EV charging on the road

How do you plan a road trip in an EV? Bryce Gaton looks at your charger options on the road and shares his tips for maximising the DC charging advantage.

Real-world EV charging stats show that over 90% of charging is done using AC chargers, mainly at or close to home. For this sort of charging, the time taken is often irrelevant, particularly as the current crop of EVs have a large range that covers many days of local use.

However, for a long trip in your EV, recharge time becomes critical. It is here that the realm of AC charging ends, and DC charging begins.

This is also where confusion often sets in. DC charging uses a different plug, and DC chargers have many names: fast charge, rapid charge, ultra-fast charge and, for Tesla owners, Supercharger 2.0 or 3.0. The differences between these come down to the charging speed of the DC charger (or, in some cases, the marketing minds who come up with terms to differentiate themselves from the pack).

AC vs DC charging rates

AC (alternating current) is what our electricity grid supplies. DC (direct current) is what EV batteries store and use. Charging an EV from the grid always involves changing AC to DC (via an inverter), as an EV battery must be recharged with DC electricity.

For lower charging rates, that AC-to-DC inverter is small and cheap enough to build into the car. Given the limits of household electricity supply, and AC-to-DC inverter size and cost, EV manufacturers mostly stick to an upper limit of 32 amps (or 7.2 kW) for AC charging.

At this 7.2 kW rate, an EV battery recharges at about 50 km charged per hour. This would mean, for example, that an EV like the Hyundai Kona (with a highway range of around 420 km) would take about nine hours to charge from empty to full. Three-phase power can cut that to a third of the time, but only where three-phase power is available and the car is set up for it (the Kona isn't).

AC charging is perfectly suited for a full overnight charge at home, or for smaller top-ups in the downtime between trips. But clearly, AC charging alone will not get you the 880 km from Melbourne to Sydney in anywhere near the time taken by a petrol car, if you need to stop for eight or nine hours every 400 km.

This is where DC charging comes into its own, with charging rates from 50 kW to 350 kW (see Table 1). The fastest 350 kW DC chargers can recharge up to 400 km of range in as little as 15 minutes.

End of story? Well, not quite. That 350 kW rate is only possible if your car can handle it. Many of the current crop of EVs are limited to lower charging rates, such as 70 kW for the Hyundai Kona electric. You can use the higher rate chargers, but they'll be limited to what the car can handle.

Conversely, a car that is capable of a high charge rate cannot charge faster than the capacity of the DC charger. For example, the soon to be released Porsche Taycan will be capable of charging at 350 kW, but will charge at one-seventh of this on a 50 kW DC charger. Table 2 shows the maximum DC charging rates for several of the new crop of EVs.

Different chargers, different requirements

Inverters to change AC to DC at these high charge rates are large, heavy and expensive, requiring significantly bigger electrical supplies than a home (or even a small factory) can handle. DC chargers have the AC to DC inverter built into a fixed external charger and

Charging at the Chargefox ultra-fast charger in Barnawartha North, in northern Victoria. There are two ultra-fast (350 kW) chargers and two fast (50 kW) chargers available.

DC charger common name	Max charge rate	Max km charged/hour (/15 min)	Kona electric—time to regain 100 km	Tesla Model 3 Long Range—time to regain 100 km
DC fast charge	50 kW	270 (68)	22 min	22 min
Rapid charge	100 kW	460 (115)	16 min	11 min
Ultra-fast charge	350 kW	1600 (400)	16 min	5.5 min
Tesla Supercharger 2.0	120 kW (software upgradable to 145 kW)	550 (137)	n/a	9 min
Tesla Supercharger 3.0	250 kW	1100 (275)	n/a	5.5 min

Table 1. DC charging rates available in Australia. The max km charged per hour or 15 minutes assumes the car is capable of receiving that charge rate, and charging is in the 0% to 80% range. The Kona and Tesla columns show the time to regain 100 km for these cars, charging in the 0% to 80% range, given the charging limits of the car and charger.

Note: This table provides a starting point only. The kilometres charged and times to regain 100 km are based on approximations assuming car efficiency of 15 kWh/100 km and adjusted slightly to match manufacturer and charging network quoted charging times. Actual kilometres charged can vary significantly with driving style, road speed and terrain.

feed DC directly to the EV battery, bypassing the AC to DC charging system in the car. This is done using a different part of the charging socket or, in the case of Nissan and Mitsubishi, a different socket altogether.

Currently, all public DC chargers (except Tesla Superchargers) are fitted with leads for both CCS2 (the emerging charging socket standard used in most EVs in Australia) and CHAdeMO (used in Nissan and Mitsubishi EVs), so all cars are catered for.

What you'll find on our highways

More and more large DC chargers are rolling out along our highways. There are now a mix of 50 kW, 100 kW, 120 kW/145 kW, 250 kW and 350 kW DC chargers installed around Australia.

The major players (ChargeFox and Evie) are installing mainly 350 kW chargers to future-proof their networks. Tesla are slowly upgrading their Superchargers from 2.0 (125 kW) to 3.0 (250 kW) versions. Others like local councils and the NRMA are sticking to 50 kW chargers.

The situation will shake itself out over the next few years as faster charging cars become available and DC charger types simplify. For engineering reasons, 350 kW is likely to stay as the top charging rate. In the meantime, I suggest the solution is to focus on the EV you own and forget about the rest.

EV	Max charge rate
Porsche Taycan	250 kW (current), 350 kW (soon)
Tesla Model 3 Long Range	250 kW
Audi e-tron	150 kW
Jaguar i-Pace	100 kW
Kona electric	70 kW
Nissan Leaf (40 kWh)	46 kW

Table 2. Maximum DC charging rates for some of the new crop of EVs.

Calculating charge times for your vehicle

One of the biggest problems is knowing how long it will take to charge your vehicle at a given charger.

Table 1 shows approximately how long it takes to regain 100 km in charge for a Kona electric and a Tesla Model 3 Long Range at a range of different DC chargers. These times are for charge levels below 80%. Times will also vary according to the efficiency of the vehicle (some vehicles can travel further on a kWh than others). You may care to create such a table for your particular EV and leave it in your glovebox.

One thing you'll note is that DC charging time is always quoted as the '0% to 80%' time. This is because the last 20% of battery charge generally takes as long as the 0% to 80% time, due to the charge rate tapering off rapidly beyond that point.

Maximising the DC advantage

Properly managed, DC charging on a long run does not slow you down compared to petrol/diesel vehicle refuelling, provided you make a few simple changes in your routine.

You'll want to start your trip with a battery charged to 100%—easy to do when you control the recharge at home. Where feasible, recharge to only 80% at your intermediate stops. Then, at the last stop of the day, recharge only as much as you need, provided you can recharge overnight at your destination.

Following this routine, here's what a typical 880 km Melbourne to Sydney trip in a Kona electric (with a 64 kWh battery, US EPA

NRMA has a good network of 50 kW DC chargers around NSW, such as this one at Dubbo.

range of 420 km and a maximum charging rate of 70 kW) might look like.

- After a 7 am start, stop around 9 am and about 180 km from Melbourne at the ultra-fast (350 kW) DC chargers in Euroa. Here you do a quick top-up while nipping in for a coffee break (you don't need to stand by the car while it's charging); 10 to 15 minutes will easily charge the Kona from around 55% to 80%.
- From there, head up the Hume a further 230 km to Holbrook, NSW. After four to five hours on the road, the slower 50 kW NRMA charger is no issue as you'll be stopping for around 30 to 45 minutes for lunch anyway. That will get you charged from around 30% to 80% and on your way again.
- Your next stop, another 157 km on, is Jugiong, NSW, a good two-hour or so stage. A top up from 45% to 80% at the 50 kW NRMA DC charger takes about 25 to 30 minutes; perfect for a much-needed mid-afternoon break.
- Continue the remaining 340 km drive to Sydney, arriving early evening. This is around the maximum distance I would plan on an 80% charge in my Kona, so a stop at Goulburn (170 km from Jugiong, 50 kW NRMA) or a dinner stop at the Mittagong RSL (230 km from Jugiong, 50 kW NRMA) might be in order. To save time, you don't need to charge to 80% at

this last stop: 50% or 60% would be fine depending on the distance to your Sydney stop. Alternatively you could stay a little longer at Jugiong to get to 90%.

So that's three to four stops along this 880 km trip and no slower or longer than I used to do it in my fossil car. One bonus of an EV is that it promotes safe driving practices as you need to make those stops!

You could be forgiven for thinking that this is a 'seat of the pants' trip and you are in strife if any one of these sites is down or crowded. But fear not: there are apps for checking charger station status before arriving (such as those from ChargeFox and Evie for their networks, and the more general crowd-sourced information on PlugShare), and an ever-growing set of alternative charging sites.

On this trip, options include Barnawartha North (150 km north of Euroa, two 50 kW and two 350 kW Chargefox chargers), Albury at either the Kiewa St market (50 kW, NRMA), or, during business hours, the Albury tip (50 kW, council owned, access via ChargeFox), Gundagai (50 kW and 350 kW, ChargeFox) and Goulburn (three 50 kW, NRMA), plus several in Sydney itself.

State of play

Many of the major routes have a skeleton of DC chargers already. NSW has a good network of 50 kW chargers thanks to the NRMA, the Queensland government has installed the "world's biggest single state EV highway" running from Brisbane to Cairns, and WA has an older 50kW network in a radius of 300 km around Perth. Victoria, SA and Tasmania are beginning to build networks (and WA to expand theirs), but without much government or motoring body sponsorship, progress has been slower as businesses wait to see guaranteed returns before investing.

In the next article, I'll look at the possible future directions for DC charging systems. These include vehicle-to-grid (V2G) and vehicle-to-home (V2H) systems, new 11 kW and 22 kW DC chargers suitable for small to medium business fleets, portable DC units and even the potential replacement of home AC charging by DC. I will also sort the fact from the fiction when looking into the reputed impacts of DC fast charging on battery life and health.

CCS2 charging socket. CCS2 is the socket type used on most of the new crop of EVs in Australia, and includes AC and DC charging in the one socket (AC at the top and DC at the bottom).

Nissan Leaf charging sockets. Nissan and Mitsubishi EVs use separate sockets for AC and DC charging. The AC socket is on the left and the CHAdeMO DC socket is on the right. Currently, public DC charging stations in Australia have leads for both CCS2 and CHAdeMO charging.

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