The Importance of Smart Charging

Supporting information for the EPBD and Market Design

Background Paper
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The electrification of transport is vital to reduce CO2 emissions and overall air pollution. Transport is currently the only sector bucking the trend on emission reductions[1], and is 94% dependent on fossil fuels. Road transport counts for around 20% of the EU's total CO2 emissions and so decarbonised transportation is vital for cleaner air, healthier cities, and reduced oil imports. However, electrified transportation, also known as 'e-mobility', is not only greener and healthier, but has the potential to be a significant source of flexibility in the overall energy system, helping the grid to integrate more renewable energy in a reliable way.

Electric vehicles (EVs) reached 1% market penetration in 2015, and have continued to grow, with European sales in January 2017 double those of January 2016[2]. As battery ranges increase and prices of vehicles come down, various car manufacturers aim to sell between 20-40% of EVs by 2020[3]. Such an increase in electrification of transport will bring many benefits[4], but will also increase overall electricity demand. This could put significant pressure on the grid and system if not managed intelligently, especially during times of peak.

In numbers:

- Cars are parked for over 90% of their lives[5]
- The average EU household consumers around 10kWh a day[6]
- Charging an electric vehicle to drive a daily distance of 40km takes around 8kWh
- This is then an 80% increase in daily demand
- A normal charging point is between 3.7kW and 22kW[7]
- An electric vehicle will increase the electricity load of a building, especially if several EVs are plugged in at once. This could put a strain on the grid, especially at peak hours, and could be expensive for the vehicle owner, if not carefully managed

This is where smart charging comes in.

What exactly is smart charging? Smart charging 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"[8], according to CEN-CENELEC, the European standardisation body. Essentially it is modulating the charging of the vehicle, in response to price signals and system capacity. This could mean delaying the charging, stopping or starting it, or speeding it up or slowing down. It would allow for electric vehicles to work in harmony with the grid, acting as a form of demand response, rather than simply additional demand. The European Climate Foundation estimates that smart charging could allow the integration of more than 20 million electric vehicles in France, compared with only 4 million under a passive charging scenario[9].

Key elements of smart charging

- Dynamic pricing
- Charging infrastructure
- Interoperability & standardisation of charging infrastructure
- Standardised data for vehicle drivers, consumers, service providers or aggregators

[1] https://ec.europa.eu/clima/policies/international/paris_protocol/transport_en
[2] http://www.ev-volumes.com/
[3] http://www.beuc.eu/publications/beuc-x-2016-121_low_carbon_cars_in_the_2020s-report.pdf
[4] http://www.platformelectromobility.eu/
[5] http://www.reinventingparking.org/2013/02/cars-are-parked-95-of-time-lets-check.html
[6] https://www.ovoenergy.com/guides/energy-guides/how-much-electricity-does-a-home-use.html
[7] http://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX%3A32014L0094
[8] ftp://ftp.cen.eu/EN/EuropeanStandardization/HotTopics/ElectricVehicles/SmartChargingReport.pdf
[9] https://www.camecon.com/how/our-work/en-route-pour-un-transport-durable/

- Business models for innovative services
- Vehicle to grid services, demand response and ancillary services

Dynamic pricing – this means that the owner of the EV has access to an electricity tariff which reflects real-time electricity prices on the wholesale spot market[10]. This will signal to the owner to charge their car at off-peak times when prices are low, and to avoid charging when prices are high. This flexibility will be reflected in a cheaper final bill, either as part of their household energy bill, or on a separate monthly or 'pay as you go' scheme through an EV service provider. If an EV is charged at times of negative pricing, at no cost to the consumer, the curtailment of wind and solar production could also be avoided, meaning that such resources are not wasted[11].

Charging infrastructure – uptake of electric vehicles will be slower if the infrastructure for charging is not in place, or if there are significant barriers to installing infrastructure in multi-apartment blocks, such as having to ask permission from several tenants. The visibility of charging points in public spaces, within cities and along highways, is also vital for installing consumer confidence in switching to an EV, and for drivers who don't have access to an individual parking space where they could install a charging point.

Smart charging can happen in many different forms. It can be integrated within the charging points, as the below image illustrates, it can occur through the EV itself, or via a consumer's home energy management system.

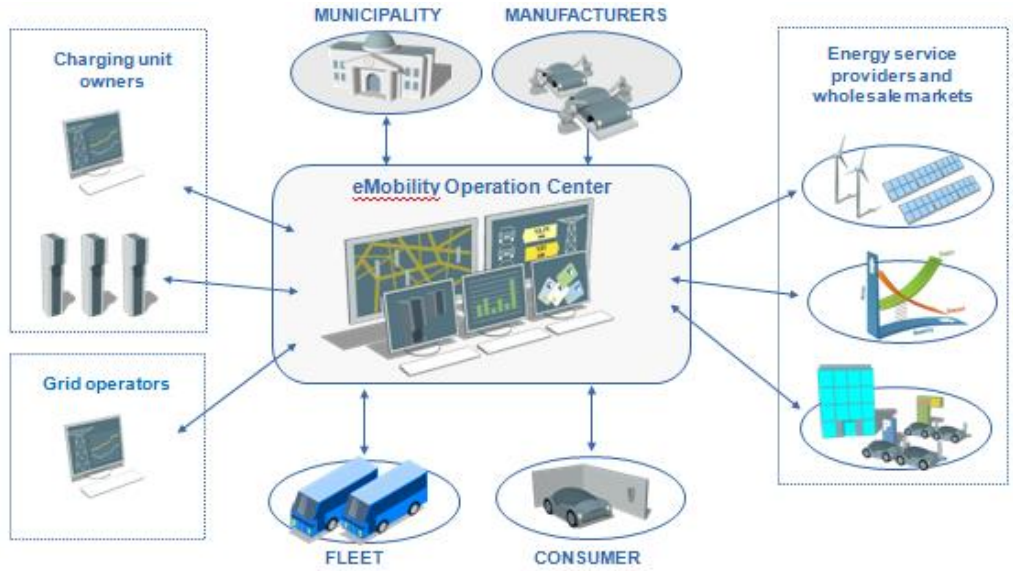
credit: enel

An equally important part of charging infrastructure is for medium-and heavy-duty vehicles, including fleets. Historically the highest carbon emitters, when electrified they provide additional charging challenges, given the large amounts of energy required to propel them[12].

In conjunction with the chargers themselves, an information and communications technology (ICT) infrastructure is needed to manage charging to prevent grid overloading, automatically take advantage of low- or negative-cost electricity, and balance charging among multiple vehicles attempting to charge simultaneously. Integration with distribution network operations is an

[10] See Article 11 of proposal for Electricity Directive http://ec.europa.eu/energy/sites/ener/files/documents/1_en_act_part1_v7_864.pdf
[11] The Climate Policy Institute estimates negative prices will occur over 1000 hours per year, in its conservative case (See *Policy and investment in German renewable energy,* Climate Policy Institute, April 2016).
[12] Examples include eBuses and eHighways (heavy trucks).

important requirement in optimizing the charging operations and minimizing overall infrastructure investment.



credit: Siemens

Interoperability – two or more systems (appliances, devices, or components) are interoperable if the systems are able to exchange information and then perform together a specific function. In the context of smart charging, this means the compatibility of the various components of the charging system's software and hardware – the user, battery, grid, efficiency and other vehicle needs – in order to have safe, reliable and optimal charging[13] for EVs.

Data access – access to the vehicle's charging data from the EV service provider, energy supplier or EV aggregator, is crucial for consumers to receive the best tariffs and for the grid to be balanced. Certain principles must be adhered to for good data management. These include protection of consumer privacy and security, consumers' access to their own data, including being able to bring their data with them if they switch service provider, and for the service provider to have access to real-time data and historical interval data[14].

Business models – smart charging business models include all of the above key elements of data access, interoperability, dynamic pricing contracts and access to charging infrastructure. Private sector ownership of EV charging infrastructure is the dominant model in Europe, and this tends to happen through partnerships with technology companies, car manufacturers and energy suppliers[15]. Smart charging infrastructure enables innovative market players such as service providers or aggregators to offer new value added services for customers and grid operators, using advanced energy management platforms and apps in convergence with other technologies, ie IoT or Blockchain. Further details on improving business opportunities can be seen in a recent study from EFS Unternehmensberatung GmBH & DNV GL[16].

Vehicle to grid services - looking to the future it is crucial to pave the way for bi-directional charging (also known as vehicle to grid charging). This is where the vehicle can feed back to the grid in times of

[13] For more details see: ftp://ftp.cen.eu/EN/EuropeanStandardization/HotTopics/ElectricVehicles/SmartChargingReport.pdf
[14] For more on data access in general: http://www.smartenergydemand.eu/wp-content/uploads/2016/09/SEDC-Position-Paper-on-Data-Access-in-the-Electricity-Market-.pdf
[15] For example: http://www.eon.com/en/media/news/press-releases/2015/10/30/bmw-eon-and-siemens-successfully-complete-dc-fast-charge-project-along-the-a9.html
[16] What's Driving Tomorrow's Electricity Grid, Position paper 2015, EFS and DNV GL

need, allowing them to act as a service to the system. In this system EVs will be able to function as actual 'mobile stations', with the ability to store and return to the grid the energy that is not used, proving ancillary services. Owners would be rewarded and remunerated accordingly. Different types of bi-directional charging are detailed in this table.

Use case	View	Functionality
V2L Vehicle to Load		For powering external loads, like water boiler, TV, refrigerator, pump water, etc.
V2H Vehicle to Home		Emergency supply (UPS) for stationary installation at home supplying the energy in case of grid failure
V2H Vehicle to Home		Home supply. Optimization regarding energy costs, RES integration, energy arbitrage, time shift, energy peak reduction and demand flattening.
V2G Vehicle to Grid		TSO services: Participation in the primary and secondary frequency regulation.
V2G Vehicle to Grid		Future DSO services: reactive compensation, voltage regulation, deferral investment, energy losses reduction, short term congestions, post fault management.

credit: enel

What are the costs and benefits of smart charging?

With the right business model and consumer tariffs smart charging makes much more sense for a vehicle owner than normal charging. It will increase the EV penetration rate without affecting the current grid infrastructure, and will maximise the integration and use of renewable energy. As mentioned it will also save considerable costs in terms of grid reinforcement. Calculations made by ERDF in France, show the following savings due to smart charging, assessed on 1 million EVs travelling globally:

Total LV grid reinforcement cost per million EV for:	Cost without smart charging	Cost reduction due to smart charging
EV charging in single houses	200 M€	200 M€ (almost total cost avoided)
Multiple EV charging in multi-dwelling or business buildings	650 M€	450 M€
Public charging spots in the streets and parking lots	240 M€	120 M€

Reinforcement costs (Million €) for low-voltage grids and cost reduction with smart charging; Source: ERDF[17]

Furthermore, smart charging and related technologies, such as V2G, enable market companies to deliver new value added services to customers and grid operators based on advanced energy platforms with IT jobs creation, providing also revenues and benefits on both sides.

The cost of charging infrastructure varies according to manufacturer. According to BEUC, the European consumer organisation, dedicated domestic charging points (wallboxes) currently cost approximately €1,000 before incentives, of which €700 is for the hardware and the remainder for installation[18].

[17] http://www.eurelectric.org/media/169888/20032015_paper_on_smart_charging_of_electric_vehicles_finalpsf-2015-2301-0001-01-e.pdf
[18] http://www.beuc.eu/publications/beuc-x-2016-121_low_carbon_cars_in_the_2020s-report.pdf