# Fast Charging Stations – Market situation and Installation guidelines

## Background

Electric vehicles (EVs) are now steadily increasing on the market. An important issue is how they shall be charged in an efficient, technically safe and economical way. Until now, in principle, electric vehicles have been referred to the so-called slow charging, with charging power up to a few kW. This has meant that the charging time is about 5 hours for a mileage of 100 km. Lithium-ion batteries in electric vehicles can also be charged with fast charging, which means charging power up to about 50-100 kW. Hereby, the charging time for a normal battery electrical vehicle (BEV) with a 16 kWh battery will be shortened to about 20 min (depending on the EV battery's current state of charge).

Charging with high currents (high power) will reduce the battery life-time. Therefore, at the moment, the *commercial* power transfer to EV Li-ion batteries is limited to 50 kW.

There are two possibilities for fast charging of EVs: One is the usage of a three phase AC current and conversion to DC inside the car. The other possibility is transferring DC current to the car with the suitable voltage level for the battery. In the first case, the transfer of the power is technically easy, but for the conversion to DC a bulky AC/DC converter is needed inside the EV. The size of the converter increases with the level of power. When charging with DC power, an AC/DC converter is not necessary. On the downside, a complex interface between the EV and the charger has to be used for that solution. Fast chargers are of high power in order to transfer as much energy as possible during every charge. A limitation is however given by the battery itself.

The fast charging demand can be expected to develop based on various benefits, such as "security" for EV-owner's fear that the battery energy is limited ("range anxiety"), efficient charging solutions for commercial fleet operators, "inter-city travelling" and for heavy vehicles (buses and trucks).

In the future, solutions with so-called "Ultra fast charging" up to 250 kW (a few minutes' charging) could also be commercially available. In order to reach this advanced level of fast charging on a wide-spread commercial level, further development of battery technologies and prices is crucial.

***In this article we mainly focus on commercially available conductive fast charging solutions for "light vehicles" (passenger- and light transport cars).*** Special charging solutions for heavy vehicles and inductive charging in general will be separately presented and discussed in coming E-mobility Newsletters.

## DC and/or AC fast charging?

Solutions for both AC (one or three phase) and DC fast charging are available on the market. Technical solutions with AC charging for light vehicles are expected to be limited to max 63A (43 kW, three phase) depending on the choice of standardised connector solutions for the vehicle. At the moment there are few models of light vehicles with three-phase AC charging solutions on the market, as most of the commercially available light vehicles were initially constructed for single-phase AC charging (in some cases combined with DC-charging options).

A Japanese solution for DC fast charging (max 50 kW) has initially gained a foothold on the market, as a number of fast chargers with the so called "CHAdeMO-protocol" have been installed world wide, the majority of these in Japan.

The CHAdeMO-protocol based DC fast charging solution is used in the following EVs:

- Mitsubishi i-MiEV
- Nissan LEAF
- Peugeot iON,
  Citroën C-ZERO
- Subaru Plug-in Stella
- Protoscar LAMPO2
- Micro-vett, Fiorino cargo


**Figure 1. Mitsubishi i-MiEV.**
Photo: Mitsubishi Motors.

New charging solutions will be standardised gradually on the global e-mobility market through the international standardisation work within IEC (International Electrotechnical Commission) and ISO (International Organisation for Standardisation).

Recently, the European Automobile Manufacturers' Association (ACEA) published a position paper stating that its members recommend the usage of Type 2 "DC&AC Combo"-connector and inlet as the standard in Europe from 2017 and onwards. Further information about the on-going international standardisation process within this area and Vattenfall position are given in a separate article in this Newsletter.

### Suppliers of fast charging equipment

The number of EV fast charger suppliers has increased rapidly during the last year. In the table and figures below three of the European suppliers of CHAdeMO-certified DC chargers and examples of their products are presented. Some of the fast charger products also have options with additional AC charging connections.

**Figure 2: DC fast charger (Terra 51) from ABB.** Photo by ABB, EV Charging Infrastructure.

**ABB, EV Charging Infrastructure**

**Terra 51 Charge Station** (50 kW)

Key features

- DC 50 kW, CHAdeMO certified
- The device is CE marked
- User interface: Color LCD and Start, Stop and Emergency buttons
- Authentication: RFID
- Powder coated stainless steel housing
- Option with additional AC connection

**Figure 3: DC fast charger from Schneider Electric.** Photo by Schneider Electric.

**Schneider Electric**

- DC and AC fast charge ready for both EV technologies
- DC 50 kW, CHAdeMO certified
- The device is CE marked
- Designed for sheltered outdoor use
- RFID key for authentication
- Charging access: RFID or Paying system
- GPRS communication for supervision system
- Services for optimum management and maintenance

**Technical characteristics:**

- DC outlet: Type Yazaki 125 A
- AC outlet: 63A on type 2

**Figure 4: DC fast charger from SGTE Power.** Photo by Park & Charge i Sverige AB.

**SGTE**

- DC 50 kW, CHAdeMO certified
- Japanese & French companies cooperation
- The device is CE marked
- License for selling the SGTE chargers in Sweden has the company Park & Charge i Sverige AB
  *(incl. optional added services)*
- Reference installation with a SGTE fast charger at Arlanda Airport in Sweden (used by Taxi 020, see Figure 6 below)

A complete list of CHAdeMO certified DC fast chargers is available at the CHAdeMO Association WEB-site *http://chademo.com/indexa.html*

### Fast charging stations and installation guidelines

General requirements for a fast charging station

Minimum requirement of a public or semi-public DC fast charging station is to be able to provide fast charging services and facility to all EVs capable of fast charging. The charging station should consist of at least one DC charging output connector and should, if possible, be suitable for multiple charging output connectors, including AC-charging at higher currents. According to the CHAdeMO protocol, one DC charger requires a nominal maximum power output of 50 kW DC.

At a fully commercial stage, the fast charging site should be able to allow a minimum of 2 cars charging at the same time and have the ability to let a third car pass the other two. Next to the charging positions there should be at least one waiting position created at the site.

The charging site should be accessible 24/7 (full time) to all EVs. Therefore, the site must be in public domain or on 24/7 accessible private grounds. Surroundings and site arrangement must always give the future customer a sense of safety and security.

Charger users (EV owners) should be able to shield themselves from wind and rain when using / contacting the charger or machine interface.

The selection of all site equipment should be made with the objective to achieve an optimisation of life cycle costs, customer comfort, safety, user friendliness and, during the initial EV charging market development, be able to gather as much valuable information on charging and customer behaviour as possible.

Examples of Fast Charging stations in operation:
Below we have examples of two typical DC fast charging station installations with CHAdeMO certified DC chargers.


**Figure 5. 50 kW DC fast charger in Östersund** (North of Sweden) close to a shopping centre area. Charger operator is the energy company Jämtkraft. Photo by Jämtkraft.


**Figure 6. 50 kW DC fast charger (SGTE) at Arlanda Airport.** Installation and Photo by Park & Charge i Sverige AB.

Installation of fast chargers

***At the moment a grid connection for a fast charging station would be treated just as a grid connection for any other consumer.*** Most fast chargers require a 400V three-phase connection with a high current capacity (a 50 kW DC charger uses max 125A). At most locations this means it is required to make a new connection to the local distribution transformer station (substation).

If there is not enough capacity at such a substation, an additional investment in the transformer needs to be made to install a fast charger. Generally, this makes it infeasible to install a fast charger today. Further, some sort of concrete foundation needs to be made, and usually a shelter to protect the charger from snow, rain and dirt is wanted. If customers are required to pay for the charging, a payment solution will also be needed. This usually amounts to a total investment cost of about € 50 000 - 70 000 for a complete 50 kW DC charger installation, even when no further power grid investments are necessary.

Fast Charger Installation Guidelines under way

As a part of the E-mobility program within Vattenfall, a R&D project regarding different fast charging related issues is now carried out. This on-going project covers the following issues:

- ***Fast charger installation guidelines*** that will be processed together with BD Distribution & Sales (BU Distribution, Business Development and Vattenfall Services Nordic) before they are finalised (ready during November 2011). *Initial results are available for those how are interested in this part.*
- ***Technical assessments regarding "Mobile fast chargers" and "Ultra fast charging"*** *(R&D reports ready in November 2011).*