The Impact of Electric Vehicle Density on Local Grid Costs: Empirical Evidence from Norway

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We observe a rapid rise in the number of battery electric vehicles (BEVs) in Norway, and there exists a literature that warns that BEV charging will cause substantial future costs to the local grid, unless measures are put in place. If indeed the aggregate uncoordinated charging by BEV owners does induce higher costs to Distribution System Operators (DSOs), then Norwegian data would be the first place to investigate. Detailed data of all Norwegian DSOs and all registered BEVs during the last ten years give a unique opportunity to analyze this relationship. To our knowledge, such an empirical analysis has not been done before on real data in a country-wide analysis. It will therefore push the knowledge frontier on a debated, but relatively unexplored topic empirically. Findings may have implications for how to regulate DSOs, how to price household power usage and how to assess the net social cost of achieving emission reduction targets through promoting BEVs.

By merging together data from NVE on annual costs of DSOs applied for regulation, their operational area, and data on registered cars at municipal level, we get a unique panel dataset for such analysis. Our data set of 107 Norwegian DSOs outputs, costs and registered BEVs in their operational area between 2008 and 2017 allows us to investigate how BEVs affect DSO costs. Exploiting local differences in the growth of the BEV fleet over time, we investigate how an increase in the number of BEVs affects the costs of the local DSO, using fixed-effects estimation that account for time-invariant characteristics of the DSO. We also control for growth in output indicators that could be correlated with growth in the BEV fleet. We look at both total costs and individual cost components.

We find that increases in the BEV fleet are associated with positive and statistically significant increases in costs when controlling for other DSO outputs and year dummies. The point estimates also imply that the effect is economically significant, with a preferred model giving a cost elasticity of 0.018 from increases in the local BEV stock. This finding is robust to the addition of several controls and removal of outliers. We also find the strongest impact through operational costs, and not capital costs. Although we find significant effects in the national sample, there is a lot of heterogeneity in these results, with the marginal cost estimates being a lot higher for small DSOs in rural areas, and a lot lower for larger DSOs. This heterogeneity also indicates that the BEV-induced costs is not a major problem that has affected a large number of consumers. The half of the sample with the largest DSOs, where the estimated cost elasticity from BEVs was close to zero, serve over 93 % of the customers in the entire sample.

Finding that increased BEV ownership is associated with higher DSO costs, implies that the case for a well-specified peak-pricing system for grid tariffs is strengthened, so that efficient load-shifting is properly incentivized. Many BEV owners would probably respond by installing smart charging systems, which would ease the household cost minimization and ensure more efficient grid capacity utilization, even with small hour-to-hour price differences.

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