Charged up? Preferences for Electric Vehicle Charging and Implications for Charging Infrastructure Planning

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Overview

Electric mobility charging behavior is at the crossroads of the sustainable energy and sustainable mobility transitions. The energy transition is characterized by a reduction of fossil fuel usage as well as of related CO_2 emissions in the energy sector, while the mobility transition aims at achieving these goals in the transport sector. Specifically, the mobility transition includes changes in the individual mobility behavior towards more sustainable solutions. The recharging of electric vehicles (EV) should adapt to both the energy transition and the mobility transition. From a user perspective, standard charging of the EV battery takes considerably longer than filling the gasoline tank. Thus, EV charging options will have to be adjusted to better fit user expectations, needs, and behavior. From a business perspective, use cases are often still missing. In Germany, up until now, necessary EV infrastructure investments are high and the revenue streams are often still too low even for relatively high electricity prices in the residential sector (0.29 €/kWh). Also, it is not clear who the preferable actors are for installing and running EV infrastructure; may it be car manufacturers, state, municipalities, or energy companies.

Consequently, it is crucial to better understand the charging preferences of current and potential future EV drivers in a more mature EV market. In the literature, there are studies that investigate single attributes of the charging process; Hackbarth and Madlener (2013, 2016), Hidrue et al. (2011), and Tanaka et al. (2014), for instance, investigate the willingness to pay (WTP) for the EV adoption whereas Ito et al. (2013) examine the willingness to pay for the EV-charging infrastructure. Franke et al. (2012) find factors influencing range anxiety. However, none of the mentioned studies has looked at the charging preferences as a whole including related services.

Therefore, we assess EV drivers' valuation of six different attributes of the charging process such as charging speed, location, share of renewables, waiting time for an available charging station, charging technology, and price. Valuation means the WTP for specific attributes, measured in monetary terms, e.g. a 10% decrease in charging duration is worth x Euros to consumers. By extracting consumers' marginal WTP, we elicit by how much attributes have to be improved so that the WTP increases over-proportionately. We then derive managerial implications both for specific attributes and for complete mobility solutions. For example, if EV drivers assign a high value to the charging duration, this could be an area to place additional focus on when offering new charging solutions and services.

Methods

Due to the low number of current EV users in Germany, analyzing consumers' EV charging infrastructure preferences and their willingness to pay (WTP) for them based on real usage data is challenging. In addition, the results would not be transferable to the development of sound business cases since the sample size would be too low. Therefore, we gathered data through a Discrete Choice Experiment (DCE) conducted in Germany (N = 4,101).

In the DCE we asked respondents to imagine that they use an EV in their daily routines. We then confronted them with two hypothetical choice bundles for certain attributes of an EV charging infrastructure. The choice bundles were described by six attributes: place of charging, charging duration (full charge), charging technology, waiting time for available charging station, share of renewables, and charging cost per month. These attributes are defined by levels that vary between choice scenarios, e.g., charging duration takes on the four levels 10 minutes, 30 minutes, 4 hours, or 8 hours. The respondents repeat these choice scenarios 12 times with different levels. The DCE has a randomized design, i.e. attributes appear randomly with one limitation (at home charging has a waiting time of zero). This design allows us to account for differences between individual choice behaviour since the respondents maximize their utility by choosing a particular charging solution which represents their individual tradeoffs between attributes and choices. By this means, we are able to estimate the effect of different factors on choice probabilities and narrow down WTP for different features of the EV charging infrastructure and further preferences for EV charging.

Results

Before starting the DCE, we let respondents self-evaluate their knowledge in EVs in general using seven screening questions. In doing so, we reached a share of 50 % (non-) EV experts. Besides the standard demographics (income, household characteristics, and location of living), we asked respondents about their car usage and parking situations. A preference order of charging location (home, work, roadside) and of payment scheme (flatrate, pay per use, pay per min) informed us about their stated preferences. As for personality traits, we asked for environmental consciousness and technophilia.

We analyzed the data using econometric methods (fixed-effects logit models to exploit the repetitiveness of choices) in order to gain actionable insights into current and future charging behavior of EV drivers. We predict tendencies of consumer behavior and show which attributes are highly valued by potential EV drivers and which ones are not. We calculate the changes in WTP for lower charging duration at specific time intervals, e.g., for a reduction in charging time from 8 hours to 7 hours, consumers are willing to pay around 8 €/month; whereas from 8 hours to 10 minutes, consumers are willing to pay around 70 €/months for all charging processes. Further, respondents were willing to pay, on average, around 22 €/month more to choose at home- over on-the-road-charging.

Conclusions

Our DCE measures the preferences for certain attributes of an EV charging infrastructure indirectly by confronting respondents with hypothetical choice bundles. The respondents preferred charging at home to at work to roadside charging, inductively to cable-charging, with a higher share of renewable energies, with shorter waiting times and shorter charging durations, at the lowest costs. Avenues for futures research of individual choice behavior could be the integration of vehicle-to-grid and smart home, e.g., combining photovoltaic systems with EVs.

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