THE IMPACT OF ELECTRIC VEHICLE STORAGE CAPACITY IN EUROPEAN DECARBONATION GOALS : INTERACTION WITH THE ELECTRICITY MARKET PRICE

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Overview

When higher levels of renewable energies (REn) will be reached in future electricity mix, some problems in spot markets incurred by these cleaner but intermittent resources will be accentuated. An excessive penetration of REn has an important decreasing impact on the electricity market. As an instrument for governments to achieve the objectives of reducing CO_2 emissions, REn have a priority place in the sale of their production in the merit order system and receive subsidies external to the market. Under these conditions, the production of REn plays an important role in the establishment of market prices. It arrives under certain conditions of electricity demand and supply that the equilibrium price decreases and fixes the market price at very low and even negative values: when there is an overproduction and that it can no longer be stored -by means of pumped hydroelectric plants- or exported -since the maximum physical capacities are reached-, or when boundary countries are also in a situation of overproduction and low consumption as well.

The aggregation of a power capacity, such as the one available with a considerable fleet of electric vehicles (EV) disposed to support the bulk power system through an intelligent and conscientious recharging system (the vehicle grid integration VGI), could have a positive impact on the electricity markets while having benefits on CO_2 emissions. Electricity consumption of some millions EV is relatively low for the large capacity of the power system, but the order of magnitude is comparable with the modulations made during the surplus of REn production. Charging EV with the same charging pattern that pumped-storage hydroelectricity plants (during peak solar production hours and during the night from midnight to 5 a.m.), would allow REn to be absorbed and avoid the modulations of other power plants, would reduce prices volatility and would reduce the formation of negative prices in the market. The analysis of price behavior in an interconnected market like the European one, makes it possible to imagine a way of valuing storage systems, such as the one offered by the aggregation of some millions EV batteries capacity, capable of absorbing overproduction.

The research is focused in the integration of EV into a national and interconnected grid. Our analysis will concentrate specifically the French and German cases, representing today 55% of the European Union EV fleet and around one third of the total particular fleet. We analyze the future variations in the demand/supply curves coming from VGI while guaranteeing the system balance during peak consumption hours and overproduction hours.

The expected demand/supply curves variations can respond to the inherent electric demand for EV batteries use (raising demand) and to the active participation of EV fleet in the system (charging during low demand hours and with the possibility of restoring electricity during pic hours though a bidirectional system). As result of a massive integration, a change in the unit commitment is attended and thereby, a change in market prices.

Methods

Three modelling tools have been designed to assess the interaction between EV and the electricity mix. The first tool is dedicated to the simulation of the car fleets behavior, their energy consumption and the CO2 emissions. The second model is a decentralized VGI simulation tool based on an algorithm for EV charge developed by Renault. Through the smart charging it manages the fleet electricity demand for charging the EV fleet during low demand periods and therefore doing valley filling on demand curve. Counterwise, the reinjections during high demand periods will be managed with bidirectional systems for doing pic shaving. Thus, we simulate the optimal EV charging according to the load curve.

For a given EV scenario, we will use the decentralized VGI algorithm for calculating the aggregated charge on the power grid by time slots that will be comparable to time slots used in SPOT electricity markets. Finally, we will use the cumulated EV charge profile in the final demand curve as input in a polynomial approach system for estimating electricity market prices.

We consider the aggregated EV fleet as one of the backup technologies for REn in the electricity mix. Thus, we simulate the introduction of EV batteries for electricity storage on the grid in an optimization model of the electricity mix. We investigate scenarios of EV adoption for 2035 with the respective CO2 objectives.

Results

We have considered several scenarios of decarbonation for the electricity mix and the transportation sector based on the European neutrality carbon objective. These scenarios include the European carbon market. The main results of the model are :

- The CO_2 emissions of the transportation sector and the electricity sector
- The electricity demand of EV charging and the contribution of EV batteries to the flexibility
- The evaluation of how VGI could be reflected in electricity day-ahead market.

Finally, we evaluate how VGI will be reflected in market prices convergence (and on negative prices decrease). We also pay attention to the reduction of the electricity price fluctuation (it oscilated between -90€ and 121€ by 2019).

Participation of EV storage in electricity markets could be part of the solution to the missing money problem for backup units, where market prices do not reflect the value of investment in the resources needed for having a reliable electric service.With the VGI we could expect to have a better remunerated power system that would contribute to promote investment in clean energies while keeping adequacy and reliability.

Conclusions

The VGI is a key tool for approaching energy transition objectifs from the transport and the electricity sectors at the same time. Moreover, the contribution of VGI is twofold: with the pic shaving and valley filling, the electricity market will have a flexibility resource for absorbing REn pics, avoiding the REn supply curtailment during low demand periods and it will have an available system for restoring electricity in high demand periods. This contribution to the electricity mix would have an impact both from an economic and an environmental point of view.

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