IEEE Transactions on Power Systems. Volume:31. Number: 1. Pages: 464-473. January 2016

Retail pricing: a bilevel program for PEV aggregator decisions using indirect load control

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Abstract— Charging schedules of plug-in electric vehicles (PEVs) coordinated by an aggregating agent may increase system efficiency of allocating generation, transmission and distribution resources. Decentralized self-scheduling and local charging control appear to be preferred by vehicle manufacturers and PEV drivers who are simultaneously concerned about the longevity and reliability of their energy storage systems. In such a setting, the aggregator would have to determine energy retail prices as means to indirect load control. This paper proposes a mathematical program with equilibrium constraints optimizing the aggregator's decisions. It endogenously determines the profit-optimal price level subject to the cost minimizing charging schedule of the final customers, who are reacting to a combination of retail price signals and distribution use-of-system network charges. This active response follows an affine demand-price relationship, which is individually parametrized for each vehicle by local information of vehicle characteristics and mobility pattern. The proposed program is applied to two cases: 1) a small case study with 3 vehicles, which highlights the model functionality with detailed hourly information per vehicle; 2) a large-scale fleet of 1000 vehicles provides insights on computational burden. Numerical results indicate that adequate competition in the retail market is necessary to limit the aggregator's monopolistic profitability. Finally, sensitivity runs show dependency on the individual's willingness to pay, the cost of alternative fueling opportunities and minimum state-of-charge requirements.

Index Terms— Bilevel optimization, optimal charging schedules, plug-in electric vehicle aggregator, retail tariffs for electricity

Citation:
Momber, I.; Wogrin, S.; Gómez, T.; "Retail pricing: a bilevel program for PEV aggregator decisions using indirect load control", IEEE Transactions on Power Systems, vol.31, no.1, pp.464-473. January, 2016.