enable or disable specific features depending on the combination of hardware and software.
b) Closed/proprietary eco-systems – Closed or proprietary ecosystems force operators into either using one manufacturer or can make it costly to integrate if integration is even available.

Figure 17: Example of how lack of standards may lead to increased cost and management overhead due to custom integrations



How data is collected (frequency, format, required data) and transported is dependent on how it is being used. For example, a grid operator may require live data at 1-minute intervals to monitor substations whereas a utility may only need hourly intervals that are sent at the end of day in to bill a customer on a time of use tariff.

Any entity who requires aggregation of different EV chargers would likely have different requirements on how data is collected and transferred, introducing complexity and cost. Communication standards should be explored to enable interoperability between all participants of the eco system whilst minimising overall costs.

5.2 Adoption of Smart Chargers

Core to achieving the benefits that smart chargers offer is the assumption that EV owners will install smart chargers at home.

There are several hurdles that need to be overcome for that assumption to be reality.

1. **The desire/need to install a dedicated EV charger.**

Consumers and businesses need to first be aware that it is an option to purchase a dedicated Level 2 EV charger versus other existing alternatives (Level 1 and Level 3). Then, the next factor is whether a large proportion of EV owners will seek out installation of dedicated chargers at their home or workplace, and whether the benefits would outweigh the costs for the user. Indicatively, pricing for a wall charger can vary between $1,000 - $2,000 excluding installation.

2. **The desire to install a smart charger over a traditional charger.**

Consumers and businesses who do decide to install a Level 2 charger at their premises will also need to be aware of the availability of smart chargers over traditional chargers. Pricing for a smart wall charger can vary from $1,500 - $3,000 excluding installation.

3. **The real-world challenges of installing smart chargers.**

As Origin has learnt during the trial, there are a number of real-world challenges to the installation of smart chargers such as installation and wiring requirements, and switchboard and capacity requirements. Whilst not unique to smart versus traditional chargers, these issues do present challenges to the adoption of chargers.

These challenges are not unique to Australia. Combatting these challenges has been largely tackled by other jurisdictions through the use of tax or financial incentives. Countries such as Germany, Italy, France, Norway, Spain, Sweden, Netherlands, and the UK are offering some form of tax credit or reduction in cost of charger installation for homes, businesses or both.

5.3 Energy Curtailment as Part of a Broader Ecosystem

Although the trial is focussed on electric vehicles, it is important to note that the overall goal is the management of energy consumption. With EVs sitting alongside other assets on a site, Origin recommends that policies and technologies are focussed on the site level whilst giving flexibility to the customer to choose how they respond to a market signal whether it be via an EV charger, pool pump or otherwise.

6. Next Steps

Origin will continue to install the remaining chargers for business participants and commence smart charging experiments with participants in late 2021.

7. Key Terms

Term	Description
AI	Artificial Intelligence
ARENA	Australian Renewable Energy Agency
EV	Electric Vehicle
NEM	National Electricity Market
OCPP	Open Charge Point Protocol
Origin	Origin Energy
PHEV	Plug-in hybrid electric vehicle
RFID	Radio-frequency identification
TCO	Total cost of ownership
VPP	Virtual Power Plant