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THE VALUE OF VEHICLE-TO-GRID FOR THE SWISS ELECTRICITY SYSTEM

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Overview

As many countries are striving to reach net-zero emissions goals, increased adoption of RES (renewable energy sources) and the electrification of energy-intensive sectors (such as the heating and mobility sector) are essential ingredients for decarbonization pathways. This will have a substantial impact on the electricity system. Possible solutions to reduce the burden on the electricity system include DSM (demand-side management) operations. V2G (vehicle-to-grid) - the bidirectional interaction between electric vehicles and the grid – is one way of leveraging the battery capacity to provide flexibility for the electricity system. In this study, we estimate the impact of V2G on the Swiss electricity system.

Methods

To compute the value of V2G for the Swiss electricity system, we use the CentIv module of the Nexus-e modelling framework. Nexus-e is a platform of interfaced high-resolution models for the energy-economic assessment of future electricity systems. The CentIv optimization framework takes detailed information of the available generation technologies and the Swiss transmission grid and computes an OPF with hourly resolution, for the desired simulation years (here 2030, 2040 and 2050). We hereby assume that V2G is used for balancing supply and demand on a system level. We investigate two reference scenarios, one with and one without V2G, and four sensitivity analyses on restricted electricity trading (NTC30), developments in neighboring countries (TDE), higher gas prices (Gas), and higher levels of V2G available (XL). In all simulations we set the V2G VOM (variable operating and maintenance) costs to zero, to obtain an upper bound of the V2G value for the system.

Results

There are three main drivers for the value of V2G in the electricity system. First, charging the EV batteries during peak electricity generation time and discharging them at times with lower RES production or high demand leads to better exploitation of installed VRES (variable RES). Second, the added flexibility by V2G allows better exploitation of market price differences between hours and days. Third, V2G can help to avoid using expensive backup generators based on fossil fuels. We analyze the impact of V2G on electricity system costs, curtailment of VRES and electricity trading with Switzerland's neighboring countries. Our results show that participation of EVs in V2G leads to electricity system costs decreases varying between 1.7 to 6.6 billion EUR for the 2020-2050 time frame (see Figures 1, 2). This translates into yearly cost savings up to 92 EUR per vehicle. The use of V2G as decentralized battery storage units allow the system to reduce curtailment by 18 to 71% (Figure 3). Additionally, imports and exports can be planned for more beneficial times and become more lucrative.

Conclusions

In all analyses, the introduction of V2G leads to economic benefits for the electricity system. The value of V2G depends on many factors, including the EV and V2G modeling assumptions and the developments in the surrounding countries. When V2G VOM costs are set to zero, the comparison between scenarios with and without V2G integration give an indication of how much is worth paying for the V2G service, from the system's perspective. This should be compared to the V2G implementation costs and the necessary payment to EV owners. However, information and studies on these costs are scarce. Additional interesting aspects to be investigated, but not present in this study, are the impact of V2G on CO2 emissions and on the required expansion of the distribution grids. Additionally, it would be interesting to observe how system costs are affected when V2G is participating in the reserves market.

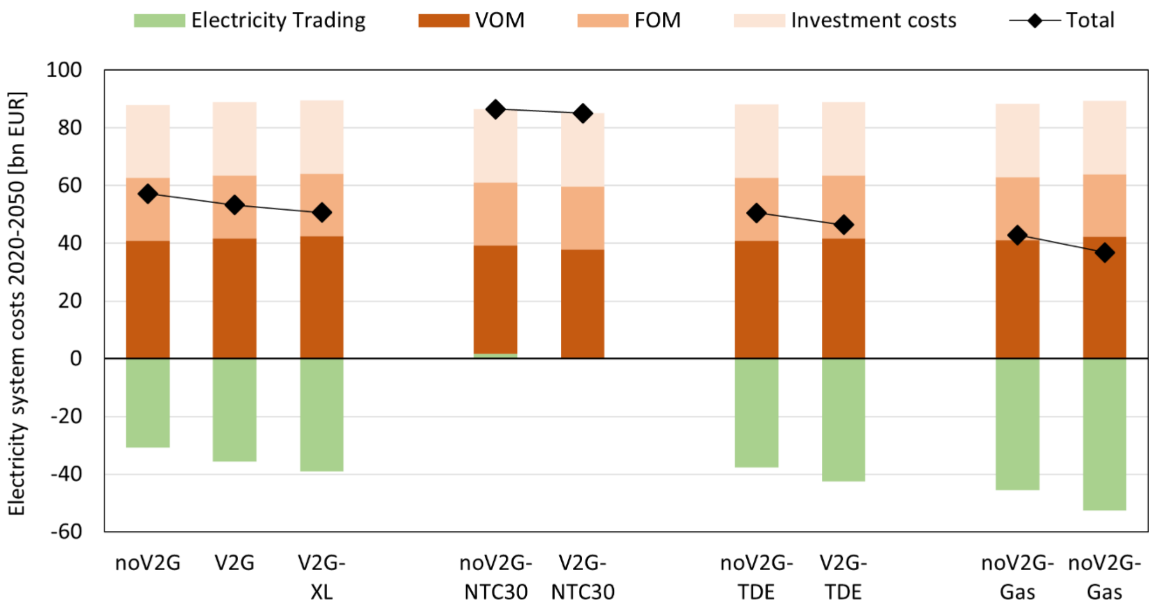

Figure 3. System costs broken down in VOM, FOM (flexible operation and maintenance), investment and trading costs.

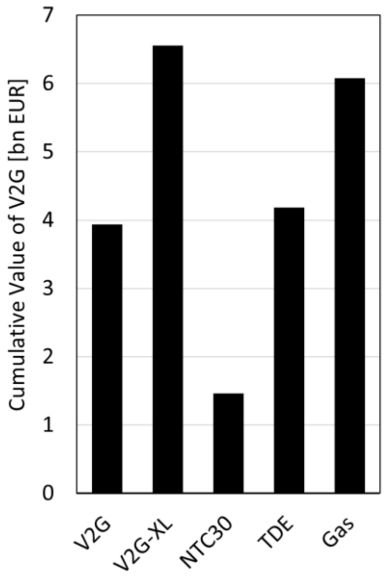

Figure 2. Total system costs.

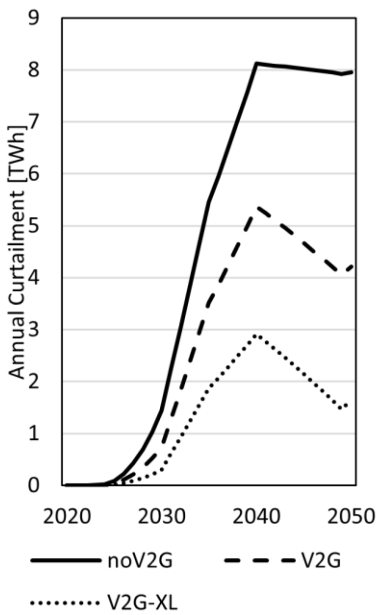

Figure 1. Annual curtailment.

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