Chargefox Electric Vehicle Charging Network Project

2018/APR125

Project results and lessons learnt

Lead organisation:	Chargefox		
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Executive Summary

Chargefox's Electric Vehicle (EV) Charging Network Project commenced in October 2018 and was completed January 2021. The Project delivered 22 ultra-rapid EV Charging Sites across Australia in order to make EV ownership more attractive and feasible.

This report documents lessons learned by the Chargefox team over the entire program. The lessons learned presented here include an innovative dynamic connection arrangement with electricity networks, a new approach to commissioning, and a new streamlined approach to project delivery. All of these have improved our ability to deliver ultra-rapid EV charging quickly and to budget.

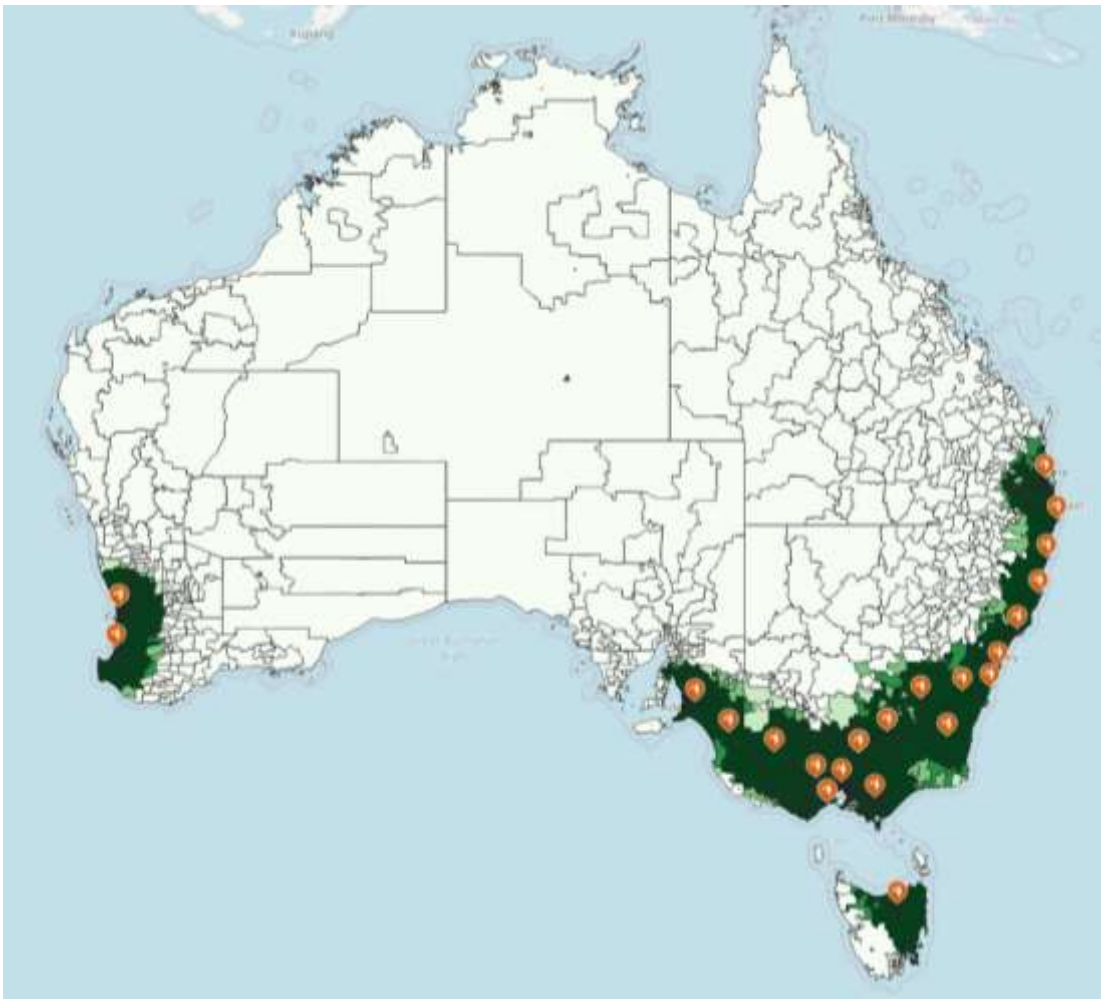


Figure 1: Overlap of Chargefox ultra-rapid network with postcode areas. The colour graduations have the lower bounds 0, 20, 40, 60 and 80% of the population covered.

Project Overview

Project summary

The Project is the development and construction of at least 21 Charging Sites along major driving routes between Brisbane and Adelaide along the coast of Eastern Australia, in and around Perth in Western Australia, and in Tasmania, at approximately 200km apart. Each Charging Site has at least two (2) DC Charging Stations of a minimum charging capacity of 150kW. Due to the additional stage 2 funding from the Victorian Government, the Melbourne site has total of four (4) ultra-rapid Charging Stations and two (2) 50kW DC charging stations. In addition, four (4) other regional Victorian sites also have two (2) 50kW DC chargers added to them, allowing four cars to charge simultaneously at those sites. The Project allows all EV models currently available for sale in Australia to charge through its stations.

Project scope

The objectives for the Project are:

- creating an EV charger management platform designed and built in Australia, which helps EV drivers find chargers and business owners manage their chargers;
- developing, constructing and operating at least 21 Charging Sites, comprising at least 2 DC Charging Stations at each site, using ultra-rapid EV chargers to dramatically reduce charging times for drivers. The stations will be accessible to all EV models currently available for sale in Australia;
- installing solar PV and a battery to provide the electricity needs for all the Charging Stations for at least one Charging Site;
- providing accessibility to Charging Stations to at least 75% of the Australian population; and
- reducing range anxiety for prospective purchasers of EVs in Australia through the creation of a network of Charging Sites along major driving routes.

Outcomes

The project is complete and the following has been achieved:

- Chargefox has delivered the charger management platform and freely accessible app on iOS and Android, and we have over 1,800 plugs on the network.
- All 21 sites in the ARENA program are complete, plus an additional ultra-rapid site delivered with the Victorian Government.
- Solar PV and battery were installed at the Euroa, Goulburn and Torquay charging sites

Lessons Learnt

Lessons Learnt Report #1: Benefits of using Dynamic connections

Project Name: *Chargefox Electric Vehicle Charging Network Project*

Knowledge Category:	Technical
Knowledge Type:	Network connections
Technology Type:	Electrical Vehicles
State/Territory:	New South Wales

Key learning

Dynamic connections allow network infrastructure to be used more efficiently and can reduce timelines and costs for EV charging and similar projects.

Implications for future projects

Dynamic connections make a greater range of potential EV charging sites feasible without needing a high voltage upgrade, which tends to be expensive. They also have the potential to reduce the time needed to deliver a site because it avoids the need to install a new high voltage network connection, which typically takes months. Having successfully implemented a dynamic connection on this project, the concept is more viable for projects we build in future.

The benefits are much wider than EV charging – any large, variable load that can implement the control strategy to the satisfaction of the network should be able to use this approach.

Knowledge gap

The power connection is one of the most significant technical challenges in an ultra-rapid EV charging site, due to the high power requirements. It is a major constraint to site selection and can be very expensive and with long lead times. Ideally, a site has power available without needing to augment the network, but sites like this are difficult to find.

Network assets are often subject to variable loads. For example, a network transformer may have 50% of its capacity available for the vast majority of the year, excepting hot summer days when air conditioning loads reach high peaks. That represents a significant inefficiency that is replicated across whole networks.

We can use electricity network infrastructure much more efficiency, and improve our site-finding process, through the use of dynamic connections. A dynamic connection measures the capacity available at a network asset at a moment in time, taking into account the size of the asset and the power being drawn by other customers connected to that asset, and allows the EV chargers to use the balance of power remaining.

This is beneficial for the network, because it means the asset is being used much more efficiently and as a result defers the need for network augmentation.

The first knowledge gap was regulatory, in that it required agreement with the network; in this case, Essential Energy in NSW. Essential Energy agreed to trial the dynamic connection for 12 months subject to a number of safety and monitoring requirements. To our knowledge, this is the first time Essential Energy has agreed to and approved a dynamic connection configuration. The pilot will give the network confidence in the concept which will influence other networks. Because it means assets can be better utilised, there are clear benefits for networks.

The second knowledge gap was the technical solution. It uses a meter to measure the total load on the network asset, and the available power is then calculated. This result is then fed to the chargers and Chargefox's servers. The chargers are controlled so that they may not exceed the maximum available power. Chargefox in partnership with JET Charge developed this technical solution including building a full operating test system to demonstrate the concept.

Background

Objectives or project requirements

Finding an appropriate connection strategy that can be delivered in project timelines and budgets is a critical issue for ultra-rapid EV charging. Dynamic connections provide us with an additional option.

Process undertaken

Through our electrical designer, we engaged with Essential Energy to first test their interest in the concept, and then to understand what they would need in order to approve a dynamic connection. This informed the technical solution which was developed by Chargefox on the software side, and JET Charge on the hardware side. We developed and constructed a working demonstration using a 50 kW DC charger to prove the concept.

Essential Energy's approval of the connection configuration set out their requirements for implementation. This is now being implemented at our Gundagai site and we expect to have it fully operational shortly.

Supporting information (optional)

N/A

Lessons Learnt Report #2: Remote commissioning gains

Project Name: *Chargefox Electric Vehicle Charging Network Project*

Knowledge Category:	Technical
Knowledge Type:	Construction
Technology Type:	Electrical Vehicles
State/Territory:	All of Australia

Key learning

Remote commissioning allows projects to be delivered faster and avoid unnecessary disruptions to timelines.

Implications for future projects

We take a flexible and lean approach to project construction, which often leaves little time for delay or error. A particular cause of delay that is often outside our control is the connection of power supply to our sites. Additionally, we have previously needed to book busy commissioning teams in advance. A last minute delay to power connection can therefore cause flow-on delays.

We can deliver projects more efficiently by implementing remote commissioning with our charging hardware suppliers. Remote commissioning is when the charger manufacturer's commissioning staff don't attend on site, and instead oversee the process as it is completed by appropriately experienced and trained electricians. Our ability to remote commission gives us greater flexibility to complete projects on time and has a side-effect of upskilling our installation teams so they can do even better work for us in future.

Remote commissioning is of significant additional benefit when delivering projects during the COVID-19 pandemic, as it avoids the need for interstate travel and reduces the number of people working on site.

We used remote commissioning for our last 8 sites, some of which would not have been delivered at all without it.

Knowledge gap

Remote commissioning was not possible previously as procedures and training resources had not been established, and there was limited experience installing unfamiliar equipment. The charger manufacturer developed these resources which were then negotiated in terms of on site practicalities. We brought in electricians who had built sites for us previously and who had already experienced the commissioning process.

Background

Objectives or project requirements

As we have rolled out this project, it became very clear that we needed a more flexible approach to commissioning that gave Chargefox's delivery team greater control of the process. This was particularly the case as our Charging Sites are located all around the country, and we are sometimes commissioning multiple sites concurrently.

Process undertaken

The charger manufacturer established processes including pre-commissioning checklists, online training modules for installation staff, and lists of equipment needed on site. During commissioning, on site and remote staff used live video streaming to undertake commissioning and documented all the commissioning tests as they were completed. After commissioning was complete, all staff involved participated in a debrief to discuss improvements for subsequent sites.

Lessons Learnt Report #3: Efficiencies of streamlining project delivery

Project Name: *Chargefox Electric Vehicle Charging Network Project*

Knowledge Category:	Logistical
Knowledge Type:	Construction
Technology Type:	Electrical Vehicles
State/Territory:	All of Australia

Key learning

It is best to deliver sites as a whole program, rather than contracting site by site, as it gives us the flexibility to direct our efforts to where we can make progress and minimises downtime.

Implications for future projects

Our ability to deliver sites efficiently and flexibly has stepped up significantly since project commencement and we will continue to improve as we deliver each site. For example:

- We can easily divert resources to different sites, as needed
- Hardware can be procured in advance, kept in storage and deployed to whichever site is ready for it
- Logistics can be simplified and made cheaper by scheduling pick-ups and deliveries to multiple sites at once – often in different States
- Our project budgets and construction schedules are synchronised better than ever

Knowledge gap

Engaging design and construction services on a site-by-site basis has benefits but can also slow projects down, for several reasons. Firstly, it usually involves more tightly scoped contracts which limits the ability to direct resources to areas where the most progress is possible. Another major reason is that aspects of design, such as switchboard design, are done per-site which means that specific pieces of hardware are tied to particular sites.

With a very busy work program involving sites being constructed concurrently, we identified the need to change our approach and engage design and construction services on a different basis. We were only able to do this after we had delivered sufficient sites such that we were able to assemble the right people who possessed the right skills, accreditations and experience across different jurisdictions, and would be able to work together flexibly and collaboratively.

We can more efficiently and flexibly deliver multiple sites concurrently by consolidating our delivery team and streamlining site design, equipment specifications, logistics and construction. We have achieved this by building a strong team to deliver multiple sites and ensuring we can easily switch focus between sites as needed across all stages of design and construction.

Program-wide delivery allows us to best capitalise on the lessons that we are naturally learning by delivering the project.

Background

Objectives or project requirements

We needed to alter our approach to project delivery so that we could deliver sites to an ambitious project schedule, whilst maintaining control of our budgets. For this, we needed to partner with organisations with a national presence and/or had experience and knowledge to deliver to the required standards, which vary between different States and electricity networks.

Process undertaken

Based on our experience with our earlier sites, we were able to identify and engage the right people to form a project delivery team. Our approach to working together has been transparent and frank, resulting in high levels of trust. The proof of this approach is in our results – we have been building and commissioning sites at great frequency since taking this approach in the second half of 2019 and through 2020.

Lessons Learnt Report #4: Ultra-Rapid usage data analysis provides insight into charging behaviours

Project Name: *Chargefox Electric Vehicle Charging Network Project*

Knowledge Category:	Technical
Knowledge Type:	Technology
Technology Type:	Electrical Vehicle Chargers
State/Territory:	All of Australia

Key learning

Drivers are tending to top up their batteries for 20 to 30 minutes, rather than trying to fully charge or to consume a particular amount of energy. 350kW chargers get used about 50% more than 50kW chargers on the same site. This suggests that people are charging opportunistically and fitting it in around other routines, such as shopping.

Implications for future projects

Ongoing analysis around usage can assist in planning for expansion of existing sites and planning of new ultra-rapid sites. Duration and power analysis, along with utilisation information, allows for infrastructure to be more focussed on actual usage. This could theoretically lead to lowering of costs for future site construction, or at least more focussed spend.

In addition, understanding usage patterns also allows for the driver experience to be improved around their interaction with the chargers. The digital experience in particular can be customised to follow usage styles, encouraging drivers to support each other and move on at appropriate times.

Knowledge gap

At the beginning of the project, the only information available around usage of ultra-rapid chargers came from European and US markets that were still nascent. No information at all was available for Australian drivers and their habits around domestic usage.

This is now changing: usage of ultra-rapid charging stations is growing over time, as new sites are constructed and the sale of electric vehicles grows in the market. Sessions on charging stations on those sites, across both 50kW and 350kW chargers, are normalising around a time duration rather than an energy consumption amount. Drivers are charging for 20-30 minutes and consuming 10-20kWh energy, meaning sessions are top-up, rather than fill-up.

As more data is collected, we will be able to identify clearer patterns such as daily and weekly charging profiles. Preliminary data analysis has shown clear differences between metropolitan and regional sites; highway and shopping area sites; and weekends and weekdays. However, there are still too few users on the network to be able to draw generalisations.

Background

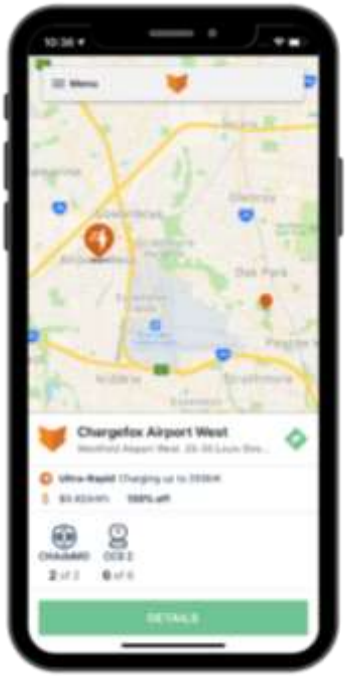
Objectives or project requirements

Our goal here was to measure usage patterns of charging stations on ultra-rapid sites to understand how Australian drivers in particular might use them.

Process undertaken

The systems developed by Chargefox record detailed information of all charging sessions, including location, duration and energy consumption. As usage of the network has grown, we've been able to analyse that data to see patterns emerging on usage.

Supporting information



The Chargefox platform is developed in-house at Chargefox's Melbourne head office and is used to manage over 1,800 plugs and counting. The Chargefox app, available for free on Android and iOS, helps EV drivers find, use, and pay for charging.

The platform also provides a portal for organisations including businesses, councils, retailers, and developers to monitor and manage charging stations installed at their premises.

Lessons Learnt Report #5: Charger Selection

Project Name: Chargefox Electric Vehicle Charging Network Project

Knowledge Category:	Technical
Knowledge Type:	Technology
Technology Type:	Electrical Vehicle Chargers
State/Territory:	All of Australia

Key learning

There is more to selecting chargers than the up front cost and power; their long-term stability and reliability significantly impacts driver experience and drives maintenance costs across the business.

In future we will not install any chargers we haven't seen detailed test and stability data for. Prospective suppliers must give us access to existing chargers so we can see for ourselves.

Implications for future projects

At the start of this project there were very few manufacturers of 175kW+ chargers, so operational data was not available to inform our decision. Instead we tried one major manufacturer with a good track record of similar equipment (inverters, rectifiers, power electronics) for our first 6 chargers. We stopped buying from them when they failed to deliver promised functionality, a critical technology failure. At this point we switched to the other available manufacturer, an Australian company with a history of reliability in other DC chargers. Their new offering was slightly cheaper than the first choice and higher power.

It has turned out though that previous equipment being reliable is a poor indicator of what new technology will be like. Every new incarnation of technology introduces new failure modes into the equipment, and these chargers have an extraordinary number of new failure modes previous equipment did not have.

Knowledge gap

The gap in this case is the difference between expected and actual operation. In future we will close that gap by observing actual units in the field. This adds time to the assessment process, and suggests that we should be assessing lots of chargers all the time in preparation for future purchases. Something in the order of 6 months of operation data should be sufficient.

Background

Objectives or project requirements

The goal is stable charger operation. Previous thinking on reliability assumed this was largely to do with the quality of the components used. High-quality components such as internal power supplies and vehicle connectors solve much of the maintenance problem, but in practice these rarely fail. Instead we find chargers failing due to software and fundamental design faults. Nothing breaks, but the software fails for a wide range of reasons. This decreases confidence in the chargers for

customers who start using other chargers very quickly. For the charger operator it greatly increases maintenance costs, with some sites requiring weekly visits to clear false alarms on chargers.

Process undertaken

These faults and reparations have been identified in the process of establishing our maintenance regime. As we visited sites more often our records have built to paint a picture of the most common faults and remedies.