The effect of different dynamic pricing schemes on the use of e-vehicle charging infrastructure

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Overview

The adoption and use of battery electric vehicles depend heavily on being able to (re)charge conveniently at preferred locations and times of the day. However, users today observe congestion at the charging stations, especially in urban locations during rush hours. This is induced by (i) the ineffective use of the existing infrastructure and (ii) misalignment of the financial incentives for the users' valuation of charging. Similar to the residential electricity consumption, despite battery electric vehicle drivers' time-varying willingness to pay (WTP) for charging throughout the day, drivers pay a fixed rate for each kWh charged. Hence, financial incentives are typically not aligned with users' valuation for charging at different times and locations.
In this study, we investigate the effects of dynamic pricing schemes on the use of the charging infrastructure with the aim to remedy the problem of congestion by using smart, price-based incentive schemes designed at motivating users to alter their charging behavior at specific times and locations.

Methods

A survey-based experiment is designed to quantify the differences in relative WTP for different pricing schemes. We investigate dynamic pricing schemes that vary across the time of the day, location, and load management. To better understand at which relative prices users are willing to accept a specific dynamic pricing scheme, we designed a quantitative survey that includes hypothetical choice scenarios for each dynamic pricing scheme. To elicit participants' relative WTP for each pricing option over the other, we apply a procedure that is based on the multiple price lists (MPL) method. Furthermore, by randomizing the order of the scenario descriptions, we eliminate part of the selection bias across the experimental treatments. We test the differences in individuals' WTP for each pricing scheme statistically and explain these differences in a regression model with fixed effects using a variation on individuals' current utilization of the charging infrastructure as well as a set of environmental and economic preferences.

Results

Our results indicate that dynamic pricing schemes facilitate shifting demand effectively, as users are willing to shift their charging time, location, and duration if they receive more competitive price offers for charging in return. Our findings show that the price reductions required to effectively shift demand vary significantly across the dynamic pricing schemes. Part of this variation in the willingness to accept alternative charging options is explained by prices individuals face in their current contracts, environmental preferences as well as existing mobility and technology adoption patterns.

Conclusions

Our results suggest that bottlenecks at charging stations could be prevented by providing the right financial incentives to users. Charging events could be shifted spatially, temporally throughout the day, or situation-dependent by the charging event at the station level by introducing dynamic pricing schemes. Technically, it is already possible to establish dynamic charging tariffs, but the associated regulatory framework is not yet in place. To make more efficient use of charging infrastructure, we recommend that policymakers should work on regulatory solutions to enable the introduction of those tariffs. The results gained have important policy implications in terms of quantifying and explaining the variation in users' WTP for the different dynamic pricing schemes. This enables to better understand the heterogeneity in the effectiveness of distinct dynamic pricing schemes.

References

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