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Smart Charging – an efficient instrument to optimise the Total Cost of Ownership of EVs

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Summary

The wide scale deployment of Electric Vehicles, in particular Battery Electric Vehicles –BEV– is a key element to address environmental issues of transport systems. Today, public financial incentives still have a direct impact on the BEV sales. Further price reductions but also additional services that could be provided by the battery inside the vehicle will likely allow electric vehicles to become economical self-sustainable, reducing the total cost of ownership for the EV owners. This paper addresses the Smart Charging concept for residential, smoothing the BEVs integration in the grid and providing financial benefits for the driver reducing its ownership cost.

Key words: Smart Charging, Smart Grid, LCC (Life Cycle Cost), Connected Car, State of Charge, Data Acquisition, renewable

1 Introduction

The Electric Vehicles (EV) market is growing significantly, with a yearly increase of approximately 50% worldwide since 2014 [1], as ambitious targets and policy support have lowered vehicle costs, extended vehicle range and reduced consumer barriers. Following from the 21st Conference of the Parties (COP21) in Paris in December 2015, EVs are seen as a major contributor to reach the emission reduction goals in transport as they increase energy efficiency and reduce carbon intensity of transport domain, while taking advantage of the reduction of GHG emissions in power generation and supporting the integration of variable renewable energy in the power generation mix [2]. The Paris Declaration on Electro-Mobility (2015) and IEA 2DS deployment targets calls for 20 million electric cars by 2020 and further expansion to 100-140 million electric cars by 2030, reaching annual new registrations of 12 Million BEV and 12 Million PHEV from 2030.

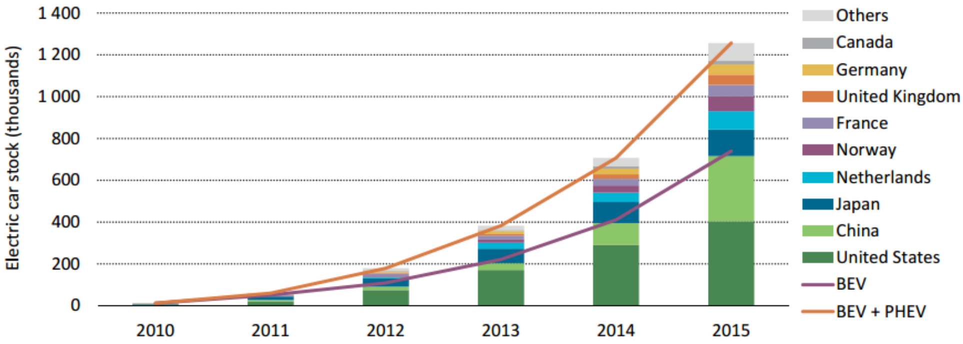


Figure 1 OECD/IEA, 2016 - Global EV Outlook 2016

1.1 The impact on the electricity system

The high penetration of Electric Vehicles on the electricity distribution grid could cause additional peaks in the electricity system, as is studied by major DSO's [3], in addition to the peaks that are introduced by intermittent renewable sources. Studies have shown that cars, including EVs, are parked for about 90% of their lifetime. This, combined with their storage capacity, can make EVs an attractive flexibility solution to supporting grid network congestion, avoiding or deferring new grid investment at the Distribution grid level. Applications such as Smart Charging, offer an opportunity to address the implications of renewables on grid stability, as addressed in the literature [4], [5], [6].

1.2 Solving the mismatch between renewable electricity production and consumption

With the integration of more un-steerable renewable sources in the electricity mix, balancing energy production and consumption becomes increasingly challenging and will unlock new revenue streams in the electricity market. As a solution to this balancing issue, the flexibility provided by the BEV is utilized during its charging process. The car is charged at moments when there is a lot of renewable production, which helps to balance the electric grid. Since electricity prices are generally lower at moments of high renewable production and by resolving imbalance issues, the car user is financially rewarded for providing the flexibility.

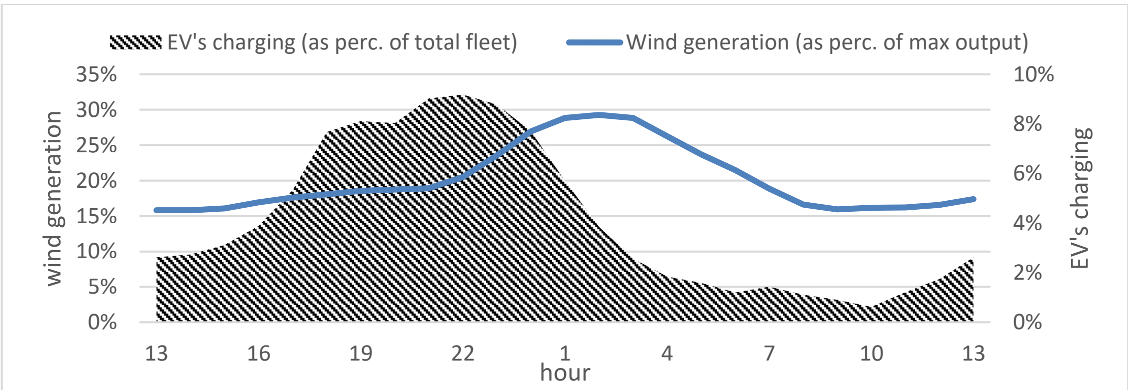


Figure 2 Imbalance in wind versus EV's charging on 23-11-2014 (source EV: own calculation based on 156 home charging stations, Source wind: MERRA-2 Wind speeds)

2 Smart Charging

2.1 Definition

Smart Charging refers to all intelligent technologies enabling to charge the car at the best possible moment, in order to achieve a given objective, among them:

- Reduction of the local Network Congestion
- Reduction of the user energy bill
- Reduction of CO_2 footprint
- Minimizing the imbalance between consumption and production

Achieving those objectives is for the benefit of the community and for the energy network in particular. Hence the EV driver should get incentivise for his participation, while its driving need should be always satisfied.

Regarding first results the present paper focuses on the grid balancing objective. The architecture is already future proof for servicing DSOs/DNOs and TSOs.

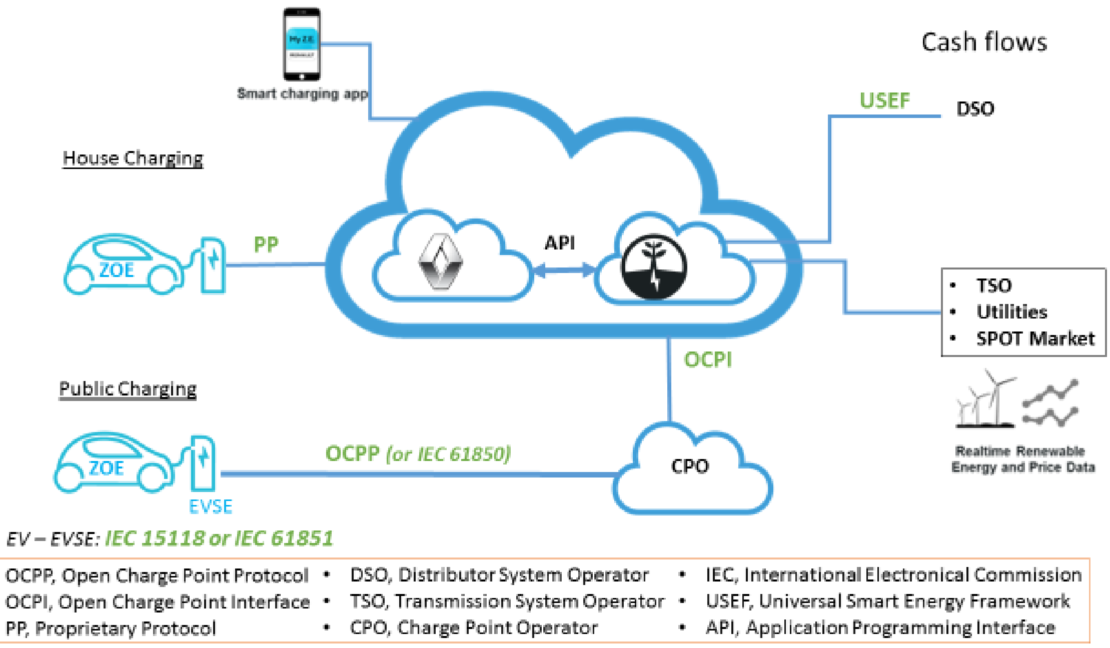
2.2 Architecture

The minimum requirement for smart charging is a connected electrical car and presence of a smart meter. The connected car is providing real-time data (e.g. state of charge) and the functionality to control the charging. The smart meter ensures that the steering of the car changes the position of the supplier and balance responsible party of the meter.

A dynamic charging plan will then be calculated by the aggregator, based on a real-time pricing and trading integration, information from the car and the user settings .The real time pricing is a derivative of day-ahead, intraday and imbalance price developments and correlates heavily with renewable energy production. The charging plan is applied to the car, either through the Electric Vehicle Supply Equipment –EVSE- or via an over-the-air control of the car.

The main disadvantage of communication through the EVSE is today the cost of the connected charging station.

The architecture described in this paper is an off-board smart charging architecture, controlled by an aggregator and through an over-the-air control of the car.



The set-up and design is in line with the European Commission's “Clean Energy for All Europeans” proposals (the ‘Winter Package’). This package states that distributed energy resources should get access to flexibility markets and are key in the energy transition. The DSO becomes a procurer of this flexibility to lower the costs of grid integration in line with how TSO’s are organizing this currently.

For the same and for more reasons the architecture also contains already integrated protocols from both the charging market, OCPI, as from DSOs, USEF.

2.3 First results in the Netherlands

First results have been obtained in the Netherlands, with Renault ZOE cars and the app developed by Jedlix. The profit derived from the flexibility is shared with the e-driver owner who creates savings mainly during the night, while he is asleep, with no impact on his range autonomy and driving needs. By means of only offering available charging times, the e-driver fully automated receives a monthly varying between €5 to €15 even though current wholesale market volatility is relatively low. More usage (kWh), load speed (kW) and availability (hours to steer the car) lead to a higher value.

Besides the value on the wholesale market, it also has been found that this flexibility can be combined with the need for steering on the distribution grid level. The current steering framework for the DSO level focuses to reduce peak moments which in general occur at the end of the afternoon/beginning of the evening. These are moments when wholesale power prices also tend to be at a high level. Intraday and imbalance prices can still be low during these hours due to events which are not foreseen. So, when providing flexibility to the DSO, some value is lost on the wholesale market, but it is clear that combining them provides synergies.

2.4 User centric design

The behaviour of the e-driver will to a great extent determine the possibilities for smart charging. In order to deal with range anxiety related issues, the solution offers both the certainty of having enough charge for the next journey and asks as little from the end-user as possible. To extent this solution, further integrations could include one's digital planner, Home Energy Management System or a set-and-forget user-interface design.

3 Conclusion

The real-life results of the Netherlands living lab, confirm the feasibility and attractiveness of the EV smart charging, as described in the literature for some years, with tangible financial gain for the EV driver. It is shown that the business model is attractive for both the EV driver and the grid. Further work can present the results of the ongoing project in the Netherlands, with the DSO of Utrecht, Renault, Jedlix, and local partners. This includes the measurement of additional possible revenue, such as storing excess power from renewable sources and discharge it at times of high demand (V2G) [8], making the EV more attractive, with a lower TCO than ICE cars. The car connectivity is certainly a key element for the success and well-functioning of the off-board smart services and other form of connectivity will grow including LoRa or Sigfox (low-speed and low frequency connections, consuming very little power) in the car industry.

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Authors

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Taco van Berkel received the MSc degree from Technical University Delft, The Netherlands in 1999. He is currently working at Jedlix, part of Eneco Group, on mobility related aspects of smart charging of electrical vehicles. Since 2010 Taco has been among the pioneers within the current breakthrough of electrical mobility. First assigned by the City of Amsterdam to purchase and manager the first large scale roll-out of public chargers in Europe. After joining Eneco Group in 2012 and founding its Electric Charging Department, he since 2015 focusses on smart charging, user-experience and applying IoT in e-mobility. Within Jedlix his special focus is on cooperating with car-manufacturers and other mobility providers.

Jorg van Heesbeen is the co-founder of Jedlix, a spin-off from renewable energy utility Eneco, that has developed a platform that connects the charging of electric cars with renewable energy production. Jorg is responsible for international business development with special attention for cooperation with energy partners. Before founding Jedlix, Jorg worked in the area of renewable energy integration and demand side management for Eneco Energy Trade and Quby in both Silicon Valley and the Benelux. Jorg holds a degree in Energy Innovation Management (2012) from a combined program at Columbia University, USA and Utrecht University, The Netherlands.