PINPOINTING THE POTENTIAL OF SMART CHARGING

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At request of the MRA-E, G4 and ElaadNL HvA is researching the potential of Smart Charging. In this blog Youssef el Bouhassani pinpoints this potential.

In an ideal future we would be eating toast in the morning, watching our favourite soap opera in the evening and driving electric vehicles (EVs). Driving EVs will reduce the carbon footprint but as a consequence of higher electricity demand for charging EV's, the load on the grid will increase.

Especially in the morning and the evening when the demand for electricity for domestic use and for charging EVs peaks (see figure 1). The moments we want to have our toast and watch our favourite soap opera will not change that much, so the question is whether we can schedule charging session such that the grid load is reduced while meeting electricity demand.

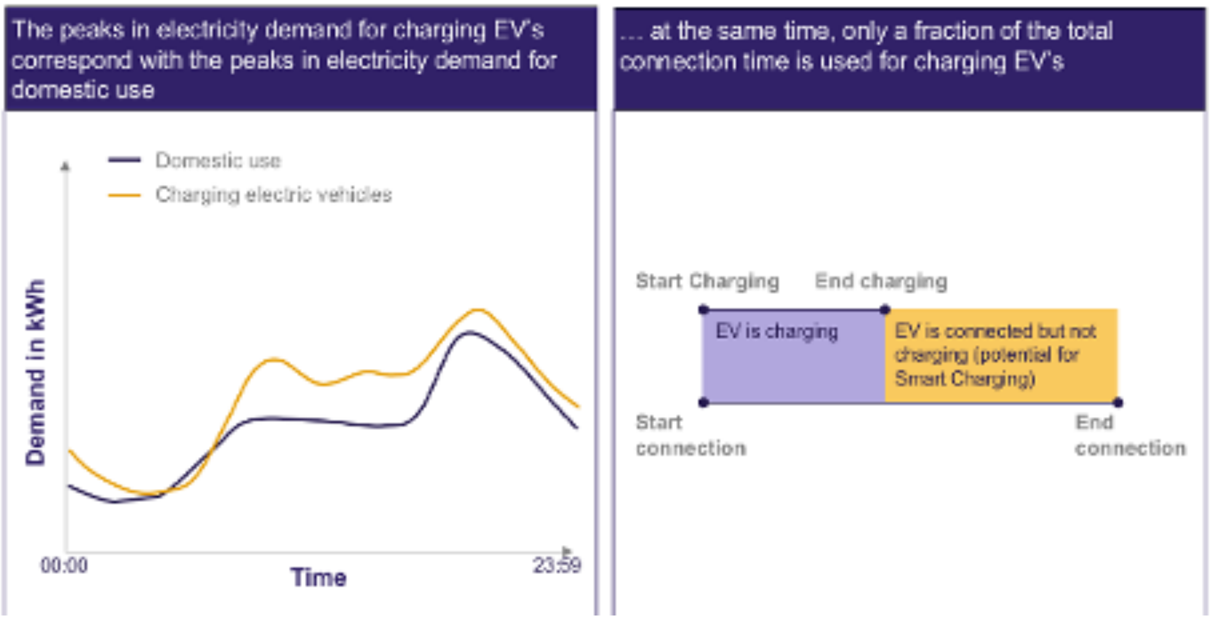

Figure 1: Smart Charging is a method to determine the optimal charging times for EV's such that the grid load is reduce while meeting the electricity demand.

The answer is yes. By using Smart Charging. Smart Charging (SC) is a method to determine the optimal charging strategy for EV's. In most sessions, the connection time of an EV (the time an EV is connected to a charging station) is longer than the charging time (the time an EV is actually charging). See figure 1.

Research by the Amsterdam University of Applied Sciences (AUAS) indicates that the average connection time is about four times the average charging time. For the first time these analyses have been carried out on a data set of charging sessions provided by the cities of Amsterdam, The Hague, Rotterdam and Utrecht, Metropolitan Region Amsterdam and complementary provinces provided by Living Lab Smart Charging. The data shows large differences in charging and connection time, making it possible to schedule a charging session during an optimal time window.

In addition to grid load reduction, Smart Charging can be used to determine the optimal charging strategy given different optimization criteria such as peak in grid capacity, availability of renewable energy or energy prices.

Different strategies

There are different flavours of SC strategies. One such strategy is to shift the entire charging session to a later optimal moment (postpone strategy). Another strategy is to cut the charging session in smaller sessions and divide these sessions over the complete connection time (cut and divide strategy). The most advanced strategy is to combine the cut and divide strategy with the option of discharging the vehicle battery to power the grid (vehicle2grid strategy). Studying the effect of different Smart Charging strategies is an interesting topic. However, in this post we will focus on understanding the potential of Smart Charging.

A good measure for the Smart Charging Potential (SCP) is the ratio between the charging time and the total connection time. This ratio indicates how much room there is to reschedule a charging session. See figure 2.

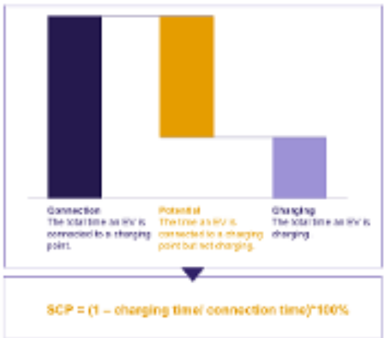

Figure 2: The Smart Charging potential is determined using the charging time and connection time.

Different users

There are different types of EV users and obviously the SCP is different for each user category. One way to define user categories is based on the starting time of a charging session (horizontal axis in figure 3) and the total connection time (vertical axis in figure 3, limited to 24 hours). We can clearly see three different clusters of EV users: the so called *office chargers, home chargers and visitors*. These three user clusters contain distinct user groups such as electric car sharing schemes and taxis.

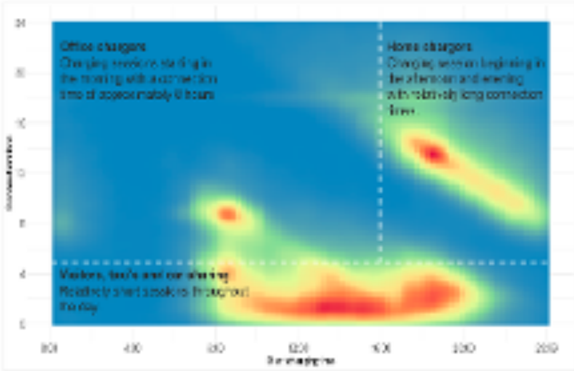

Figure 3: Based on the starting time of a charging session and the total connection time, three user categories are defined. The color of the heat map is an indication of the number of charging session for a given combination of start time and connection time. Red for high, blue for no session.

For each charging sessions we can compute the SCP and use these values to create a heat map as shown in figure 4. This heat map shows the distribution of the charging sessions given the connection start time and the SCP. In this figure we recognize the user categories as shown in figure 3, but the distribution of the charging sessions is different.

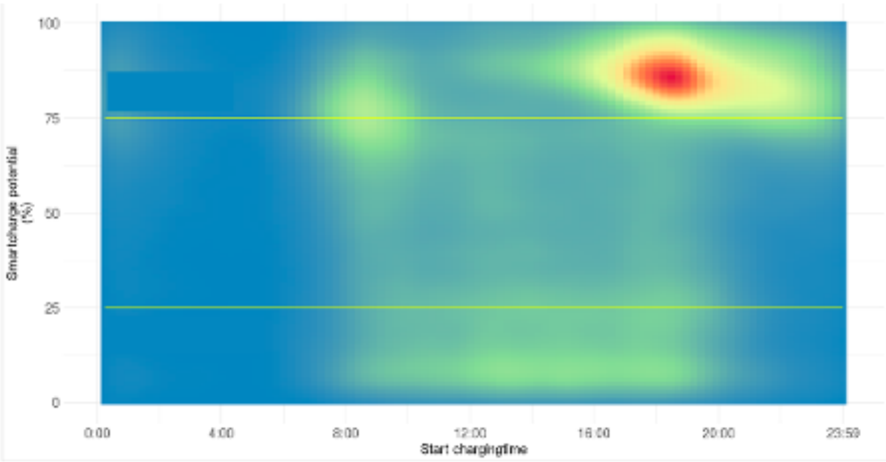

Figure 4: A large number of charging sessions have an SCP higher than 75%. These sessions are associated with home chargers (starting between 16:00 and 20:00).

In figure 4, we can see the majority of charging session start between 16:00 and 20:00 and have an SCP of more than 75%. Charging sessions starting between 16:00 and 20:00 are associated with the typical *home chargers.*

There is a cluster of sessions starting in the morning with an SCP of more than 50%. These are the typical *office chargers*. And then there is a range of sessions with relatively small SCP (less than 25%) for the typical *visitors*.

The thresholds of 25% and 75% are used here to illustrate how the heat maps can be used to get an understanding of the SCP. Obviously, different values can be chosen if necessary. The beauty of using these heat maps is in their simplicity to pinpoint where the SCP quick wins are located.

Different strategies for different users

The key takeaway of this post is that the typical *home chargers* have the highest potential for smart charging and that this group constitutes the largest share of transactions. Their charging sessions start after 16:00 and tend to end early in the next day. A suitable Smart Charging strategy for this group is to postpone the charging session to a later moment in the evening to reduce the peak load early in the evening. A Smart Charging strategy that optimizes for renewable energy is more feasible for wind than for solar energy since the SCP is highest in the evening when the sun is unlikely to shine but the wind is likely to blow.