Energy. Volume:141. Pages: 2218-2233. December 2017

Impact of EV penetration in the interconnected urban environment of a smart city

C. Calvillo, A. Sánchez, J. Villar, F. Martín

Abstract— The smart city seeks a highly interconnected, monitored and globally optimized environment to profit from the synergies among systems such as energy, transports or waste management. From an energy perspective, transport systems and facilities are among the bigger energy consumers inside cities. However, despite the research available on such systems, few works focus on their interactions and potential synergies to increase their efficiencies.

This paper address this problem by assessing the benefits of the interconnection and joint management of different energy systems in a smart city context. This is done using a linear programming problem, modelling a district with residential loads, distributed energy resources (DER) and electric vehicles (EV), which are also connected to an electrical metro substation. This connection allows to store the metro regenerative braking energy into EVs' batteries to be used later for other trains or for the EVs themselves. The objective of the linear programming model is to find the optimal planning and operation of all the considered systems, achieving minimum energy costs.

Therefore, the main contributions of this paper are the assessment of synergies of the interconnection of these systems and the detailed analysis of the impact of different EV penetration levels. Results show important economic benefits for the overall system (up to 30%) when the investments and its operation are globally optimized, especially reducing the metro energy costs. Also, analysing the energy transfers between metro-EV, it is evident that the metro takes advantages of the cheaper energy coming from the district (through the EVs), showing the existence of «opportunistic» synergies. Lastly, EV saturation points (where extra EVs represent more load but do not provide additional useful storage to the system) can be relatively small (200-300 EVs) when the energy transfer to the metro electrical substation is restricted, but it is also reduced by the presence of DER systems.

Index Terms— Demand Response; Distributed Energy Resources; Electric Vehicle; Energy Management; Public Transport Systems; Smart City; ,

Citation:
Calvillo, C.; Sánchez, A.; Villar, J.; Martín, F.; "Impact of EV penetration in the interconnected urban environment of a smart city", Energy, vol.141, pp.2218-2233. December, 2017.