THE EFFECT OF VEHICLE-TO-GRID IN FRANCE AND GERMANY, IN A CONTEXT OF MARKET COUPLING BY 2035

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Overview

In the next two decades, European energy landscape will face new structural challenges considering worldwide climate objectives. French and German climate policies thus include several main components, including modification of the national electricity mix and promotion of electric vehicles (EV). By 2035, French electric mix will be mainly composed of renewables and nuclear whereas German mix will be mostly divided between renewables and gas. Besides, France and Germany expect 10 to 15 million EV on their respective networks. Finally, these structural changes must be put in perspective of a strong European will to liberalise the electricity market through the installation of new interconnection lines.

Such measures bring uncertainty to energy stakeholders such as Transmission System Operators (TSO), energy suppliers, consumers and car manufacturers since the intermittent nature of renewable generation and the EV induced electricity demand could change the behaviour of spot price and bring new constraints. In addition, the growth of interconnection capacity could also be a key component of the electricity market structuration.

This study focuses on the evolution of economic and climate key indicators regarding the effects of EV penetration in the French and German networks. It then assesses the mitigation of those effects through vehicle-to-grid development, in a reinforced market coupling context.

Methods

The question is treated as an optimization problem, implemented in GAMS (General Algebraic Modeling System). In a first place, we have modeled the power generation systems of France and Germany separately, with a bottom-up approach. Both electric mixes are based on respective national energy plans for 2035. The study is conducted over 3 weeks, chosen as being representative of the plurality of load curves and meteorological conditions throughout a year. The technical characteristics of both systems such as capacity mixes and marginal costs of production are entered as inputs, and the total cost of running the system is minimized, following a merit-order logic. The two national models are then merged under a constraint of interconnection capacity in order to make physical flows possible between the two countries. At first, several scenarios are investigated considering several pathways toward carbon neutrality in 2050. The model is set free to invest in new storage capacities and interconnection capabilities. Secondly, a sensitivity analysis is done, for each scenario, assessing the impact of interconnection capacities and electric vehicle spread along with vehicle-to-grid possibilities.

Results

The analysis of the results points out the fact that a higher interconnection capability between the two electric systems leads to a price convergence on the wholesale market and a better economic efficiency as a whole, as predicted by theory. This phenomenon applies more especially in a situation where very few storage capacities are available, while the spreading of the latter produces a growing gap between the respective electricity prices. Ultimately, in a situation of a large interconnection between France and Germany and of wide access to storage, France uses nuclear and hydrological power units as a baseload throughout the 3 studied weeks, while Germany produces mainly with renewables. The significant flexibility induced by the massive amount of storage capabilities and interconnection fills the discrepancy between

national production and consumption whenever it is needed. As a consequence, a strong interconnection leads to an important decrease in German electricity prices while it increases French prices on the wholesale market. In addition, the growth of electricity vehicles along with vehicle-to-grid possibilities have some ambiguous consequences. While it tends to increase the electricity prices when the interconnection is low, it has the opposite effect from a certain interconnection threshold. Globally, for a high interconnection capacity, the greater the storage capacity, the greater the export from France toward Germany, and the greater the gap between both market prices.

Conclusions

According to the analysis, the impact of vehicle-to-grid on electricity prices is ambiguous given the demand and supply mechanisms at work and depends on the interconnection level between France and Germany.

The European willingness to develop a unique electricity market between states is based on theoretical and empirical evidence that a highly integrated electricity market leads to an overall better economic efficiency. In a context of strengthening the several interconnection lines between countries, the exponential spread of electric vehicles can be an opportunity to help reducing the risk of black-out during peak loads. Results have shown a close complementarity between France and Germany electric systems by 2035, which is strengthened by the use of storage and vehicle-to-grid capacities. This complementarity between both countries could lead to a form of "specialisation" where France would be a net exporter toward Germany, either to fill-in German storage capacities, either to fulfil German electricity demand directly.

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