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Stochastic programming applied to EV charging points for energy and reserve service markets

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Abstract— A more realistic management of electric vehicle (EV) charging points requires to cope with stochastic behavior on vehicle staying patterns. This paper presents a stochastic programming model to achieve optimal management taking into account price variation in day-ahead and intraday electricity markets, together with regulating reserve margins. In this model, first-stage decisions determine day-ahead energy purchases and sales and the upward and downward reserve margins committed. Second-stage decisions correspond to intraday markets and deal with reserve requirements and several possible scenarios for vehicle staying pattern.
The design of the objective function prioritizes supplying energy to EV batteries while minimizing the net expected energy cost at the EV charging point. A case study describing a parking for 50 EVs is analyzed. The case includes household, commercial and mixed EV staying patterns with several intraday arrival and departure scenarios. Pure and hybrid EVs are included, taking into account their respective energy characteristics. Sensitivity analysis is used to show the potential energy cost savings and the impact of different non-supply penalizations. The case study considers several vehicle staying patterns, energy price profiles and discharge allowances. The model achieves energy cost reductions between 1% and 15% depending on the specific case. A model validation by simulation has been done.

Index Terms— Day-ahead and intraday markets, electric vehicle batteries, grid to vehicle, regulating reserve, stochastic programming, vehicle to grid.

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