Charging technology

Tapering

One important thing to understand when we talk about EV charging is that speed of charging is not the same during the charging process. As the battery is closer to its 0% level, charging is faster, but as the battery gets more charged, to top up the cells current reduces, and more time is needed to fully charge the battery. This event is called “tapering”, and it can be noticed at approx. 80%, and most noticeable at last 5%. Some charging stations even cut off your charging process as soon as your battery reaches 80%.

Supercharge times for each 5%	
This applies to 60,70, 85 and 90 kWh batteries. They all supercharge to same percentage at the same time.	
0%-5%	02 min 48 sec
5%-10%	02 min 00 sec
10%-15%	02 min 06 sec
15%-20%	02 min 18 sec
20%-25%	02 min 24 sec
25%-30%	02 min 36 sec
30%-35%	02 min 42 sec
35%-40%	03 min 00 sec
40%-45%	03 min 06 sec
45%-50%	03 min 18 sec
50%-55%	03 min 36 sec
55%-60%	03 min 54 sec
60%-65%	04 min 06 sec
65%-70%	04 min 30 sec
70%-75%	04 min 54 sec
75%-80%	05 min 24 sec
80%-85%	06 min 12 sec
85%-90%	07 min 18 sec
90%-95%	09 min 54 sec
95%-100%	32 min 54 sec

Picture 1 - Tesla Supercharger - % over time – user measured (https://docs.google.com/spreadsheets/d/19khEGozqREIoAN6hd440o4qrzS2ADMVokv8G5FWmWSk/edit)

In picture 1, we can see how this works in practical use. One Tesla Model S owner measured the time required to charge his EV. Increase in time required to charge 5% is visible as the battery gets closer to 100%, and the last 5% needs 16 times longer than first 5%.

Charging duration

Duration of battery charge is affected by these factors:

1. **Battery capacity;** The bigger the battery capacity,the longer it takes to charge it. Different EVs use batteries with different capacity. This ranges from 10 kWh up to 90 kWh.

2. **Charging mode;** As explained before, there are 4 modes of charging, each having different charging duration. The slowest mode is mode 1, using maximum of 16 A - 3,7 kW, and the fastest is DC charging in mode 4, using a maximum of 400A – 400 kW.

3. **State of charge (SOC);** SOC is information of battery charge level at the begging of charging cycle. Lower the SOC, longer it will take to charge the battery to 100%.

4. **Battery charger;** As explained earlier, EV is equipped with on-board charger which converts AC to DC, and in this way charges the battery. These chargers regulate the power capacity used to power the charging process, and they are rated accordingly. Mostly used is 3,3 kW battery charger.

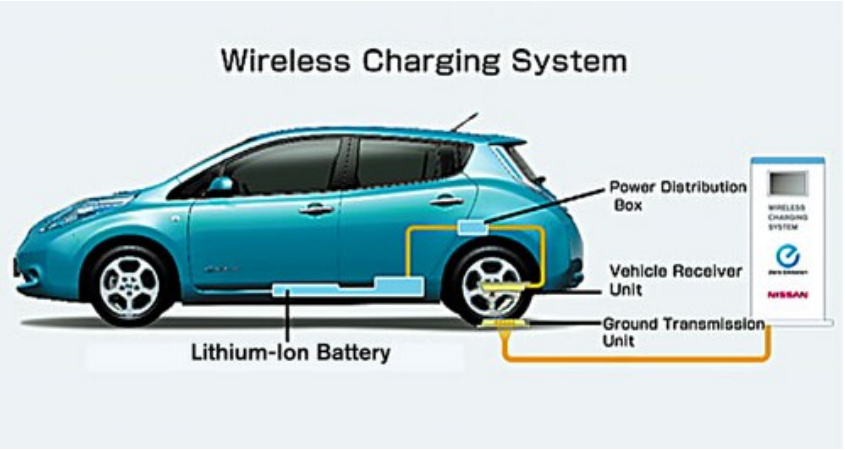
Directly related to duration of charge is charge frequency. Driver cannot influence the charging duration, but frequency is entirely related to EV owner. The same as in ICE vehicles, aggressive driving, rapid accelerations and strong braking use more “juice” from the battery, and thus discharge it faster.

Charging expenses

When talking about charging expenses, there are few points that must be noticed.
First of all, there are two types of expenses that appear. First one appears only once, and is not required for EV owners. This is the cost of purchasing and installing an EVSE. This is one time only expense, and can range from 100€ up to 10 000€. As stated, this is not an obligatory expense because EV owners can use home electricity for charging EVs.
The second cost is one of energy usage. For home charging, the most basic calculation is to calculate how many kWh you use to travel 100 km, and then multiply it with cost of 1 kWh. This means if EV has battery of 30 kWh with 150 km range, 20 kWh is needed to travel 100 km. Cost of 100 km travel is cost of 20 kWh in household usage.
For public charging, this is a little bit different. Every commercial company installing EV chargers for public use can decide their own type of payment system. This means that public chargers can have coin, paper money or credit card slots for payments, or they can use mobile phone payment, RFID identification etc. Charging rates can be determined by kWh used per hour, amount of time used per charge or flat rate with pre or post payment. Also, charging can be free in some cases. This specially refers to EV chargers owned by energy supplying companies which include this charge in their monthly fees.
Special case of charging cost is Tesla Supercharger. As mentioned before, owners of Tesla Models S and X can use these Superchargers free during their life time.

Future

The future of charging technology is hard to predict. Today, wireless charging is available for Nissan Leaf, and few years ago, it was a science fiction. Electric busses with fast chargers on bus stations, wireless charging lanes for non-stop EV charging, and lots of other inventions are implemented, or near implementation today. With such rapid evolution of EV infrastructure it is very difficult and ungrateful to predict what the future will be.



Picture 1 - Nissan Leaf Wireless Charging

Picture 3 - BusBaar - bus station fast charging

Picture 4 - EV re-charging lane proposal

One step closer to energy efficient charging in future are smart charging grids. These grids include solar collectors, smart home batteries and smart EVSEs.

For example, EV owner can use smart grid in a way that energy collected from the sun is stored in home battery, and this power is later used to charge the EV. Also, there is a possibility to charge the home battery with low cost energy rate (at night), and use it to

charge the EV during the high cost energy rate.

Endless possibilities lay in evolution of EV charging technology, and we must look forward to this.