

It's long been known that key issues in the growth of the electric vehicle market involve charging. What range can electric cars cover on a single charge? How quickly can a battery be charged? And how should the charging network be developed? For the public to embrace EV technology, these questions must be answered satisfactorily.

Range will need to be comparable to that of a car with an internal combustion engine and a full tank of fuel, but that in itself will not be enough if an EV takes an hour or more to charge. Few drivers would accept such a delay on long journeys, and automakers are working towards faster charging capability to mitigate that problem. Tesla is the current leader in this area with its supercharger stations able to charge a battery to 80 % within 30 minutes, providing 170 miles of range. Tesla has been busily introducing a supercharging network across the USA and Western Europe, but other automakers haven't been overly keen to partner with Tesla and adopt its technology.

There is a need for a standardized charging connection and network. OEMs and regulators are working towards such harmonized standards, but a fully-compatible European-wide charging network is yet to be established. When Porsche unveiled the Mission E concept at the Frankfurt Motor Show last year, it introduced the first 800 Volt charging concept, which has the potential to change the landscape of the electric vehicle market. However, with no 800 Volt charging stations or agreed standards at present, the concept also poses a variety of questions and challenges.

# **Fast charging standards**

The two open fast charging standards on the market today - CCS and CHAdeMO - were both originally designed to work at 400 V. The Combined Charging System (CCS) was developed by seven car makers and designed for charging at up to 80 kW at 400 V. The standard is backed by major European and US OEMs, and is positioned as the preferred option for a European network. CHAdeMO was an initiative of Japanese carcompanies, and was originally designed to charge at up to 50 kW at 400 V.

Currently most chargers of either system can charge EVs at 50 kW, but charging time remains the issue, and most automakers have already introduced cars with faster charging capability. In 2014 Kia introduced the Soul EV with support of charging up to 100 kW using CHAdeMO to demonstrate higher power charging, although at the time there was no official CHAdeMO higher power standard. In 2016 BMW, Nissan, Volkswagen and Ford confirmed upgrades to batteries for existing EV models, which could enable them to step up to 80 kW fast charging - within the current CCS standard. Also this year, Hyundai announced the introduction of the full electric loniq Electric model, which the automaker confirmed will be able to charge at up to 100 kW using CCS.

The next generation of vehicles will require the next generation of chargers, and standards will need to be developed and introduced to suit. Accepting that fast charging is critical to the adoption of electric vehicles, several OEMs have skipped the intermediate stage of 100 kW and progressed straight to vehicles designed to charge at 150 kW. Audi introduced the Q6 e-tron quattro concept at Frankfurt in 2015, which is able to charge at 150 kW and scheduled for production in 2018. It was at the same show that Porsche introduced the Mission E concept, which is scheduled for 2020, but notably supports charging at 300+ kW.

CharIN is currently working on enhancing the CCS standard to support 150 kW charging by increasing the amperage, and the next CCS standard is expected to allow speeds up to 350 kW. The CHAdeMO Association in 2016 already announced a 150 KW amendment to the current protocol, with the first high power chargers expected to be installed in 2017. The 'plug' will remain the same, and new chargers will be compatible with current EVs charging at 50 KW.

# **Porsche Mission E Concept**

The Mission E concept demonstrates not only the best of Porsche technology, but also highlights the reasons that fast charging is becoming a necessity. Electric cars must compete on every level with petrol and diesel vehicles to be fully accepted by the mainstream public, and that includes refueling as well as power, performance and safety.

Porsche's concept car packs over 600 hp (440 kW) of system power, and over 500 km of driving range. The sports car features all-wheel drive and all-wheel steering, and can travel from zero to 100 kph in under 3.5 seconds. The goal of the future vehicle is to provide everything the customer expects from a Porsche - in an electric vehicle. Central to the Porsche ideal is that charging an electric vehicle should be comparable to refueling a conventional vehicle. To achieve this, the carmaker has introduced 800 V charging technology and will build the Mission E to be ready for such an envisioned charging network.

With the 800 V system - dubbed Porsche Turbo Charging - the battery can be charged to approximately 80% capacity within 15 minutes, providing up to 400 km of range.

## 800 Volt charging

Although no official plans for 800 V charging capacity are in place, Porsche is set to go ahead with production of the Mission E in 2020. It will be compatible with existing 400 V charging technology and future-ready for 800 V technology if/when it arrives. Both Volkswagen (with the Budd-e all-electric van concept) and Mercedes (with the launch of Generation EQ) have confirmed that their vehicles will be capable of charging of speeds up to 150 KW for fast charging. Both OEMs have also confirmed that they envisage a future step up to 300+ kW and 800 V systems.

However, the race to decrease charging time is limited by a number of technical factors. Today's DC rapid-charging stations use 400 V and charge at speeds of 50 kW, resulting in a charge time of approximately 80 minutes for a range of 400 km. The capacity of charging pins in current charging plugs can support up to a maximum of 100 kW, potentially halving the charge time to 40 minutes. However, any further increases in charging power will require new cooling concepts to prevent overheating.

The cost of introducing an 800 V charging network will be considerably high due to the required technological measures, but Porsche maintains that a holistic view of the system from grid connection to charging point could prove to be more cost-effective for operators of charging networks in the long term. The functional scope of the envisioned 800 V high power charging station enables the charging of current vehicles as well as the next generation of electric vehicles with 400 V technology. The interface to the vehicle is adapted to the CCS charging standard and is completely downward compatible. It could also be adapted to be compatible with other charging standards and vehicle categories.

### **Fast charging challenges**

Fastned - one of Europe's leading charging network operators - says that many of its stations are already prepared for 150 KW chargers, and that the first installations of these higher rated chargers will be in 2017. Tesla's network of superchargers has a capacity of 145 kW at 450 V, but remains incompatible with any other vehicles' charging ports.

Increasing current charging voltage in Europe from 400 V to 800 V would require significant changes to grid connections and infrastructure, but in essence would increase a charging station's throughput and therefore sales. However, Porsche admits that the technology is not fully viable yet. Various companies are working on cooling concepts in parallel to the developing Mission E, and it is generally accepted that liquid cooling of charging cables may be required in future DC charging stations. This is something that Tesla has already been looking at in terms of its Supercharging network.

#### **Summary**

It was never likely to transpire that the auto industry would simply adopt Tesla's fast-charging technology, and more recently talk has been of adaptable charging plugs to enable compatibility across networks.

The announcement from Porsche about its 800 V concept is a potential game-changer. It is the logical step as automakers look to minimize electric vehicle charge times, but with the weight of parent company VW behind it and the likely support of the German auto industry, the Porsche concept has a good chance of becoming a reality.

#### Sources:

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