

EV Charging Standards

Professor Thomas Bräunl
The University of Western Australia
Technical Director WA Electric Vehicle Trial

Quite a lot of progress has been made in EV charging standards over the last few years. This following is a brief summary of the technology and terminology used in EV charging standards IEC 62196, IEC61851 and IE15118.

1. Level

The charging level describes the power level of a charging outlet:

Level 1: Home charging, max. 2.4kW in Australia.

For our 23kWh EV-Works Ford Focus vehicles, this means
10 hours charging from empty to full

Level 2: Fast AC charging, either 7kW (32A single phase) or 21 kW (three-phase). We are using 7kW stations in the WA trial, which means
3 hours charging from empty to full

Level 3: Fast DC charging, up to 50kW, which means
20min. charging from empty to 80% full (for DC charging, the last 20% take a very long time, so DC charging is usually measured up to 80%)

2. Mode

The charging mode describes the safety communication protocol between EV and charging station. These standards are identical worldwide.

Mode 1: Home charging from a standard power outlet with a simple extension cord, without any safety measures. Although this is what many (private) EV conversions use today, “Mode 1” has been outlawed in several countries and Australia is likely to follow.

Mode 2: Home charging from a standard power outlet, but with a special in-cable EVSE (EV Supply Equipment), aka “occasional use cable”, usually supplied with an EV from the manufacturer. This cable provides:

- In-cable RCD
- Over-current protection
- Over-temperature protection
- Protective Earth detection (from wall socket)

Power will only follow to the vehicle if the EVSE has detected:

- Protective Earth is valid
- No error condition exists (over-current, over-temperature, etc.)
- Vehicle has been plugged in (detected via *pilot* data line)

- Vehicle has requested power (detected via *pilot* data line, usually linked to the car's central locking mechanism)

Mode-2 cables provide a moderate level of safety and are the minimum standard today for charging an EV. (And we have already found a number of incorrectly wired power outlets by using Mode-2 cables). However, most automotive OEMs accept “occasional use cables” (as the name suggests) only for occasional use, e.g. when visiting a friend's house and insist on installing a proper Mode-3 home charging station (“wall-box”) in the EV owner's garage for continuous use. Some car manufacturers even make the customer sign an agreement confirming installation of a wall-box at the time of ordering an EV.



Figure 1: Occasional use cable

Mode 3: Wired-in AC charging station, either in public places or at home, allowing a higher power level than Mode 2. The safety protocol is identical to Mode 2.



Figure 2: Charging station at EMC Solar, West-Perth

Mode 4: Wired-in DC charging station, either in public places or at home. In DC charging stations, the charger is part of the charging station, not part of the car.

3. Type

The type of a charging station (or vehicle inlet) describes the actual connector being used. Unfortunately, there are several different world standards and Australia as of today has not yet adopted one of them. The terminology is:

- socket: on charging station
- plug: on cable towards charging station
- inlet: on EV
- connector: on cable towards EV

Type 1: The connector/inlet pair used in the U.S and Japan, aka “SAE 1772” after the corresponding U.S. standard. As the U.S. and Japan do not have a three-phase power grid, this standard is limited to single-phase and lower power output than Type 2. Also note that for Type 1, the charging cable is permanently fixed to the charging station.

Type 2: The connector/inlet and plug/socket pairs used in Europe, aka “Mennekes” after the company first proposing this standard. Type 2 supports both single-phase and 3-phase charging at higher power rates than Type 1. This is why it is expected that Australia will eventually adopt the Type 2 charging standard.

For Type 2 charging stations, the charging cable is detachable, so a Type 2 station can charge both, Type 1 cars and Type 2 cars with the correct charging cables. A Type 1 charging station on the other hand can only charge Type 1 cars, as the cable is fixed to the station and the usage of adapters is prohibited.



Figure 3: Type 2 (left) and Type 1 (right) charging cables

Type 3: France and Italy are campaigning for yet another connector/inlet and plug/socket solution, which has “shuttered contacts”, i.e. contacts that are

physically covered by a non-conductive cover when not in use. Proponents of Type1 or Type 2 (both non-shuttered) point out that these are safe without shutters, as current can only flow when an EV connection has been detected.

China: One notable exception because of their large market is China. While the Type 2 standard continued to evolve and underwent a number of changes in the last few years, China decided to freeze an earlier (and now incompatible) version of the Type 2 standard as the Chinese standard.

It is expected that Type 2 will be the standard in all countries with 3-phase power grids, which countries without them will adopt Type 1. Type 3 is unlikely to be adopted outside France and Italy. The fact that Standards Australia has not made a recommendation for either Type 1 or Type 2 is not a good situation, as in the mean time both station types and both vehicle types are being imported into the country, creating a legacy problem.

All charging stations installed the WA Electric Vehicle Trial and the EV Charging ARC Linkage Project are Level 2, Mode 3, Type 2 stations. They can AC fast-charge at 7kW (provided the EV has an AC fast charger on board, such as the EV-Works Ford Focus), and can charge either Type 2 cars (all UWA-built cars and EV-Works Ford Focus), as well as Type 1 cars (incl. the currently imported Mitsubishi i-MiEV and Nissan Leaf).

4. DC Charging

While the first DC charging standard was the Japanese CHAdeMO, the leading eight automotive OEMs have now agreed to support the new Combo charging standard, which combines AC and DC charging in a single connector/inlet. CHAdeMO in contrast, is a DC-only standard. So cars with CHAdeMO (such as Mitsubishi i-MiEV and Nissan Leaf) always require two separate connector/inlet pairs, one for AC and one for DC (in many cases even under separate hatches), which makes the car more expensive than necessary. As Combo is incompatible to CHAdeMO, it is expected that CHAdeMO will be replaced by the Combo charging standard in all countries (including the U.S.) except Japan.

Since Combo is compatible to AC-only charging (e.g. at an AC charging station or by using the AC “occasional use cable”), the distinction between Type 1 and Type 2 also exists for Combo stations.

5. Inductive Charging

Inductive charging will be the next big advancement for EV charging over the next decade. A large number of companies are working on getting this technology ready for the next generation of EVs. With this, the debate over which type of charging connector to use might finally be over.

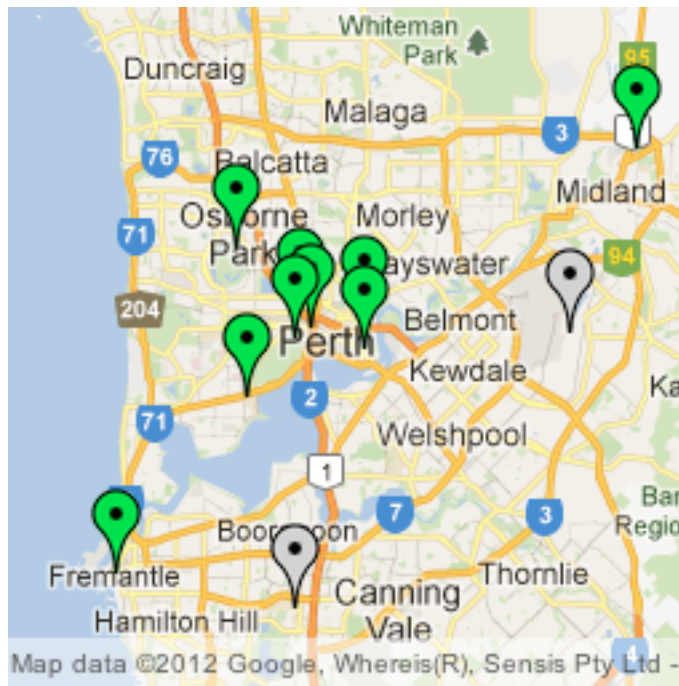


Figure 4: Networked Charging Stations in Charging Linkage Project and WA EV Trial

Contact

Professor Thomas Bräunl
The University of Western Australia
Technical Director WA Electric Vehicle Trial
Director Renewable Energy Vehicle Project (REV)
<http://theREVproject.com>
Thomas.Braunl@UWA.edu.au