AGL Electric Vehicle Orchestration Trial

Lessons Learnt Report 2

September 2021

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This Project received funding from ARENA as part of ARENA's Advancing Renewables Program.

1. Executive Summary

AGL's Electric Vehicle Orchestration Trial has received funding from ARENA as part of ARENA's Advancing Renewables Program. The trial comprises three streams:

- A trial of orchestrated residential EV smart charging comprising 200 participants who will have their charging controlled via a smart charger installed in their homes.
- A trial of two emerging charging technologies:
    - Vehicle to grid (V2G) – 50 participants who will have vehicle charging and discharging controlled via a V2G charger installed in their homes.
    - Vehicle API charging control – 50 participants who will have their vehicle charging controlled remotely via an API supplied by the vehicle manufacturer.
- A control group of 100 customers on a time-of-use (TOU) tariff to assess the effectiveness of a tariffication incentive against that of firm charging control.

Recruitment of participants for the smart charging and vehicle API streams have been completed. 156 of the 200 smart chargers have been installed, with covid lockdowns in NSW and Victoria slowing the installation rate in the last few months. Smart charging vehicle API aggregation software development is complete. These two trial streams are slightly ahead of schedule and will remain so provided that the covid delayed installations can be completed in Q4 2021.

The TOU control group has also been selected and metering data is being accumulated for this group.

The requirement to obtain certification of V2G chargers to AS4777.2 has delayed the supply of these chargers, which are now expected in early 2022. Technical questions remain regarding interfacing to and controlling the V2G chargers; these are being worked through at present. This stream of the trial is currently slightly behind schedule.

2. Introduction

The AGL Electric Vehicle Orchestration Trial project commenced in November 2020 and has received funding from ARENA as part of ARENA's Advancing Renewables Program.

The trial comprises three streams:

- A trial of orchestrated residential EV smart charging to assess the value of controlled charging as a distributed energy resource – 200 participants who will have their charging controlled via a smart charger installed in their homes.
- A trial of two emerging charging technologies:
    - Vehicle to grid charging – 50 participants who will have vehicle charging and discharging controlled via a V2G charger installed in their homes.
    - Vehicle API charging control – 50 participants who will have their vehicle charging controlled remotely via an API supplied by the vehicle manufacturer.
- A control group of 100 customers on a time-of-use (TOU) tariff whose performance will be compared with the participants on controlled charging to assess the effectiveness of a tariffication incentive against that of firm charging control.

There are three phases to the trial:

Phase 1: Recruit and Build – recruitment of all trial participants, installation of charging hardware in homes and development of an aggregation platform to manage and control charging. This phase takes place during calendar year 2021.

Phase 2: Operate – test and understand the feasibility and value of smart charging as a distributed energy resource; trial the emerging vehicle API and vehicle-to-grid technologies; assess the experiences and perceptions of participants regarding EV charging orchestration; in conjunction with the Distribution Network Service Provider (DNSP) partners in the project, understand the positive and negative impacts of EV orchestration on the distribution network. This phase takes place during calendar year 2022.

Phase 3: Close-out – transition customers from the trial, analyse any remaining data and publish the final project report. This phase takes place in the first half of 2023.

3. Aggregation Software Development

3.1. Smart Charging

To control the smart chargers installed in participant's homes and to give participants visibility and control of what is happening with their charging, a charging aggregation platform has been developed for the smart charging stream. The platform comprises three elements:

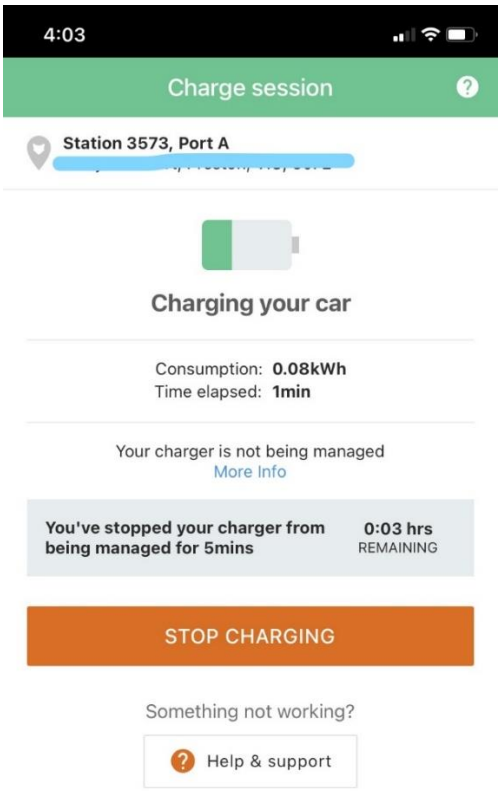
- A smartphone app that allows customers to:
    - see their current charging status
    - see what charging control is planned over the next few days
    - be notified of up-coming ad-hoc charging control events
    - override controlled charging when needed.
- EV charger aggregation software that:
    - manages the database of individual chargers in the field
    - sends control and programming commands to the chargers
    - manages the data behind the customer app, including notifications
    - groups chargers into blocks of controlled load that can be dispatched individually or together
    - manages the collection of data from the chargers
    - provides an interface for setting up charging schedules and ad-hoc charging control.
- A second software platform that collects data from the charger aggregation software and provides visibility and analysis tools to allow EV charging to be viewed together with other distributed energy resources being operated by AGL.

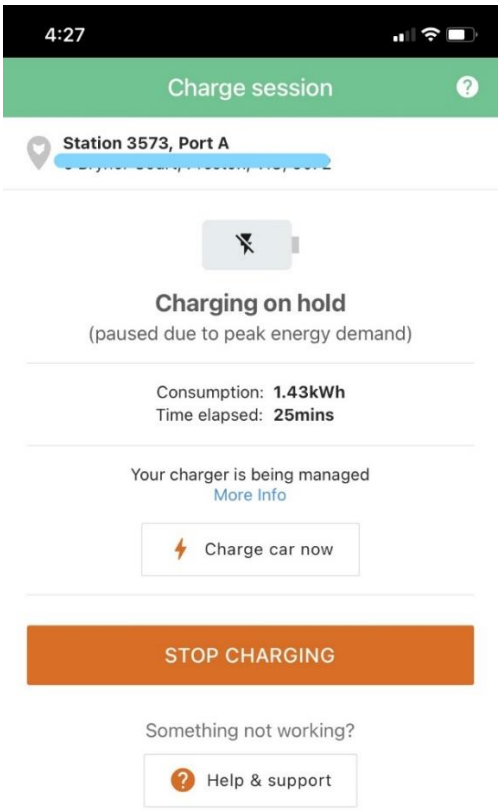
The first two elements of the platform have been developed by Chargefox specifically for this project, as extensions to the existing Chargefox software and app used for the management of public chargers. The third element has been developed as an extension to AGL's internally developed NEO platform that manages distributed energy resources such as residential batteries.

Detailed development of these elements commenced in January 2021. The extensions to both the Chargefox aggregation platform and smartphone app are now complete and tested. The required modifications of the AGL NEO system and the API connection between the Chargefox and NEO are also complete, tested and cut over to the production version.

The development of this software has proceeded smoothly with no significant issues encountered. The existing Chargefox platform and app has proved to be an ideal base to add the orchestration functionality required for the next phase of the trial. The fact that the Chargefox platform is built around the Open Charge Point Protocol (OCPP) should make the future integration of different brands and models of chargers relatively straightforward.

Baseline data is currently being collected from the chargers that have already been installed. This will be used to compare against charging patterns under the various control scenarios to be trialled. The first scheduled control of customer chargers is programmed to commence in the coming weeks.





Sample screens from Chargefox app

3.2. Vehicle API

The software to manage the control of charging via the vehicle API is similar in concept to that being used for smart charging except that the software communicates directly with individual vehicles via an API provided by the vehicle manufacturer for this purpose. The vehicle then manages its own charging no matter what charger it is connected to, be it a smart charger, a “dumb” charger or even just an extension lead plugged into a general purpose outlet.

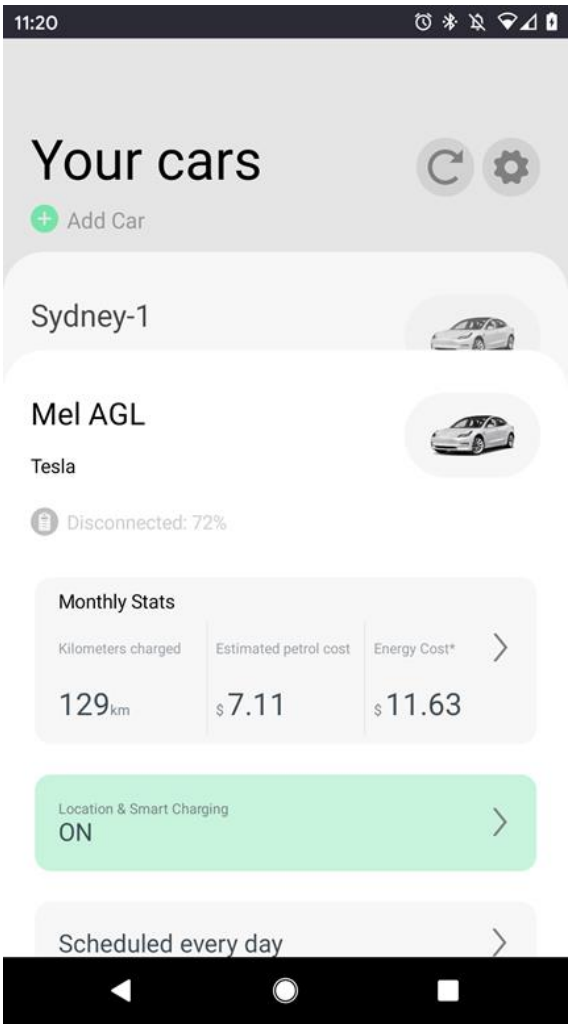
For this part of the project AGL, is using the platform developed by US company Flexcharging Inc, with minor modifications to meet the trial requirements.

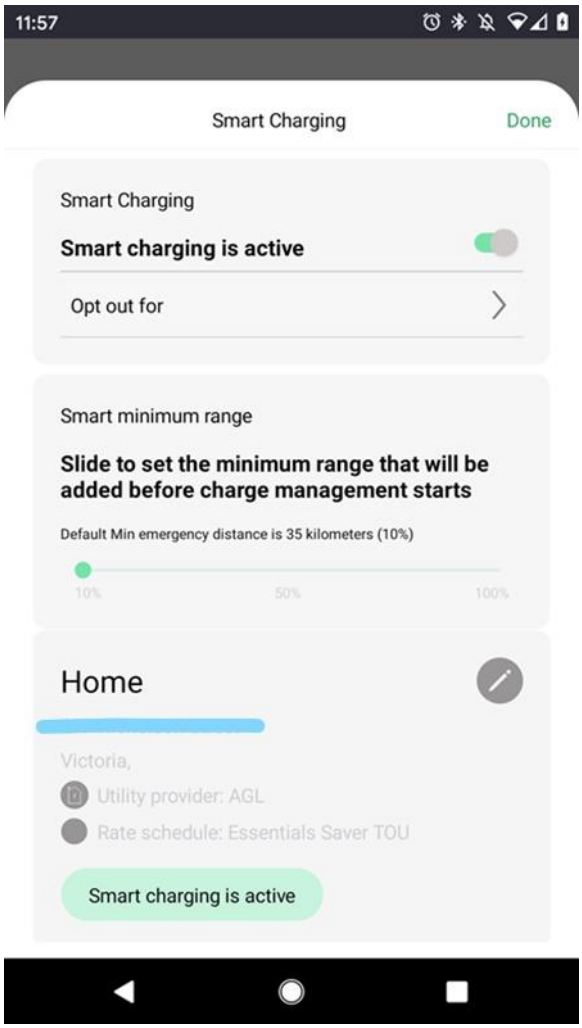
The overall architecture of the vehicle API platform is similar to that of the smart charging platform:

1) A smart phone app to allow the customer visibility and control of their charging.

2) An aggregation platform that manages the data and control aspects of the trial and communicates with the vehicles via the vehicle manufacturer API. (AGL will be using Tesla vehicles for this part of the project as Tesla have a well-developed API in operation globally, including in Australia.)

3) A data interface to the AGL NEO software for data management and analytics.





Sample screens from Flexcharging app

This development is now complete, including data transfer from the Flexcharging platform to NEO. The project was fortunate in that a new version of Flexcharging software released towards the end of 2020 was almost exactly what was required for this project and the modifications needed were therefore minimal.

Baseline data is currently being collected from the vehicle API participants. We anticipate turning on scheduled control of charging of these vehicles in the coming weeks, in line with the smart charging stream.

3.3. Vehicle-to-Grid

Development of the vehicle-to-grid aggregation software has not yet commenced. Delays the availability of the V2G chargers, and a lack of clarity in the specification and functionality of the chargers, has meant that it has not been possible for software development to be properly defined and scoped. Development will commence when these issues have been resolved. This is discussed further in section 5.2.

3.4. Lessons Learnt

3.4.1. Smart Charging

Development

Whilst the charger control functionality required for the trial is not commonly available from software vendors off-the-shelf, it did not involve significant technical challenges and used charger management functionality already existing in Open Charge Point Protocol (OCPP) version 1.6. Development of the smart charging platform was therefore relatively straightforward. A minor time overrun was allowed for in the project plan and did not affected ARENA milestone delivery or other project activities.

The fact that Chargefox's existing software and app already had the basic elements in place to manage and control OCPP chargers was a significant plus for this part of the project, as was the fact that they had previous experience with control and monitoring of Schneider EVLink chargers.

3.4.2. Vehicle API

Development

The vehicle API development has also gone smoothly. At the time Flexcharging were contracted to provide the vehicle API aggregation platform for this project, they advised a new version of their software and app was due to be released at the end of 2020 that had almost all the functionality necessary for the trial already built in. Testing confirmed this. Consequently, only minimal modifications to the Flexcharging platform have been required.

Security

The vehicle API part of the trial is confined to Tesla vehicles as these are the only EVs that currently support the required functionality in Australia. To access the vehicle telemetry, the Flexcharging app requires drivers to log in using their Tesla credentials.

This normally works without problems, however whilst we have been working with Flexcharging on introducing the software and recruiting customers, Tesla has modified their security requirements for driver login multiple times. This has necessitated Flexcharging, who get no advance notice of these changes from Tesla, to do a lot of rapid work in the background to modify the login process in the software and app to accommodate the changes. Fortunately they are able to do this, however the frequency of changes required over that period has been a surprise.

It is hoped that the Tesla login process stabilises during the remainder of the trial. Alternatively, in the longer term, a separate access process for corporate users could be provided by vehicle manufacturers to mitigate this problem.

3.4.3. Vehicle to Grid

Technology Readiness

Project work to date has found that V2G technology is still at a very early stage globally, with small scale trials being undertaken using pre-production hardware and rudimentary software systems. V2G chargers are not generally being sold as commercially available product.

The integration/interfacing of V2G chargers with control and aggregation software is not yet standardised – OCPP Version 2 promises to do this in the future but is not yet a reality. Consequently, a number of technical questions remain regarding the method to interface with and control the V2G chargers in the trial, and it will be necessary for the project to resolve these before moving ahead with development of the aggregation platform. This issue is being worked through with our hardware and software partners at the present time.

4. Customer Recruitment

4.1. Participant Offer

The participant offer has remained unchanged throughout the participant recruitment process. It comprises:

- Smart charging – free smart charger and installation (for a "standard" install), bill credit and carbon neutral energy plan.
- Vehicle API – bill credit and carbon neutral energy plan.
- V2G charging – discounted charger, bill credit and carbon neutral energy plan.

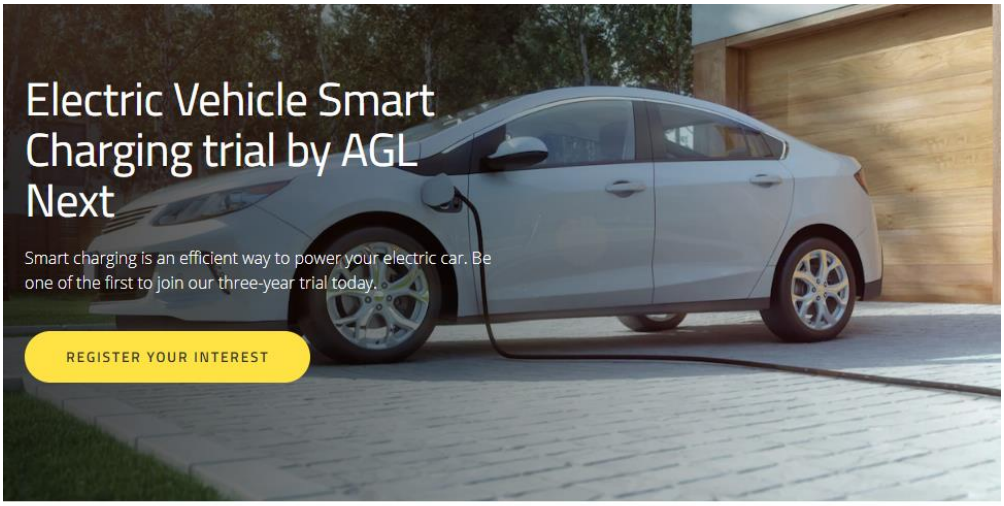
4.2. Expressions of Interest and Participant Recruitment

The AGL EV Smart Charging Trial was announced publicly via media release on 18 November 2020. To support the announcement, a landing page was launched on AGL's website providing customers with further detail on the trial and allowing them to express interest in joining.

The announcement gained significant exposure via earned channels such as news media outlets, energy market websites/blogs, and electric vehicle related forums. As a result, around 400 expressions of interest were received between the time the trial was announced and when we commenced customer recruitment in late March 2021. Over 1,300 expressions of interest were received in total during the period up until the registration portal was closed in September 2021.

Customers who expressed interest in joining the trial were contacted by a specialist team who provided them with further details, discussed eligibility requirements, read out trial terms and conditions, and gained their consent to participate. As expected, conversions of expression of interests into trial participants was very high. Of those that failed to convert, this was primarily because they were ineligible due to their vehicle or property type.

At the time of writing all 200 smart charging participants and all 50 vehicle API participants had been recruited, although a small number of vehicle API participants subsequently dropped out over concerns that their vehicle was being "woken up" by background communications to it. These are presently being replaced.



About the trial

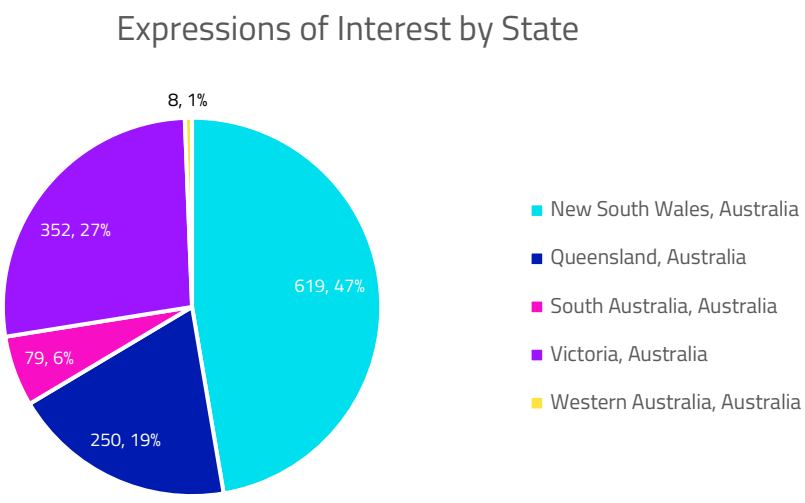
If every electric car driver comes home from work and starts charging at the same time, while the grid is already at peak demand, it's just going to add to the pressure. To cope with that, we may need a bigger grid, which would be expensive - and could mean higher electricity bills for everyone. But what if we could just get smarter about when we charge our cars?

Introducing smart charging

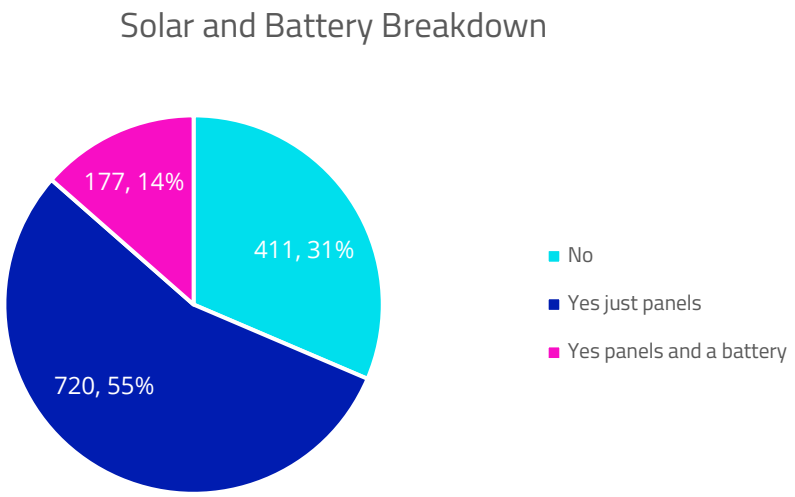
Smart charging means we can communicate with your charger, or car, to start charging when the demand for electricity is lower - like overnight or in the middle of the day. And since most cars are plugged in for longer than they actually need to charge, we can be flexible with charging times.

Part of the trial landing page

Of the 1,308 expressions received, 47% were in NSW followed by 27% in Victoria.



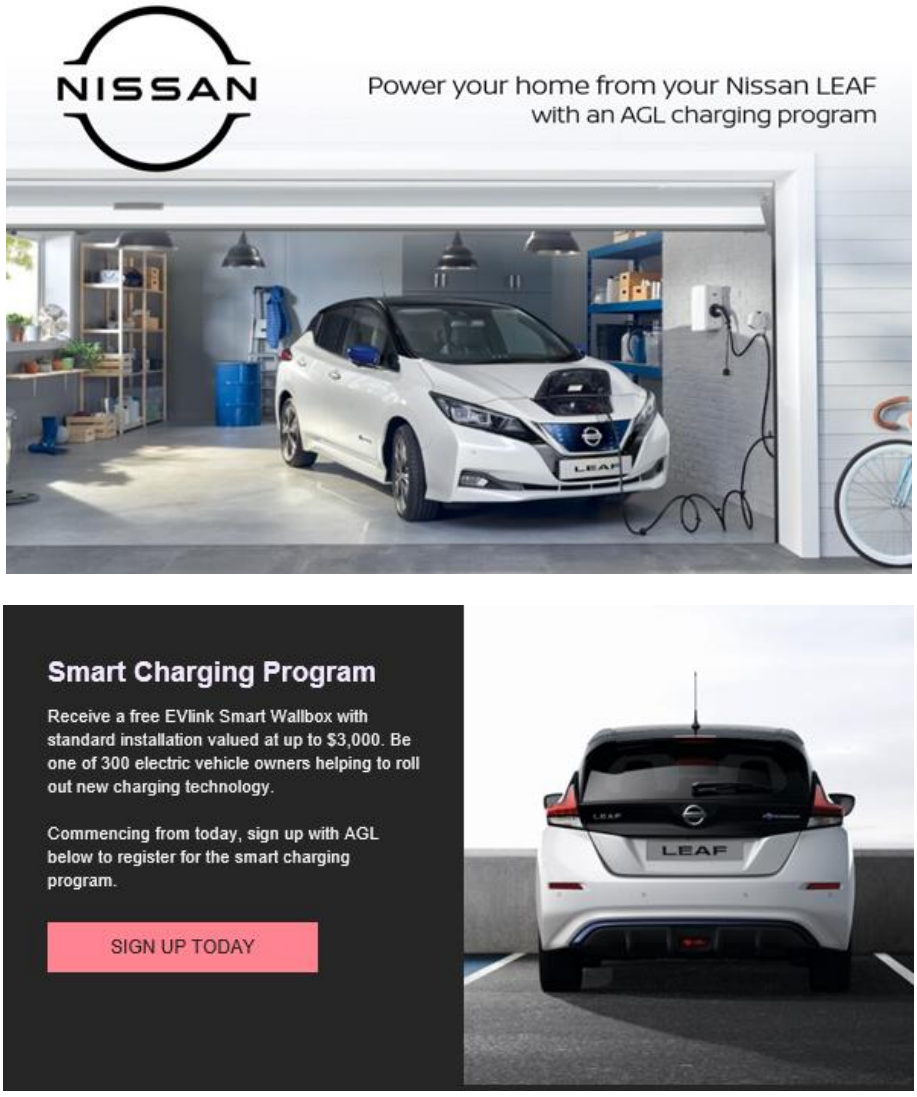
Furthermore, 69% of those who expressed interest in joining the trial had solar panels, with 55% having solar PV only and 14% having both panels and a battery. This is more than double the national average.



4.3. Marketing

A marketing strategy was developed to ensure enough expressions of interest were generated to fill the trial customer quota; however, due to the strong interest shown prior to commencing customer recruitment, many of the marketing activities planned were not required.

To generate additional expressions of interest to those acquired organically we worked with EV manufacturers Nissan, Hyundai, and MG on a targeted electronic direct mail (eDM) campaign. The eDM presented customers with the trial proposition and included a "call to action" which linked to the AGL Smart Charging Trial landing page. The campaigns were a success achieving a conversion rate of around 40% from unique send to expression of interest submitted.



Example recruitment email, in this case from Nissan

4.4. Vehicle API

Recruitment for the vehicle API stream of the trial was quite rapid with all 50 participants recruited inside five weeks. The key eligibility criterion for this group was ownership of a Tesla vehicle, as Tesla is currently the only EV manufacturer with necessary vehicle API capability available in the Australian market. The rapid recruitment can at least partly be explained by the low impact nature of this part of the trial, as there is no installation needed in the home and no need to organise a tradesman visit.

A small number of vehicle API participants withdrew from the trial shortly after signing up. We will investigate the reasons for this as the trial progresses.

4.5. Vehicle-to-Grid

Recruitment for the vehicle-to-grid stream is presently on hold until we have a clearer view of charger availability and resolution of the technical architecture issues.

There was considerable interest in this stream from Nissan Leaf owners and there are many registrations of interest from this group currently being held. Recruitment will occur from this list.

4.6. Lessons Learnt

The highly engaged nature of the EV driver cohort has meant that recruitment for the trial has been much easier than expected and many of the marketing channels that we had planned to use have not been necessary.

Recruitment to the vehicle API group was particularly rapid and this may be at least partly explained by the attraction of a charging management solution that requires no hardware installation.

5. Charger Supply Chains

5.1. Smart Chargers

AGL has selected the Schneider EVLink Wallbox charger for the initial stages of the smart charger rollout, and this charger has been used in all installations up to the time of this report. To date, there have been no supply chain issues with this charger – supply has been very reliable – and there have been no technical failures of the charger in the field.

AGL is currently assessing a different model charger to potentially take over from the Schneider EVLink Wallbox at a later stage of the trial. This model offers additional functionality in a smaller footprint with a lower cost and would therefore be very attractive for a wider-scale rollout. At the time of writing, this charger has still not been fully validated for use in the trial.

5.2. Vehicle-to-Grid Chargers

AGL's original plan was to commence installation of chargers for the V2G stream in June 2021. The charger proposed to be used is the Wallbox Quasar, being supplied in Australia through JET Charge. This is one of only two residential V2G chargers currently available for trial purposes on the global market to our knowledge.

As V2G chargers contain a grid-connected inverter, they must comply with the Australian Standard for grid connected inverters, AS 4777.2. Unfortunately, the timeframe for the Quasar charger to achieve certification to this standard extended by many months from what was initially forecast.

AGL received certification that the Quasar has passed testing to AS4777.2 in September 2021. JET Charge is now going through the process to obtain Clean Energy Council (CEC) accreditation for this charger, which is a pre-requisite to connecting them to the electricity network. We have been advised that chargers for the rollout should be able to be supplied in early 2022.

However, a number of issues remain to be resolved regarding how the charger will be integrated into an aggregation platform for control and monitoring. A key assumption when the project was being scoped was that V2G chargers would use the OCPP Version 2.0 protocol, the first OCPP version to include V2G functionality, and that they would connect to the internet in the same way as other smart chargers. As more technical information on the Quasar charger has started to emerge, it has become clear that this is not currently achievable. Further to this, discussion with a number of overseas parties suggested that the software systems used for some of the UK trials were quite minimal and would not achieve the objectives for this trial.

AGL is currently in discussions with our aggregation and charger partners to develop a suitable approach to control and monitor the V2G chargers for the trial that will fit within the trial timeline and budget.

5.3. Lessons Learnt

The selection of a major global smart charger manufacturer with a stable product, tests and approvals in place, well established supply chains and excellent local representation has resulted in a trouble-free supply of smart chargers for the trial.

At the time this trial was being scoped in late 2019 and early 2020, very little was known about V2G charging and chargers. This part of the trial was undertaken with an expectation that equipment in its very early formative stage, developed and used overseas for small scale trials, could be used here too, and that V2G would be further productionised by the time we needed to roll out the chargers. Unfortunately, these assumptions were incorrect.

Nevertheless, solving these problems is the reason technology trials are undertaken, and AGL thanks ARENA for its understanding and support while we develop a solution to enable this part of the trial to proceed.

6. Charger Installation

6.1. Smart Chargers

AGL has partnered with JET Charge for the supply and installation of smart chargers. The installation program commenced on 31 March 2021. At the time of writing 156 of the 200 smart chargers required for the trial have been installed. Covid lockdowns in NSW and Victoria have slowed the installation rate in recent months, with more than 30 installations currently queued for installation in those states once restrictions ease. Installations in South Australia and Queensland have been largely unaffected by this.

Typical trial charger installation

There have been very few problems encountered with the installation of chargers in houses. The installation process has generally gone very smoothly, although it should be noted that AGL has deliberately excluded some types of installations from being eligible for the trial to keep costs within budget. These exclusions include strata-titled properties where body corporate approval would be

needed for charger installation, and properties where trenching would be necessary to install the charger supply cabling.

Customer feedback on the recruitment and installation process has been very positive, with a very high net promoter score of +58 from those customers who have had a charger installed. This is reflective of the good work being done by the AGL and JET Charge personnel involved in the process, but will also be influenced by the fact that customers are receiving a free charger.

6.2. Vehicle-to-Grid Chargers

There have been no vehicle-to-grid charger installations to date.

6.3. Lessons Learnt

Not all residential chargers can be installed with the full charging capacity enabled due to house wiring, switchboard and service fuse limitations. With around 75% of the 200 trial chargers now installed, 44% have had their charge rate limited to less than the nominal 7.4kW (32A), with the average maximum charge rate of this particular group of chargers being 6.3kW. Anecdotally, charger installers have advised us that it is very common to limit the maximum power of chargers installed in homes.

The breakdown of maximum charge rates for the trial installations so far is:

Maximum Power (kW)	Current (A)	Percentage of installations
7.4	32	56%
6.0	26	11%
5.8	25	6%
4.6	20	26%
3.7	16	1%

This data will be updated in the next report when all chargers have been installed. It may prove of value for electricity system planning purposes.

7. Customer Research

As a condition of joining the trial, customers agreed to be contacted regarding participating in surveys and research over the duration of the program. Ultimately participation in research and surveys remains voluntary, however past research experience and anecdotal evidence gave confidence that participation rates would be high.

An important component of the trial is understanding customers attitudes toward a smart charging arrangement and whether their feelings change over the course of the trial. For smart charging to achieve its stated goals, adoption must be high, therefore it's critical to understand customers experiences of smart charging to ensure future propositions are designed with customers at the centre.

7.1. Online Survey Results

An online survey was sent to 133 trial participants and 89 completions were received, a completion rate of 65% (participants were not directly incentivised to complete the survey). Recipients of the survey included a mix of participants from the 'Connected Car' and 'Connected Charger' streams.

7.2. Survey Participant Demographics

Due to the lack of randomisation in the survey sampling we cannot say the demographic makeup of survey participants is representative of the broader EV market. However, anecdotal evidence and other EV research suggests common traits emerging within the current cohort of EV purchasers.

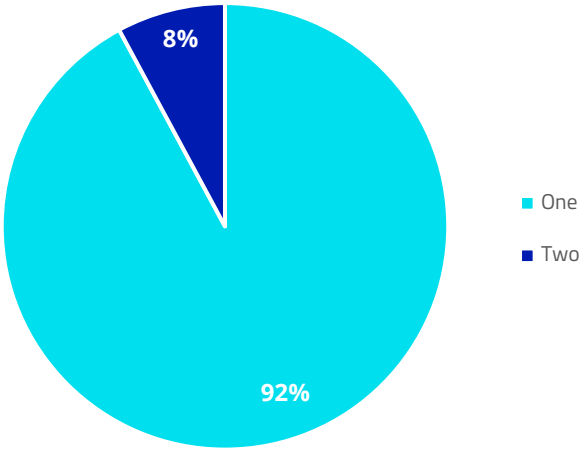
81% of survey respondents were male, 50% were aged between 45 and 60, and 68% said they work full time. Of those who responded to the question, 43% fell into the 'high income' bracket with an annual household income >$200k, and 60% said they work in a 'highly skilled profession', eg, doctor, engineer, office-based executive.

7.3. Vehicle Use and Ownership

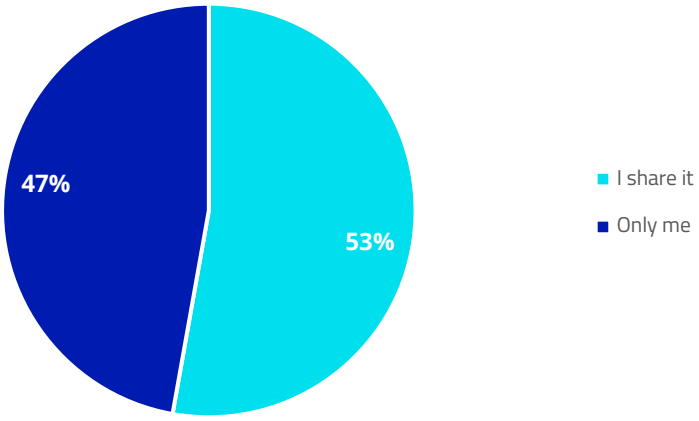
Average driving distances, vehicle type, battery size and the primary purpose of the vehicle are all variables that are likely to impact the degree of flexibility in charging times. If, for example, the vehicle is a company car used to travel long distances frequently, the customer will likely have longer charging requirements providing less opportunity to orchestrate.

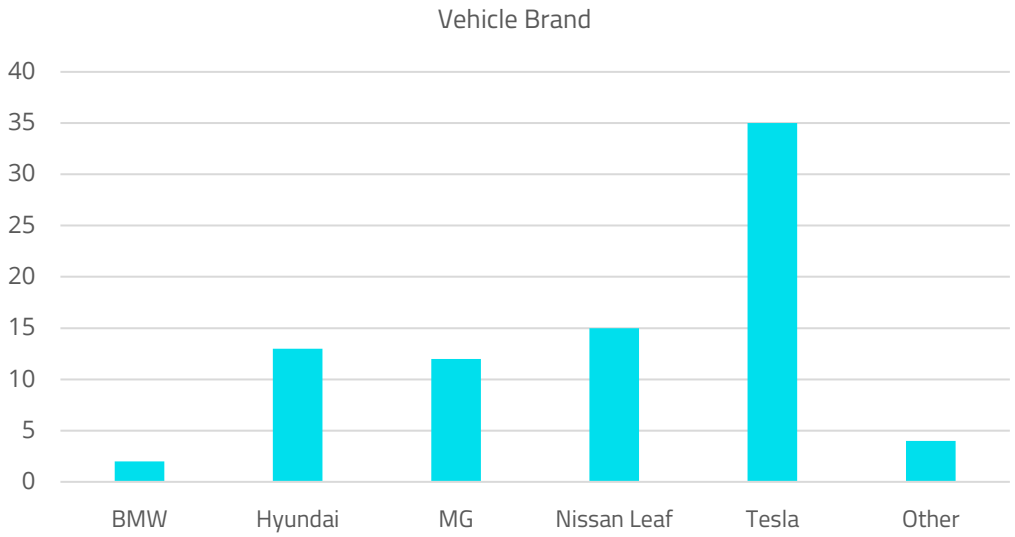
Most respondents said they primarily use their vehicle for 'social/leisure, and commuting to work', 53% said they were the only ones who use the vehicle, and 8% of respondents reported having two electric vehicles.

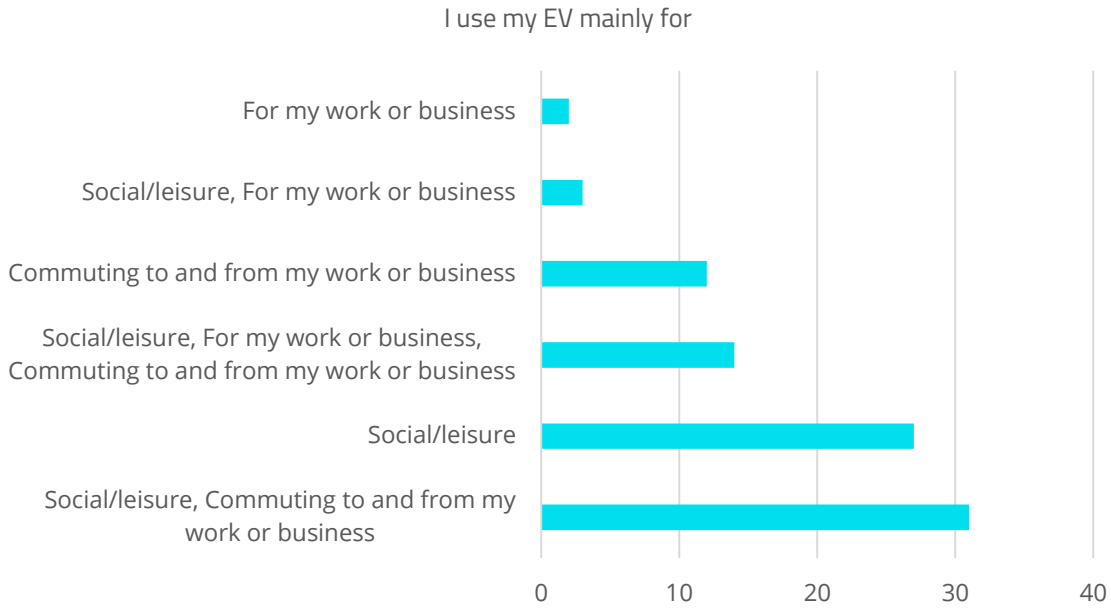
How many EV's do you own?



Who drives your electric vehicle normally?



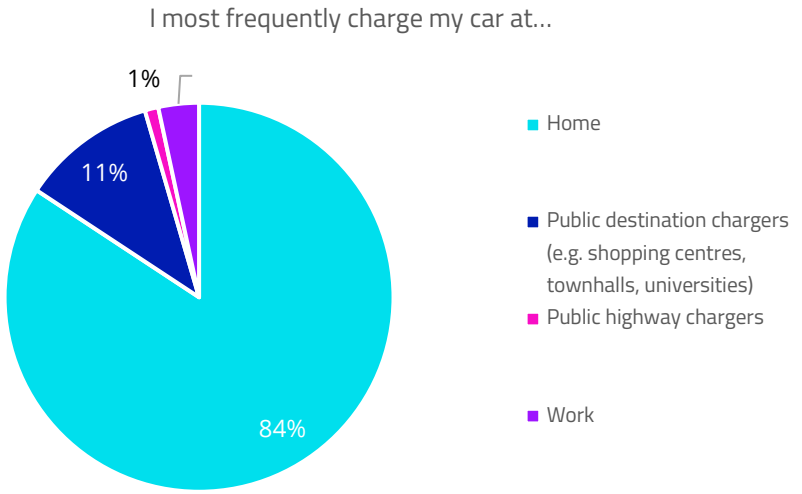


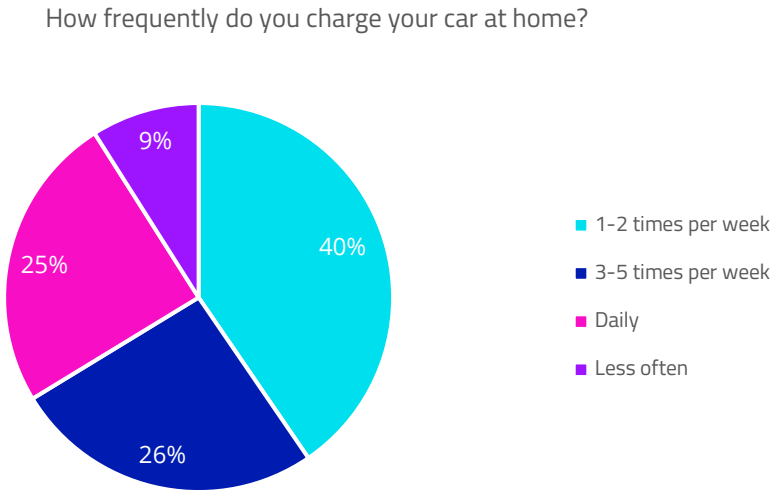


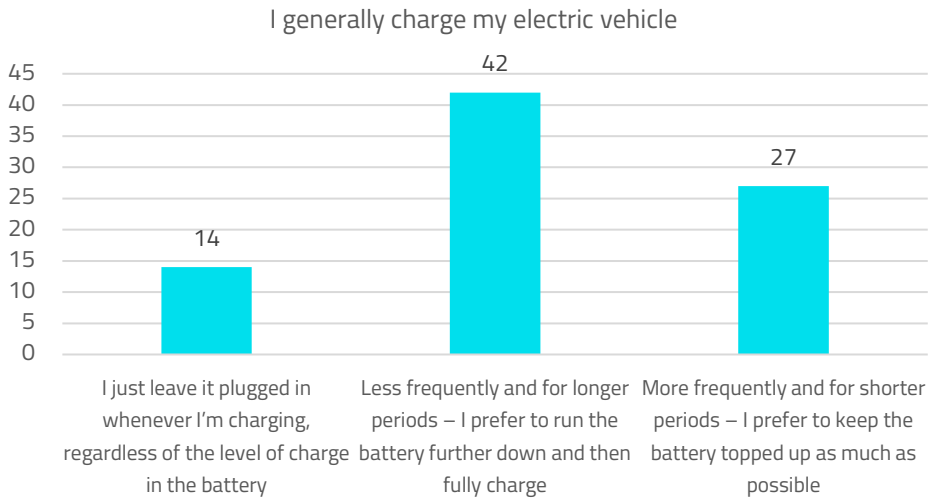
7.4. Charging Behaviours and Preferences

Early indications suggest electric vehicle drivers are deliberate about the times they charge their vehicle. Only 20% of respondents said they don't have a particular time that they usually charge, 55% said they charge during the day and 35% charge during off peak times. Whether it be charging via solar, or overnight at a cheaper "off peak" rate, evidence suggests EV owners seek to minimise their charging costs.

Consistent with most other research on EV charging behaviours, 84% of respondents said the location where they most frequently charge is at home, with the majority saying they prefer to charge “less frequently, for longer periods” (validated by 40% stating they most frequently charge 1 – 2 times per week).







7.5. Understanding of Smart Charging

"Smart charging" is a broad term that can mean different things to different people. In this context, smart charging, or charging orchestration, is broadly defined as a third party having some level of control over household EV charging times to provide an energy system benefit.

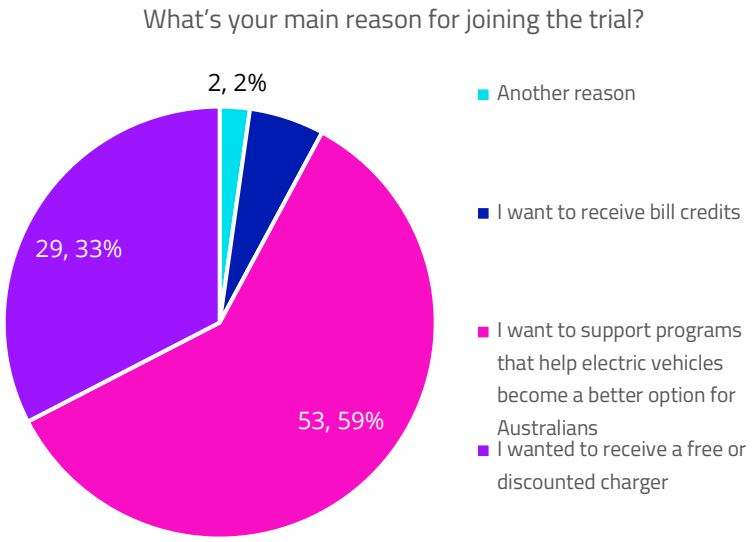
Survey respondents showed a high level of understanding of the concept of smart charging and its benefits. When asked "what does the term smart charging mean to you", most respondents understood it to mean charging during lower demand periods to benefit the energy system, with one respondent explaining it succinctly as "charging at certain times of the day to maximise energy efficiency".

Respondents understanding of smart charging is a function of their participation in the trial (the objectives and benefits have been explained to them) and their higher-than-average engagement in the energy market. Whilst understanding of smart charging amongst the non-trial participant population is likely to be low, and even lower amongst the ICE driver population, anecdotal evidence suggests people have an intuitive understanding of "peak demand" and why it would be bad if all EV's charged at the same time.

7.6. Motivations for Joining the Trial

Anectodical evidence suggests electric vehicle owners are passionate about the transition to electric mobility. They are eager to see more Australian's adopt electric vehicles and support programs that help contribute toward accelerating Australia's path toward a decarbonised transport sector.

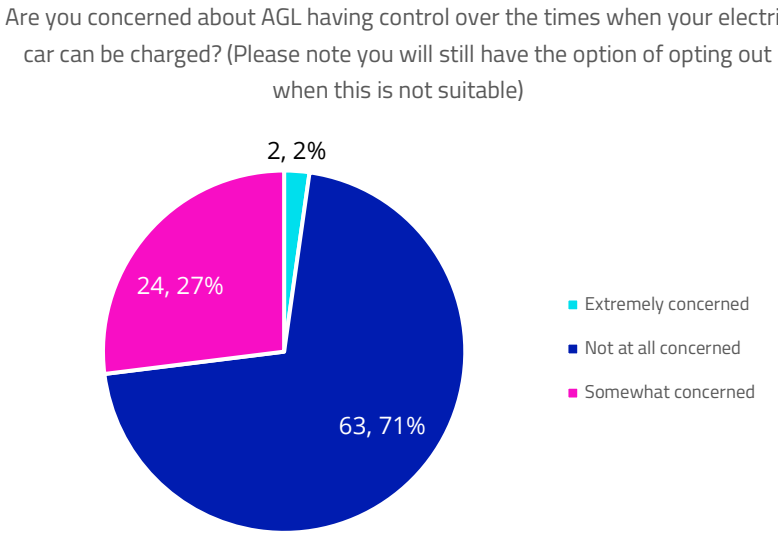
When asked "what was your main reason for joining the trial", 59% of survey respondents said they "want to support programs that help make electric vehicles become a better option for Australians". This is an encouraging sign, however it's safe to assume that as we move along the EV adoption curve, consumers motivations for participating in a smart charging scheme will change.



7.7. Initial Feelings toward Smart Charging

Gaining consumers trust will be crucial to the success of any future smart charging proposition. Therefore, it was important to understand whether trial participants had any initial concerns around relinquishing control of their electric vehicle charging, how these feelings may change over the course of the program and what could be done to alleviate concerns if there were any.

When asked "are you concerned about AGL having control over the times when your electric car can be charged?", 71% of survey respondents said they were "not at all concerned", and 27% said they were "somewhat concerned".



It's important to highlight that self-selection bias is likely playing a significant in role in these results. As participation in the trial is entirely voluntary, it's reasonable to assume most consumers participating in a charging management trial do not have strong concerns regarding charging management. What's perhaps more insightful are the reasons why some participants had concerns about charging management and the things that could be done to alleviate those concerns.

7.8. Concerns and Alleviators

When participants were asked to elaborate on why they were concerned about AGL having control over charging times, the most common themes were:

- the car not being charged to a sufficient level for their next trip
- not having the flexibility to charge as per their needs
- not having the ability to maximise solar self-consumption.

One respondent said, "in some instances, I may need to charge outside low peak period due to ad hoc needs, eg emergency, and need a high charge level before leaving the house" and another said they were concerned "the charging times does not provide enough electricity for the car to be ready for next day long trip". Those with solar mentioned they "ideally want to do all the home charging during the day when we have excess solar being generated rather than feeding into the grid" and that they "prefer to charge when I elect, as I have a solar system which allows me to charge at no cost".

To alleviate their concerns, one survey respondent stated they should be given the "option to allow us to charge whenever we need to if there is an emergency", and another suggested we "[ask] permission before you take control". One respondent asked whether they can "set a minimum charge for overnight so I know the car will always have say 40% in the morning and allow AGL to top it up during the day".

It's still too early to draw any firm conclusions regarding customers feelings toward charging management and their likelihood of continuing with a smart charging arrangement. What is apparent, however, is that smart charging cannot be a one size fits all approach – it must provide some flexibility for consumers' different circumstances.

We believe providing the ability for consumers to opt-out of managed charging events will be crucial in ensuring large scale take up of a smart charging proposition. Moreover, we believe smart charging should allow customers to optimise for various scenarios, eg solar self-consumption, cost, or carbon intensity.

8. DNSP Engagement

The Distribution Network Service Providers (DNSPs) that have elected to participate in the trial are:

United Energy

AusNet Services

Jemena

SA Power Networks

Ausgrid

Endeavour Energy

Energy Queensland (Energex and Ergon)

The DNSP Technical Reference Group has met once during the reporting period, on 21 July 2021. Apart from a status update on the trial, the key agenda items were a presentation from AGL on customer research findings and a discussion on the likely network connection requirements and connection process for V2G chargers.

The next Technical Reference Group meeting is planned for November 2021.