Smart charging definition

Let's start with an understanding of what we mean with smart charging. It is a broad topic, and many examples of it are mentioned by companies, researchers and media. Though, in general it can be defined by the alteration of the EV's charge cycle with the goal to better integrate it as a load into the grid. This way we can prevent possible grid issues, and still maintain the mobility requirements of the customer.

Eurelectric has defined smart charging as the following:

> **Smart charging of an EV**
>
> *"is when the charging cycle can be altered by external events, allowing for adaptive charging habits, providing the EV with the ability to integrate into the whole power system in a grid- and user-friendly way. Smart charging must facilitate the security (reliability) of supply and while meeting the mobility constraints and requirements of the user. To achieve those goals in a safe, secure, reliable, sustainable and efficient manner information needs to be exchanged between different stakeholders."*
>
> *(Eurelectric)*

Charging costs

Lets consider the average case of an EV's charging costs. Based on driving roughly 15,000 km per year, at average consumption of 5 km per kWh, and an electricity price of 0,20 cents per kWh, the annual charging costs will be around 600 euros. If

we can reduce these costs through smart charging and still ensure that the user can use his car the way he wants to, we might save hundreds of euros per year. This can make the choice for any person to choose for an electric vehicle easier. However, there are also other stakeholders involved for whom EV charging can become a problem, and thus leading to costs. It would be of value to ensure that EV charging does not become an issue.

Smart charging types

Smart charging can be done by:

- Influencing the charging time/ time-slot -> delayed charging when energy is cheaper or grid is less constrained.
- Influencing the charging power -> lowering power when demand is high.
- Bi directional charging -> powering back to the grid

There are five different strategies to reach smart charging.

Load balancing

The first of the five strategies is Local load balancing. Imagine an office where we aim to charge multiple newly acquired EVs. However, in most buildings, the grid connection was never designed for this. It might happen that the cars are charged around the time that the office demands peak power from the grid.

Upgrading this grid connection will not only require an investment, it will also increase the yearly costs charged by the grid operator.

What we can do is tap into the flexibility provided by the fact that not everyone needs to charge immediately or constantly with full power. We can apply two smart

charging strategies: The first is to decide to charge the EVs later or, with less power, to reduce possible peaks on the grid connection. The second is to divide the power to the vehicles in a smart way. This way we can charge EVs but still use the current grid connection. This way we do not need to invest to reinforce it, and we can save thousands of euros.

Smart charging for DSO

The second possibility is Smart charging for DSO. There is a clear similarity to the previous example. We want to charge our EVs without overloading the local grid. In some places grids are old, and are already in danger of overloading. Imagine an inner-city street where many people have an electric vehicle and there are many on-street chargers connected to the low voltage electricity grid. This grid is operated by the Distribution System Operator or District Net Operator. Again, since EV charging creates a substantial load, there is the danger of overloading grid cables and transformers. So to accommodate a growing amount of EVs, but prevent costly investments in grid infrastructure, we can choose to incentivize smart charging. For example, if electricity prices are linked to the time-of-use, EVs could charge in times of low electricity prices. This will reduce charging costs for the user, and the DSO can save tens of thousands of euros on a neighbourhood grid.

Energy markets

Strategy three deals with participating in Energy markets. Based on supply and demand, the price of energy will vary during the day. Smart charging in this context

means changing the charging cycle according to the electricity price, in order to minimize charging costs. This can be done based on the spot price in the Day ahead market and the Intra-day trading market. It also allows us to better match EV charging with renewable energy production on a regional or national scale.

Balancing services

Strategy four is Balancing services. This deals with creating value for the Transmission System Operator. This party is responsible for high voltage transport of electricity through a country and across its borders. To keep this grid stable, it needs to maintain the grid frequency at a certain value. All across Europe that is 50 Hertz. Therefore balancing markets have been constructed where actors get paid to assist the TSO in maintaining the grid frequency. These are the primary, secondary and tertiary reserve markets. However, names can be different in different countries. Back to how it works. Well, the grid frequency can be kept stable by changing either supply or demand. By performing smart charging, EVs can influence the electricity demand and thus influence the frequency. This allows EV drivers to receive money from the TSO for providing this service. This way electric car drivers can earn several hundreds of euros per year.

Vehicle-2-Grid (V2G)

The last strategy is V2G services. By not only changing the charging time and power but also being able to send energy back to the grid, more value per vehicle can be created. This form of smart charging will be dealt with in the next lecture.

Barriers to smart charging

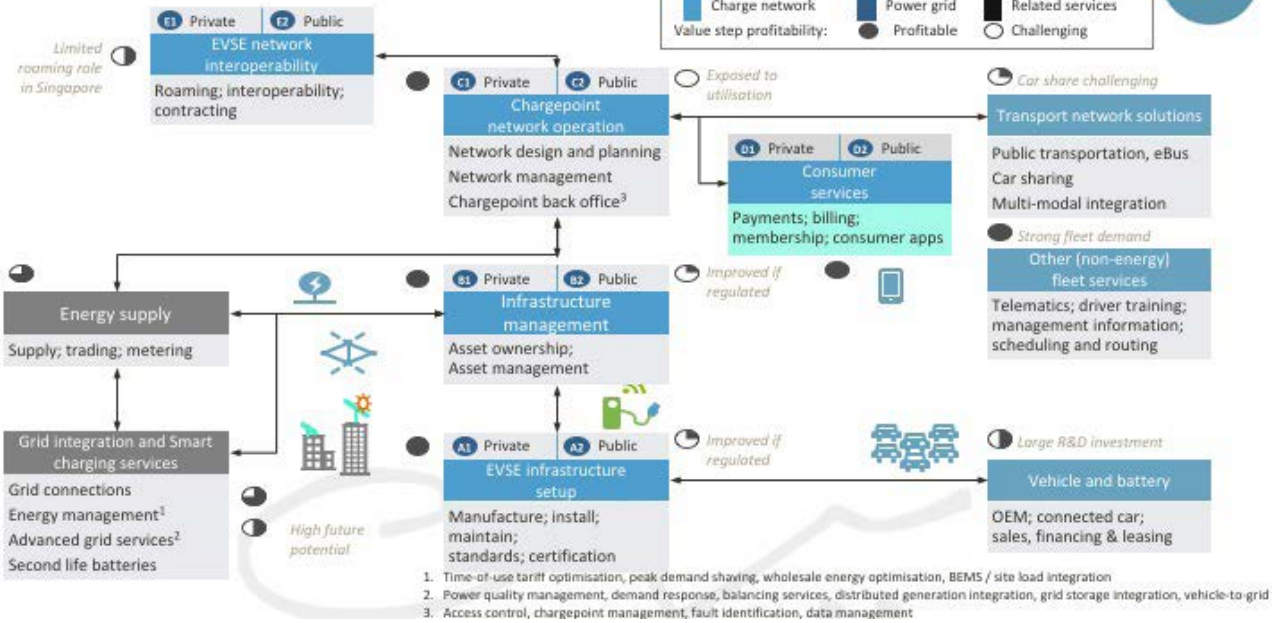
So we have seen what's possible. But why is this not been done on a large scale yet? Well there are several reasons for this. But to name a few, let me start with saying that for the case of the DSO there currently is not a real market structure in place where EVs get paid for smart charging. However pilot projects are done in multiple areas around the globe to develop and test this.

For the case of the national energy and balance markets we see that the entry level into these markets is high due to strict regulations and large scale requirements. This means it is difficult for new parties that lack experience, and scale, to enter this market. And more specifically, we see that net-metering and feed-in tariffs lower the value of local use of for example solar energy, because this can be fed into the grid for an attractive price. This means that financially it might more attractive to send the solar power into the grid instead of using it to charge the cars.

Value in the EV charging chain

The figures on the next page will show you what the value chain of EV charging looks like, and which companies are involved in which parts.

Who makes money in the EV value chain?



Mapping case examples to the value chain