Investigating strategies to promote smart charging decisions of battery electric vehicle users: An empirical study considering users` range preferences

Madlen Günther[1], Yelyzaveta Vasetska[2] & Josef F. Krems[3]

[1]madlen.guenther@psychologie.tu-chemnitz.de, Department of Psychology, Cognitive and Engineering Psychology, Chemnitz University of Technology, Chemnitz, Germany
[2] Chemnitz University of Technology, Germany
[3] Chemnitz University of Technology, Germany

Research field: ☐ Economics, ☐ Technology, ☐ Politics, **X Social Aspects**
Preferred Presentation Type: **X Oral** ☐ Poster

Abstract

Introduction and Motivation

Battery electric vehicles (BEVs) are a promising mobility solution for reducing emissions in the transport sector when they are charged with energy from renewable sources. As the availability of electricity from renewable sources in the power grid can be highly variable, smart charging is an effective approach to balance the grid in times of 'green' energy shortage or overload (Spencer et al., 2021; Wong et al., 2023). However, smart charging requires more flexibility from the users, such as longer charging times and smaller range buffers (Marxen et al., 2023; Huber et al., 2019), and may reduce users' willingness to participate in smart charging (Kämpfe et al., 2022). Various behavioral interventions have been shown to be effective in promoting smart charging decisions of BEV users (Kramer et al., 2023; Marxen et al., 2023; Wong et al., 2023). Therefore, within this study the effectiveness of a monetary intervention and a coping-oriented intervention to motivate BEV users to accept smaller range buffers were empirically tested.

Applied Method

The study was conducted as an online experiment and conceptualized as a between-subject design with a pre-post-comparison. Participants were randomly assigned into three groups. Participants in experimental group one (EG1) received a monetary intervention (n = 20) and participants in experimental group two (EG2) received a coping-oriented intervention (n = 25) to motivate BEV users to accept smaller range buffers. The third group served as a control group (KG), including no intervention (n = 29). Participants were given two hypothetical charging tasks in which they had to configure a charging process for a BEV. The tasks were embedded in a prototypical smart charging app and participants were asked to select their required range in kilometers for a 150 km trip the next day.

The study included a total sample of 74 participants, of whom 50 self-identified as female and 24 as male. The participants' average age was 23 years (*SD* = 3.87; *min* = 18 years; *max* = 36 years). In terms of educational attainment, the majority of the participants reported having completed high school education (*n* = 57). Almost a third of the participants (*n* = 21) already had previous BEV experience. Demographic variables did not differ significantly between the three groups ($p > .152$).

Results

In task one (pre-intervention), participants preferred ranges well above the distance to be driven with an average range buffer of 93km (*SD* = 61.59, *min* = 50km, *max* = 250km). After receiving the interventions, participants in EG1 and EG2 accepted significantly lower range buffers of 71km on average (*SD* = 57.92, *min* = 20km, *max* = 250km). Repeated measurement ANOVA revealed a significant increase in participants' mobility flexibility ($F(1, 71 = 7.60$, $p = .007$, $\eta^2 = .10$) between the pre- and post-intervention condition.

Pairwise comparisons revealed a significant decrease in preferred range in the coping group (*M* = -27km, $p = .002$), but no significant changes in the monetary (*M* = -16km, $p = .082$) and in the control group (*M* = +3km, $p = .722$).

Conclusions

The results showed that it is necessary to enable BEV users to better utilize the range in order to increase the potential of smart charging. The user-centered HMI design proved to be a helpful strategy. Surprisingly, only the coping-oriented intervention was successful in motivating users to accept smaller range buffers, indicating that users' range preferences and their mobility flexibility need to be considered when promoting smart charging.

References

Huber, J., Schaule, E., Jung, D. & Weinhardt, C. (2019). Quo Vadis Smart Charging? A Literature Review and Expert Survey on Technical Potentials and User Acceptance of Smart Charging Systems. *World Electric Vehicle Journal, 10*(4), 85. https://doi.org/10.3390/wevj10040085

Kämpfe, B., Zimmermann, J., Dreisbusch, M., Grimm, A. L., Schumann, J. H., Naujoks, F., Keinath, A., & Krems, J.F. (2022). Preferences and perceptions of bidirectional charging from a customer's perspective–a literature review and qualitative approach. In: Liebl, J. (eds) *Electrified Mobility 2019*. Proceedings. Springer Vieweg, Wiesbaden. https://doi.org/10.1007/978-3-658-32471-1_16

Kramer, J., Riza, L., & Petzoldt, T. (2023). Carbon savings, fun, and money: The effectiveness of multiple motives for eco-driving and green charging with electric vehicles in Germany. *Energy Research & Social Science, 99*, 103054.

Marxen, H., Ansarin, M., Chemudupaty, R. & Fridgen, G. (2023). Empirical evaluation of behavioral interventions to enhance flexibility provision in smart charging. *Transportation Research. Part D, Transport And Environment, 123*, 103897. https://doi.org/10.1016/j.trd.2023.103897

Spencer, S. I., Fu, Z., Apostolaki-Iosifidou, E. & Lipman, T. (2021). Evaluating smart charging strategies using real-world data from optimized plugin electric vehicles. *Transportation Research. Part D, Transport And Environment, 100*, 103023. https://doi.org/10.1016/j.trd.2021.103023

Wong, S. D., Shaheen, S., Martin, E. & Uyeki, R. (2023). Do incentives make a difference? Understanding smart charging program adoption for electric vehicles. *Transportation Research. Part C, Emerging Technologies, 151*, 104123. https://doi.org/10.1016/j.trc.2023.104123