ECONOMIC AND ENVIRONMENTAL BENEFITS OF ELECTRIC VEHICLE SMART CHARGING IN A LARGE-SCALE EV INTEGRATION SCENARIO FOR FRANCE

Simona De Lauretis, RTE (Réseau de Transport d'Électricité), +33 (0)1 41 02 10 20, simona.delauretis@rte-france.com
Alberto Tejeda de la Cruz, RTE (Réseau de Transport d'Électricité), +33 (0)1 41 02 40 13, alberto.tejeda@rte-france.com
Florian Bourcier, RTE (Réseau de Transport d'Électricité), +33 (0)1 41 02 11 01, florian.bourcier@rte-france.com
Mathilde Françon, RTE (Réseau de Transport d'Électricité), mathilde.francon@rte-france.com
Cécile Goubet, AVERE France, cecile.goubet@avere-france.org
Cédric Léonard, RTE (Réseau de Transport d'Électricité), +33 (0)1 41 02 17 17, cedric.leonard@rte-france.com

Overview

Massive transport electrification is an important driver of both greenhouse gas emissions and air pollution reduction, and several countries are taking steps in that direction. France has recently put into the legislation a ban on sales of ICE vehicles using fossil fuels by 2040 [1]. While the impact of EV charging on peak electricity demand needs to be carefully analysed, the flexibility of EV charging patterns can provide demand-side response opportunities to facilitate the penetration of intermittent renewable energy sources, reducing the needs for peak load power plants [2-4]. In this study, we quantify the potential economic and environmental benefits of EV load management strategies in a long-term scenario (2035) for France, with a high share of renewable electricity generation (48%) and a significant development of e-mobility (up to 15.6 million vehicles). The analyses are conducted in a welfare analysis framework, using a large-scale model of the European electricity system.

Methods

The methodology used to assess the benefits of smart charging and V2G relies on the combination of two models: a model describing the driving patterns and uncontrolled charging demand of EVs and a power system simulator. The simulation of EV behaviour is based on data from the latest French national travel survey (Enquête Nationale Transports et Déplacements [5]). Three scenarios, with variants considering different numbers of EVs, are analysed to represent different combinations of hypotheses. For each scenario, the EV model provides the users' mobility requirements, plug-in periods, plug-in power and uncontrolled charging demand (Fig. 1). The Antares power system simulator [6] minimises the expected operating cost of the European transmission-generation system for interconnected power grids at an hourly resolution, using a Monte-Carlo approach. A detailed representation of EV behaviour is implemented to estimate the flexibility of EV charging while ensuiring the satisfaction of the users' mobility requirements. The model provides the smart-charging demand of EVs, electricity prices, CO2 emissions and electricity generation costs.

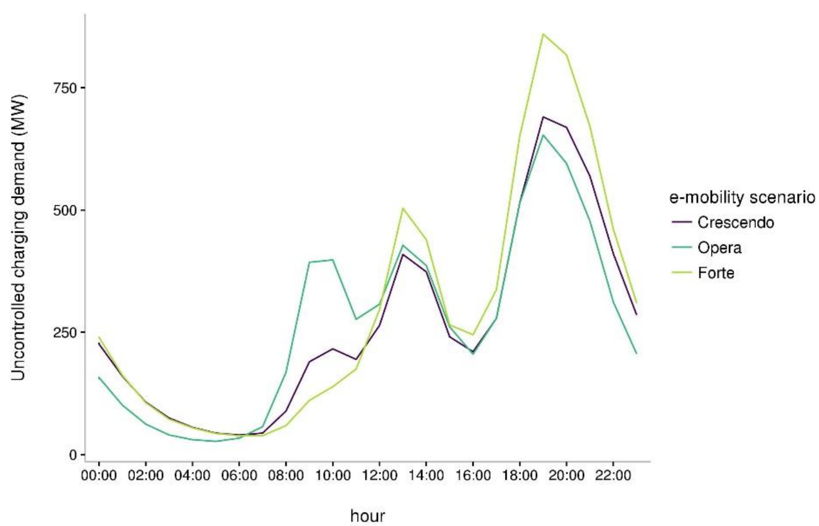

Figure 1: Uncontrolled charging demand for a weekday, for one million EVs in different e-mobility scenarios

Results

For an equivalent level of transport electrification, the cost of electricity generation for charging electric vehicles varies considerably according to the e-mobility scenario, depending foremost on the type of smart charging and its diffusion (Fig. 2). This cost is calculated compared to a scenario without any development of e-mobility. The widespread deployment of even simple smart charging appears to be a "no regret" option, leading to significant collective savings (0.6 billion euros/year when comparing Forte high scenario to uncontrolled Forte high) with low costs. Sophisticated smart charging between the system and vehicles, combined with V2G injection and high access to charging stations away-from-home, leads to substantial additional savings : the cost of electricity generation for EVs is 1.1 billion euros/year lower in Opera high scenario than in Forte high. The flexibility of EVs improves the environmental performances of electricity generation as well. With a high level of smart charging and V2G, the introduction of electric vehicles can decrease total greenhouse gas emissions of electricity generation compared to a scenario without electric vehicles, despite the increase in electricity generation.

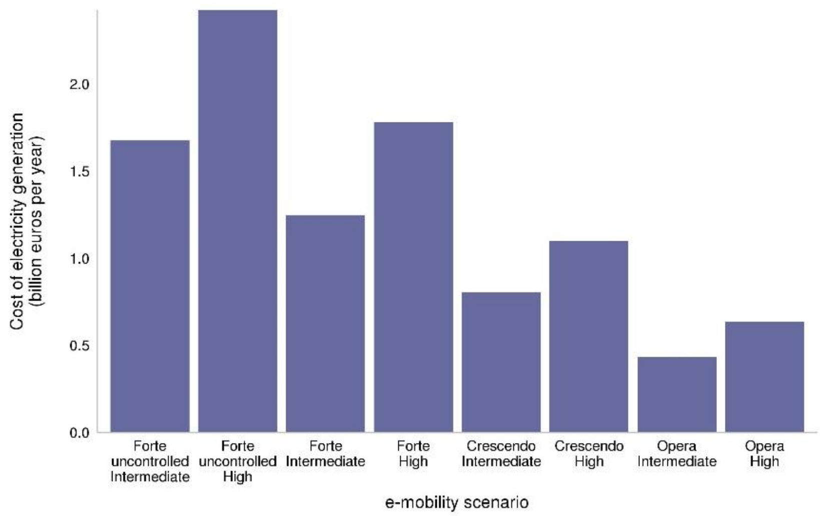

Figure 2: Cost of electricity generation for EV charging in different e-mobility scenarios

Conclusions

With an expected evolution of the power system towards a high share of renewables in the generation mix in France by 2035, the development of e-mobility, associated with the development of smart charging, can be an asset for the economic and environmental optimisation of electricity generation.

References

[1] La loi mobilités, https://www.ecologique-solidaire.gouv.fr/loi-mobilites#e2, accessed on 2020-01-22

[2] F. Teng et. Al., Benefits of flexibility from smart electrified transportation and heating in the future UK electricity system, Applied Energy, ISSN 0306-2619, 167(2016), 420-431

[3] J. Coignard et. Al., Clean vehicles as an enabler for a clean electricity grid, Environmental Research Letters, ISSN 1748-9326, 13.5(2018), 054031

[4] J. Delgado et. Al., Impacts of plug-in electric vehicles in the portuguese electrical grid, Transportation Research Part D: Transport and Environment, ISSN 1361-9209, 62(2018), 372-385

[5] ENTD 2008, https://www.statistiques.developpement-durable.gouv.fr/enquete-nationale-transports-et-deplacements-entd-2008, accessed on 2020-01-22

[6] Antares simulator, https://antares-simulator.org/, accessed on 2020-01-22