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

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Abstract

This study assesses respondents' preferences for privately-used passenger electric vehicle (EV) charging with respect to the six attributes: (1) place of charging; (2) charging duration (full charge); (3) charging technology; (4) waiting time for charging spot to become available; (5) share of renewables in the electricity mix used for vehicle charging; and (6) total cost for the whole bundle of attributes per month. Due to the low number of current EV users in Germany, investigating consumers' EV charging infrastructure preferences and their willingness to pay (WTP) for it based on real usage data is challenging. In addition, the results would not be directly transferable to the development of sound business cases since the sample size is too small. Therefore, we gathered data through a Discrete Choice Experiment (DCE) conducted in Germany (N = 4,101). Our DCE measures the preferences for certain attributes of EV charging infrastructures indirectly by confronting participants with hypothetical choice bundles. We analyze the data using conditional logit models, including fixed effects at the participant level, in order to gain actionable insights into the expected charging behavior of current and future EV drivers. We predict tendencies of consumer behavior and show that locational and time attributes are highly appreciated. Respondents are willing to pay, on average, around 22 €/month more for charging at home rather than at work and 46.26 €/month more for charging at home rather than on the roadside. For a reduction in charging time from 8 h to 7 h, respondents are willing to pay around 8 €/month; whereas from 8 h to 10 min, respondents are willing to pay around 70 €/month for all monthly charging processes. We also find WTP of five specific consumer categories (environmentalists, EV owners, EV experts, at-home charger, and home owners). Our results could be useful for charging point operators.

Keywords: Electric mobility charging behavior, Discrete Choice Experiment, Econometric modeling, Willingness to pay

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1. Introduction

Electric vehicle charging behavior is at the crossroads of the sustainable energy and sustainable mobility transition in Germany. 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 privately-used passenger electric vehicles (EVs) 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 (Daina et al. 2017).

With 83,175 EVs out of 47 million passenger cars in total having the possibility to charge at around 15,000 public charging spots (as of January 1, 2019: Kraftfahrtbundesamt 2019; ChargeMap.com), the share of EVs in Germany seems still too low for profitable business cases (Schroeder and Traber 2012; Gnann et al. 2018; Madina et al. 2016). In Germany, up until now, necessary EV infrastructure investments are high and yet, the revenue streams are often still too low even in the presence of relatively high electricity prices in the residential sector (of about 0.29 €/kWh). Also, it is not clear who should establish and run the EV charging infrastructure from a social welfare perspective, and whether any subsidization can indeed be justified. Charging point operators (CPOs) could be car manufacturers, state, municipalities, or energy companies. For that purpose, Gnann et al. (2018) predicted occupancy rates of fast-charging points and deduced price premiums to break even with the cost of fast-charging spots ranging from 0.04-0.16 €/kWh on electricity prices for three power rates (50, 100, 150 kW), three range levels (100, 200, 300 km), and a payback time of ten years. Consequently, it is crucial to better understand the charging preferences of current and potential future EV drivers using choice experiments, which is also stated by Daina et al. (2017).

Numerous choice experiments investigate single attributes of the charging process; Hackbarth and Madlener (2013, 2016), Hidrue et al. (2011), Hoen and Koetse (2014), and Tanaka et al. (2014), for instance, investigate the willingness to pay (WTP) for EV adoption, whereas Ito et al. (2013) examine the WTP for the EV charging infrastructure. More specifically, Hackbarth and Madlener (2016) as well as Hoen and Koetse (2014) assess the WTP for alternative fuel vehicles such as electric, biofuel, or natural gas drivetrains, whereas Hidrue et al. (2011) focus on the WTP for technical characteristics in general such as range and acceleration. Tanaka et al. (2014) compare the WTP for alternative fuel vehicles in the US and Japan. The WTP for renewable energy for EV charging has been elicited by Nienhueser and Qiu (2016). A review of "consumer preferences of and interaction with EV charging infrastructure" is given by Hardman et al. (2018), who reviewed studies published between 2011-2017 covering the US, Canada, Europe, and China. The conclusions reported in those studies correspond to our results (section 3). All of those studies concern privately-used passenger EVs and associated charging infrastructure interaction, as opposed to commercially-used light-duty EVs used by delivery drivers and their charging infrastructure interaction as was the focus of Wolff and Madlener (2019). One of the earliest studies on the recent uptake on EV usage in Germany examined the behavioral dynamics driving the charging behavior of 69 early EV adopters (Franke and Krems 2013a). Wolbertus et al. (2018b) show the effects of daytime charging policies, i.e. during the day, charging stations are exclusively reserved for EVs, whereas at night times any kind of vehicle is allowed to use them for parking. This policy decreases parking pressure due to prior underutilized charging stations now being used as night parking spots; however, it creates uncertainty about the availability of charging stations near home, which in turn may decrease EV purchase propensity. The authors conclude that creating certainty about the availability of charging stations near home should be a policy goal. Likewise, the possibility to reserve a charging spot was considered as important by 21% of our participants (section 3.2). Further, Wolbertus et al. (2018b) find that EVs are being charged even though the battery is nowhere near flat. Comparable to opportunity-driven mobile phone charging, Franke and Krems (2013b) call this charging behavior *habitual charging*. Similarly, Wolbertus et al. (2018a) find that charging spot connection times by far exceed the time span needed to actually recharge EVs. One of the most recent EV charging studies focused on the evaluation of public EV charging spots in Germany (Globisch et al. 2018; N = 1,003) who use a similar approach to ours but with the focus on public charging only.

None of the mentioned studies has looked at the consumer preferences regarding individual attributes of the charging process including charging infrastructure specifications and related services. Therefore, we designed a DCE to assess current and future EV drivers' valuation of six attributes of the charging process of privately-used passenger EVs in Germany: charging location, charging speed, charging technology, waiting time for a charging spot to become available, share of renewables, and monthly charging cost. We define the attributes by varying levels, e.g. monthly charging cost is either €50, €100, €150, or €200. Valuation means the WTP for specific attributes, measured in monetary terms, e.g. a 10% decrease in charging duration is worth €x to participants. By extracting the respondents' marginal WTP, we elicit which attributes are more or less important to them in monetary terms. Specifically, we divide the sample ex-post into five specific consumer categories (*environmentalists*, *EV owners*, *EV experts*, *at-home charger*, and *home owners*). We then derive managerial implications both for charging point operators for specific attributes and for complete mobility solutions. For example, if respondents assign a high value to the charging duration, this could be an area to place an additional focus on when offering new charging solutions and services.

Therefore, our three research questions are: (1) What are the preferences of individuals regarding specific attribute bundles of the EV charging process? (2) What is their WTP for certain attributes of the EV charging process? Following from that: (3) What are the implications for charging infrastructure policy, business models, and infrastructure planning? We focus on privately-used passenger EVs in Germany but the DCE design, specifically the attribute selection, and the accompanying survey are versatile and can thus straightforwardly be adapted to other user groups, countries or drivetrain technologies as well.

The remainder of this paper is structured as follows. Section 2 introduces the reader to the discrete choice experiments. The results of the discrete choice modeling and willingness to pay derived are reported and discussed in detail in Section 3. Section 4 concludes.

2. Survey Design

2.1 Discrete Choice Experiment

Due to the previously mentioned low share of current EV users in Germany, analyzing respondents' preferences for privately-used charging infrastructure services and their WTP for them based on real usage data is challenging. In addition, the results would not directly be transferable to sound business cases since the sample size would be too small. Therefore, we gather data through a Discrete Choice Experiment (DCE) conducted online in Germany.

A DCE consists of hypothetical choice sets where the participants repeatedly have to choose between choice alternatives A and B. In our DCE, we asked respondents to imagine that they use an EV in their daily routines and that the range of the e-car is sufficient for their daily driving needs.

Table 1: Example of a choice task

Place of charging	At home	At work
Charging duration (full charge)	10 min	4 h
Charging technology	Tethered charging (with cable)	Inductive charging (without cable)
Waiting time for available charging station	0 min	30 min
Share of renewables	25%	75%
Charging cost per month	€5	€150
	◯ Choice A	◯ Choice B

Table 2: EV charging infrastructure attributes and levels

Place of charging: Location where you would like to charge most of the times. For *at home*, assume that the necessary charging infrastructure is at your disposal at your home. For *at work*, assume that the necessary charging infrastructure is at your disposal at your work place. *Roadside* means charging in a public space; e.g. in the city quarter or at the supermarket. Here we differentiate between *Roadside: main goal* and *Roadside: side activity*. *Roadside: main goal* means that you choose a particular charging spot and drive there with the sole goal of charging your car. The search for a charging spot is an end in itself, similar to the search of a gasoline station. *Roadside: side activity* means that you happen to charge at a charging spot at the supermarket or during your leisure time (fitness studio etc.). Charging is a side effect.	At home	At work	Roadside: main goal	Roadside: side activity
Charging duration: Duration it takes to fully charge the battery of the electric car.	10 min	30 min	4 h	8 h
Charging technology: With *tethered charging*, you manually connect the electric car with a cable to the charging station. With *inductive charging*, you park the electric car at a specific position at the charging station. The charge process takes place automatically and without a cable.	Tethered charging (with cable)		Inductive charging (without cable)	
Waiting time for available charging station: Public charging spots can be occupied by other cars. *Waiting time* gives you the time you have to wait until the spot becomes available for you. At-home charging is always paired with a waiting time of 0 min. Otherwise, combinations appear randomly.	0 min	5 min	10 min	30 min
Share of renewables: Share of renewables (wind or solar energy) in the electricity mix used for charging. This could be electricity produced in your own photovoltaic system on your roof top or green electricity mode available at public charging spots.	25%	50%	75%	100%
Charging cost per month: Total costs for the whole bundle of attributes per month.	€50	€100	€150	€200

We then asked them to imagine how and where they would like to charge the e-car's battery (under the assumption of a generic e-car that is identical with respect to size, range, motor power etc.). We asked them 12 times in a row to make a choice between two choice alternatives where attributes varied in their levels (Table 1). The choice alternatives are described by six attributes found to be the most important and intuitive ones: (1) place of charging; (2) charging duration (full charge); (3) charging technology; (4) waiting time for charging points to become available; (5) share of renewables in the electricity mix used for charging; and (6) total cost for the whole bundle of attributes per month. These attributes are defined by levels that vary randomly between choice scenarios, e.g., charging duration takes on either one of the four levels 10 min, 30 min, 4 h, or 8 h (Table 2). We chose values that can be considered as realistic within the next 5-10 years. The DCE has a randomized design, i.e. when the respondents are confronted with the choice scenarios 12 times with varying attribute levels, the attribute levels appear randomly with the limitation that at-home charging always has a waiting time of 0 min. The design algorithm ensures that all levels appear on the same number of choice cards. This design allows us to account for differences between individual choice behavior since the respondents maximize their utility by choosing a particular charging solution that represents their individual trade-offs between attributes and choices. We did not include the choice alternative "None of the two options A and B" because for being able to drive the EV, users have to charge it somehow somewhere. One advantage of not including "None of the two" is that participants are required to consider their individual trade-offs and decide between option A and B. Hole (2007) calls this the Random Utility Maximization. We wanted to induce participants to trade-off between the choice alternatives, especially those respondents who might be opposed to e-mobility in order to gain unbiased behavioral data. Thus, we follow McFadden (2001) and Hole (2007) and use the Random Utility Theory, where U_{njt} is the utility of individual *n* when choosing alternative *j* in choice scenario *t*. The utility consists of the systematic utility V_{njt} and the random error term ε_{njt}.

$$U_{njt} = V_{njt} + \varepsilon_{njt}. \tag{1}$$

The systematic utility V_{njt} is a function of the attributes of alternative *j*. The probability that individual *n* selects alternative *i* rather than alternative *j* is the probability that the utility of selecting *i* is higher than selecting *j*.

$$P_{nit} = P(U_{nit} > U_{njt}) = P(V_{nit} + \varepsilon_{nit} > V_{njt} + \varepsilon_{njt}) = P\left(\varepsilon_{njt} - \varepsilon_{nit} < V_{nit} - V_{njt}\right). \quad (2)$$

We use conditional logit models, including fixed effects at the participant level, to exploit the repetitiveness of choices and subsequently follow Hole (2007) again to calculate the WTP, i.e. the amount respondents are willing to pay for the base case level compared to each alternative level and the corresponding confidence intervals. By this means, we are able to estimate the effect of different factors on choice probabilities and narrow down the WTP for different features of the EV charging infrastructure and further preferences for EV charging.

2.2 Survey

Alongside the DCE, we asked participants for standard demographics (income, household characteristics, and location of living) and about their car usage and parking situation. 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 asked control questions regarding which attributes were the most/least important in the respondents' decision. Before starting the DCE, we let participants self-evaluate their knowledge in EVs in general by using seven screening questions. With this self-stated knowledge on EVs, we later divided the sample into *non-EV experts* and *EV experts*.

3. Results and Discussion

3.1 The data

Table 3 exhibits the socio-demographic characteristics of the sample. The sample consists of drivers' license holders only and we restricted it to ≤ 75 years *ex ante*. The youngest and oldest person to answer our survey and DCE is 19 years and 72 years old, respectively. As for personality traits, environmental consciousness and technophilia exhibit mean values above three on a 5-point Likert scale.[1] The average daily car commute amounts to 36.86 km which corresponds to the German average commuting distance (German Mobility Panel 2019; own calculations) as well as

[1] Environmental consciousness and technophilia were measured on a 5-point Likert scale with 1 - completely disagree to 5 - completely agree.

to EV literature with a focus on Germany (Franke and Krems 2013a). The sample corresponds to the German population, also with respect to the regional dispersion of participants.

Table 3: Socio-demographic characteristics

Variable	Value	Total sample
Gender	Female	0.47
Age	Years (mean)	49.50
Marital status	Married	0.53
	Single	0.31
	Divorced	0.13
	Widowed	0.03
Education	High-school diploma	0.27
	Trade school diploma	0.15
	University degree	0.15
	Higher education entrance qualification	0.14
	Other (types of high-school diploma, PhD etc.)	0.29
Employment	Fully-employed	0.47
	Unemployed (including retired)	0.29
	Part-time-employed	0.11
	Other (students, self-employed etc.)	0.13
Respondent/household income	Less than €500	0.03
	€500-1,500	0.16
	€1,500-2,500	0.28
	€2,500-3,500	0.23
	€3,500-5,000	0.16
	More than €5,000	0.50
	No answer	0.10
Home ownership rate	Home owners	0.42
Persons in household	Multi-person households	0.74
	Single-households	0.26
Housing type	Detached single- or two-family home	0.33
	Semi-detached single- or two-family home	0.16
	Apartment building with 3-8 units	0.35
	Apartment building with more than 9 units	0.16
Type of location	Village (< 2,000)	0.14
	Rural town (2,000-5,000)	0.11
	Small town (5,000-20,000)	0.20
	Medium-sized town (20,000-100,000)	0.22
	City (> 100,000)	0.33
Type of dwelling	Residential areas	0.61
	Mixed-use area	0.36
Car ownership: 1 or more cars[(a)]	ICEV (N = 3,851)	0.94
	EV (N = 84)	0.02
	Hybrid (N = 172)	0.04
	No car (N = 140)	0.03
Car-sharing	Regular users of car-sharing, of which[(b)]	0.12
	ICEV	0.09
	EV	0.03
	Hybrid	0.02
Average daily commute	Km	36.86
Parking situation	Parking available, of which[(b)]	0.77
	directly at residence	0.72
	not at residence	0.07

Note: [(a)] Due to households owning more than one car, ratios not necessarily add up to 1. [(b)] Multiple choices were possible. Thus, numbers not necessarily add up to 1.

Before beginning with the DCE, we let respondents self-evaluate their knowledge on EVs in general using three screening questions.[2] In doing so, we reached a share of 50% *(non-)EV experts* that we later use for differentiating the consumer category *EV experts*.

Regarding the preference ranking in Table 4, the most preferred location for EV charging, home (80%) and work (12%) are the most preferred locations. As for the payment schemes for EV charging, pay-per-kWh (47%) followed by a flatrate for a fixed monthly fee (42%) are the most preferred ones. The two other payment schemes, pay-per-minute and monthly subscription (fixed costs & pay-per-minute), are preferred to an equal share of 5%. Pay-per-kWh might be the most popular option because it corresponds the most with refuelling a conventional car where costs are clearly stated (Hardman et al. 2018). The most preferred services at EV charging stations are a supermarket (76%) and a bakery shop (35%).

Table 4: Preference ranking

First preference of preferred location for EV charging		First preference of preferred payment scheme for EV charging		Preferred service at EV charging station[(c)]	
Home	0.80	Pay-per-kWh	0.47	Supermarket	0.76
Work	0.12	Flatrate for a fixed monthly fee	0.42	Bakery shop	0.35
Supermarket	0.03	Pay-per-minute	0.05	Cinema	0.18
Parking lot	0.02	Monthly subscription[(b)]	0.05	Fitness studio	0.18
Train station	0.01			None	0.16
Other[(a)]	0.01			Other[(d)]	0.05

Note: Figures given in %. [(a)] Free text: Gasoline station, highway, etc. [(b)] Fixed costs & pay-per-minute. [(c)] Multiple choices were possible. Thus, numbers not necessarily add up to 1. [(d)] Free text: free time activities, restaurants. etc.

3.2 Discrete Choice Models

Figure 1 depicts the marginal effects derived from the conditional logit model for the entire sample, in terms of popularity effects (%) with the direction of the bars depicting negative and positive effects, respectively, and the coloring reflecting the size of the effects. Because our DCE participants trade off their choice options, we have to interpret their final choices in terms of tradeoffs, i.e. always in comparison to some base case.

[2] The three screening questions were: (1) Have you ever driven an EV or a hybrid car (for a test drive, with friends or family, or using car-sharing services? (2) Which drivetrain technology would you buy in the next 3 years? (3) On a scale from 1-5, how do you assess your knowledge about electric mobility?

For example, the popularity effects of the first attribute, *charging cost per month*, always have to be compared to the base case of €50: The cost attribute exhibits the two largest effects: On average, a choice set with cost of €200 (€150) is selected 28% (21%) less often compared to a choice set with cost of €50. The results are intuitive: lower costs are preferred.

Charging duration reveals the third-highest effect: On average, a choice set with a charging duration of 8 h is selected 14% less often compared to a choice set with a charging duration of 10 min. Further, we find hardly any difference in preferences between the 10 and 30 min of charging duration (30 min is selected only 2% less often than 10 min). This might be plausible because in case EV users plan to charge the EV somewhere, they make plans for spending more than 10 min there anyway, running errands etc. Even though the longer time span for EV battery charging compared to shorter time span for filling a gasoline tank appear to be a user inconvenience, our results show that participants hardly differentiate between a charging time of 10 min or 30 min. This raises the question whether there is a need for fast-charging with a duration of less than 30 min. In the next section, we show that respondents are willing to pay more for fast charging.

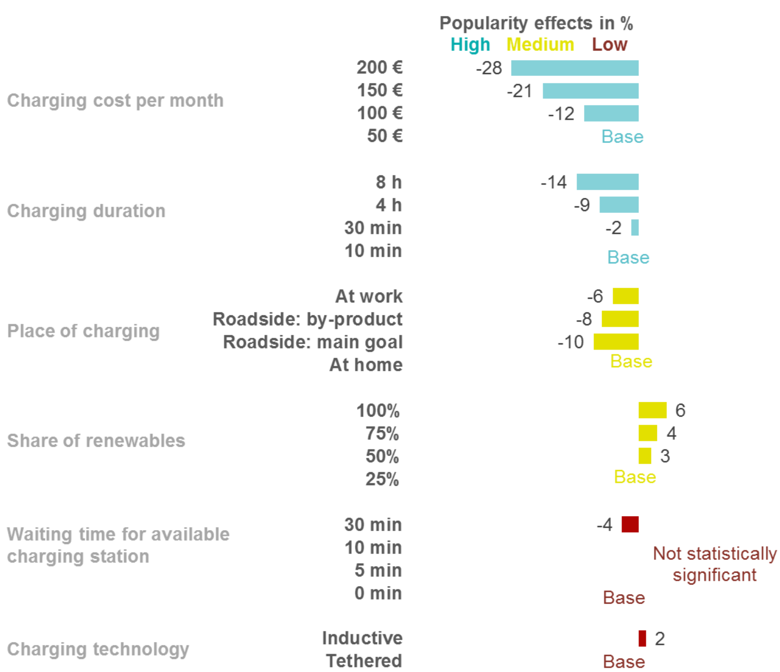

Figure 1: Marginal effects of the conditional logit model shown as popularity effects (high, medium, low)

Regarding the choice of location, participants prefer charging at home to at work to roadside charging as a side activity to roadside charging as the main goal. Yet, the differences between charging at work and both roadside options, respectively, are only 2%. The distinction between roadside charging as a side activity as opposed to roadside charging as the main goal tells a story of respondents' perceptions of roadside charging, e.g. streetlamp parkers would have to rely entirely on roadside charging points.

Similar to the cost attribute, the results for the share of renewables are intuitive as well: higher shares of renewable energies (RES) are preferred.

Waiting time exhibits only two values that are statistically significant. Thus, we are only able to compare the base case of no waiting time with a 30 min waiting time and see that the 30 min waiting time is chosen 4% less often than the base case of a zero waiting time.

Lastly, there are weak preferences for inductive charging which could mean that inductive charging technology increases perceived comfort.

Using control questions, we checked for consistency whether the attributes that were said to be the most or the least important for the respondents' decision matched the choice behavior in the DCE (Table 5): respondents attribute a high importance to costs, charging duration and location. The type of charging technology and the share of RES were ignored most often. Most attributes were clear and understandable. Range of the EV, dynamic pricing (e.g. a discount for night charging), compatibility of charging points of different providers, and the possibility to reserve a charging spot were not part of the DCE but were considered as important which corresponds to Wolbertus et al. (2018b). From these apparent EV consumer needs we can derive some business model ideas and recommendations for planners of charging infrastructure and policy makers.

Table 5: Importance of attributes according to control questions

	Important attributes	Ignored attributes	Uncertain attributes	Other important attributes	
Place of charging	0.40	0.19	0.05	Payment scheme	0.30
Charging duration	0.58	0.10	0.03	Compatibility of charging points of different providers	0.39
Technology	0.13	0.40	0.03	Possibility to reserve a charging spot	0.21
Waiting time	0.27	0.22	0.03	Dynamic pricing (e.g. discount for night charging)	0.38
Share of RES	0.23	0.38	0.03	Possibility to use the EV as power storage	0.15
Costs	0.73	0.08	0.04	Range of the EV	0.68
None	0.03	0.18	0.88	Other[(a)]	0.02
				All decision-relevant attributes were mentioned	0.19

Note: Figures given in %. Multiple choices were possible. Thus, numbers not necessarily add up to 1. [(a)] Free text: costs (of EV battery), at-home charging, availability of charging spot, etc.

Table 6 displays the marginal effects derived from the six conditional logit models, i.e. for the entire sample (as depicted in Figure 1) compared to five subgroups: *environmentalists*, *EV owners*, *EV experts*, those who gave as a first preference *charge at home*, and *home owners*.

Table 6: Marginal effects derived from the six conditional logit models

Attribute	Attribute level	Total sample (*N* = 4,101)	Environ-mentalists (*N* = 311)	EV owners (*N* = 84)	EV experts (*N* = 2,051)	First preference: At-home charging (*N* = 3,266)	Home owners (*N* = 1,736)
Place of charging	At home	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)
	On the road: charging as main goal	-10.0*** (0.71)	-3.5 (2.26)	-2.0 (6.10)	-10.3*** (1.03)	-11.2*** (0.76)	-12.9*** (1.0)
	On the road: charging as side activity	-8.2*** (0.72)	-2.4 (2.27)	-2.2 (6.01)	-8.4*** (1.05)	-9.4*** (0.78)	-11.2*** (1.0)
	At work	-5.7*** (0.74)	-0.9 (2.31)	-1.0 (6.20)	-5.2*** (1.09)	-7.3*** (0.80)	-.9.2*** (1.0)
Charging duration [min, h]	10 min	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)
	30 min	-1.7*** (0.32)	-1.9 (1.02)	-2.0 (2.81)	-2.1*** (0.47)	-1.5*** (0.34)	-1.5*** (0.47)
	4 h	-8.7*** (0.27)	-8.8*** (0.91)	-7.0 (2.78)	-9.5*** (0.40)	-8.5*** (0.29)	-8.0*** (0.39)
	8 h	-13.8*** (0.25)	-15.0*** (0.83)	-12.5*** (2.60)	-14.6*** (0.37)	-13.4*** (0.27)	-13.0*** (0.36)
Technology	Tethered	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)
	Inductive	1.6*** (0.18)	1.9** (0.57)	1.6 (1.66)	1.9*** (0.26)	1.5*** (0.18)	1.2*** (0.25)
Waiting time [min]	0	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)
	5	0.2 (0.64)	-5.0* (2.27)	-3.5 (5.66)	-0.2 (0.95)	0.45 (0.67)	2.3*** (0.88)
	10	-0.5 (0.64)	-5.1* (2.29)	-0.2 (5.70)	-0.6 (0.94)	- 0.47 (0.67)	1.37 (0.87)
	30	-3.7*** (0.62)	-8.7*** (2.23)	0.20 (0.57)	-3.7*** (0.92)	-3.4*** (0.65)	-1.7*** (0.84)
Share of renewables [%]	25	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)
	50	2.7*** (0.28)	5.5*** (0.92)	6.4 (0.28)	3.2*** (0.41)	2.6*** (0.30)	1.9*** (0.40)
	75	4.1*** (0.30)	9.6*** (1.02)	6.3 (2.83)	4.6*** (0.44)	3.9*** (0.31)	3.5*** (0.43)
	100	6.2*** (0.32)	14.0*** (1.13)	8.0*** (2.86)	7.2*** (0.47)	5.9*** (0.33)	5.2*** (0.45)
Cost [€]	50	(Base)	(Base)	(Base)	(Base)	(Base)	(Base)
	100	-12.1*** (0.35)	-14.3*** (1.06)	-2.5 (3.01)	-11.7*** (0.49)	-12.4*** (0.37)	-12.2*** (0.50)
	150	-21.3*** (0.32)	-22.0*** (0.98)	-14.5*** (2.73)	-20.5*** (0.45)	-21.3*** (0.35)	-20.8*** (0.47)
	200	-28.2*** (0.34)	-31.0*** (0.96)	-22.9*** (2.44)	-27.6*** (0.47)	-27.7*** (0.39)	-26.9*** (0.52)

Note: Effect in %. Significant at the *p<0.05, **p<0.01, and ***p<0.001 level. For the whole sample: McFadden's Pseudo $R^2 = 0.2198$, *N* = 4,101. Standard errors in parentheses.

These five groups are of interest for scrutinizing the behavior of different consumer categories and thus defining user-specific managerial as well as population-specific policy implications.

The *environmentalists'* answers in the survey are consistent with their choices in the DCE: For RES, the environmentalists show higher marginal effects compared to the total sample, i.e. their stated preferences in the questionnaire (i.e. behaving environmentally benign) are identical with their stated preferences in the DCE (i.e. repeatedly choosing the environmentally more benign option). At the same time, however, *environmentalists* exhibit a minimally larger value (31%) than the whole sample for choosing the highest cost option (€200) less often compared to the base case. This shows that *environmentalists* favor higher shares of RES but also that costs do matter. In fact, when making the choice between two different levels of RES, the *environmentalists* took lower costs more often into account than the entire sample. For waiting and charging time, they also reveal the largest values (8.7% and 15%, respectively) for choosing the longest duration (30 min and 8 h, respectively) less often compared to the base case. They seem to be more sensitive to time than the total sample. For location, *environmentalists* do not exhibit statistically significant values, i.e. to them it does not matter where they charge. They placed a slightly higher preference on inductive charging than the overall sample.

EV owners' choices diverge substantially from the entire sample's. Some choice attributes show statistically not significant values since this subsample is restricted in size (N = 84). Yet, some observations can be made: they selected 8 h charging time 12.5% less often than the base case of 10 min. This is the lowest value among the five subgroups, indicating an advanced usage experience where long charging hours are utterly tolerable. Moreover, they selected higher shares of RES more often than the entire sample. Compared to the whole sample and the four other subsamples, *EV owners* tend to disregard higher costs for the sake of, in their perception, more decisive attributes. Thus, they seem to be less cost-sensitive.

EV experts show only small divergences from the whole sample's choices. They select a 100% share of RES more often and seem to be less sensitive to cost. Most interestingly, they seem to be more sensitive to charging time, i.e. they have a stronger preference for shorter charging durations than the sample. The differences in the marginal effects of the *EV experts* and of the non-experts add up to the differences in the marginal effects of the whole sample and the *EV experts*. Note further that the subsample *EV owners* is part of the subsample *EV experts*.

Those who gave as a first preference *charge at home* acted consistently in the survey and the DCE: they indeed show higher preferences for at-home charging compared to the whole sample because for all three locational attributes, they exhibit larger marginal effects. This subgroup (and *home owners*) selects choices with lower shares of RES more often. Otherwise, this group matches with the entire sample. Note that for at-home charging, waiting time is always set to 0 min.

Home owners' choices largely deviate from the total sample's choices: they have the strongest preference for charging at home instead of anywhere else among all groups and the whole sample. This indicates that they assume to be able to charge at home anyhow. Further, they have the lowest preference for inductive charging as well as for increasing shares of RES. This could imply that they do not consider the possibility of charging greener electricity or inductively at home.

With these results at hand, we can answer research question (1): among the six attributes of the EV charging process, *costs*, *charging duration*, and *location* have the strongest effects on the decision for specific attribute bundles. Respondents prefer charging *at home* to *at work* to *roadside charging as side activity* to *roadside charging as the main goal*, *inductively* to *cable-charging*, with a higher share of *renewable energies*, with shorter *waiting times* and shorter *charging durations*, at the lowest *costs*. Overall, the differences between the five groups and the whole sample are statistically significant for most attribute levels. Costs and charging duration remain the most important attributes across all groups.

As a next step, we calculate the WTP and look closely at the factors that determine preferences for charging infrastructure.

3.3 Willingness to pay

From the six conditional logit models, we extract the respondents' marginal WTP next. Table 7 shows the monetary values the respondents assign to the attributes by making the tradeoffs in the DCE. The lower and upper bounds, indicators of the confidence interval (Hole 2007), give the price ranges.

For a reduction of 1 min in charging time, respondents in the whole sample are willing to pay 0.16 €/month extra. However, for a reduction of 1 min in waiting time, respondents are willing to pay as much as 0.82 €/month more. It seems that participants – hypothetically – value a reduction in waiting time substantially more than a reduction in charging time even though they might spend their time in the same manner, independently from the car's charge status. Figure 2 exhibits this difference in time valuation: for a reduction of 1 h in charging (as opposed to waiting) time, respondents are willing to pay €9.60 and €49.20 more, respectively. On average, respondents are willing to trade in between 4.49-5.87 min of charging time for 1 min of waiting time per charging process.

Table 7: Willingness to pay with lower and upper bounds of the sample

Variable	WTP (€/month)	Lower bound	Upper bound
Charging duration (reduction by 1 min)	0.16	0.15	0.16
Waiting time (reduction by 1 min)	0.82	0.71	0.93
Renewable share (increase by 1%)	0.42	0.39	0.46
Technology (inductive instead of cable)	8.38	6.60	10.15
Charging location:			
At home	(base)	(base)	(base)
On the road (main goal)	-46.26	-49.69	-42.83
On the road (side goal)	-35.64	-39.04	-32.24
At work	-22.31	-25.68	-18.93

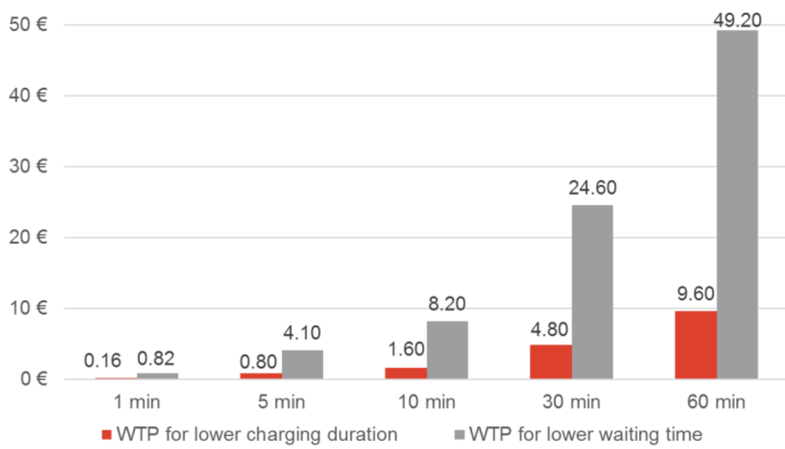

Figure 2: WTP (€/min per month) of the sample for a reduction in time attributes

For a reduction by 1 min in charging time, the average WTP for charging varies between 0.15-0.16 €/min per month. Similarly, for a reduction by 1 min in waiting time, the WTP could vary between 0.71-0.93 €/min per month.

The difference in WTP between a 0% and a 100% share of RES amounts to 100·€0.42 = 42 €/month. *Environmentalists* are willing to pay more than twice that much (see below).

For inductive charging compared to tethered (i.e. with a cable) charging, the WTP is 8.38 €/month. Participants in the total sample are indifferent between tethered and inductive charging when tethered charging costs 50 €/month and inductive charging costs 58.38 €/month. For inductive charging, the WTP varies between 6.60-10.15 €/month.

Regarding the location, respondents in the total sample are willing to pay 22.31 €/month more for charging at home, compared to charging at work. Participants are willing to pay, on average,

€46.26 (lower and upper bounds: €42.83-€49.69) more per month for charging at home rather than on the roadside, where we take roadside charging as a main goal and as a comparable charging event because the main goal is to charge.

Respondents are willing to accept a charging duration that is between 119-163 min longer (i.e. 2 h-2 h 40 min) for charging at home compared to charging at work, for each charging process. For example, respondents are indifferent between charging 1 h at work and 3 h at home. From this, we cannot deduct, however, that people who want to charge at home care less about charging duration.

Table 8 displays the marginal WTP of the entire sample compared to the five subgroups *environmentalists*, *EV owners*, *EV experts*, those who gave as a first preference *charge at home*, and *home owners*.

Environmentalists' WTP for a higher share of RES is more than twice as high as compared to the whole sample (0.42 €/month compared to 0.93 €/month for an increase of 1% in RES). For increasing the share of RES from 0% to 100%, *environmentalists* would pay as much as 93 €/month. They also have a stronger preference for shorter waiting times and would be willing to pay 0.10 €/month more than the *EV experts* to reduce waiting time by 1 min (0.89 €/month vs. 0.79 €/month). For a reduction in charging time, however, they show an identical WTP. Even though *environmentalists* do not exhibit statistically significant values for the attribute *location* in the conditional logit model, it is worth mentioning it here: they would only be willing to pay 34.63 €/month to charge at home rather than at the roadside, as opposed to the sample's WTP of 46.26 €/month. *Environmentalists'* smaller WTP – compared to the sample – applies also to the other charging locations. Overall, *environmentalists* seem to be more sensitive to costs than the whole sample when it comes to location, or, in other words, they do not value the location of charging as much as they value the share of RES.

EV owners exhibit many statistically not significant values due to subsample size restrictions ($N = 84$). Yet, we can say that their WTP for an increase in RES is the second-highest in the third row in Table 8. Thus, for a RES increase, *EV owners* are willing to pay considerably more than the whole sample. Their WTP for a reduction in charging time matches the total sample's WTP. This should be interpreted with caution, though, because only the marginal effect of the longest duration (8 h) is statistically significant.

EV experts would be willing to pay more for a reduction in charging time, which is in line with the marginal effects where *EV experts* allocate stronger preferences to shorter charging durations than the entire sample. Yet, they would pay less for a reduction in waiting time than the whole sample. This again shows their advanced EV experience level where longer waiting times would be tolerable because they might rarely occur in their daily routines. Also, this matches with the third-highest WTP for not charging at the roadside but at home (50.82 €/month), i.e. when charging at home, one does not expect to wait for the charging spot to become available. Thus, if charging durations decline, *EV experts'* WTP is higher than the total sample's. Further, their experience level shows that when preferring inductive charging over cable charging the additional willingness is to pay as much as 10.28 €/month.

Table 8: Willingness to pay (€/month)

Variable	Total sample (*N* = 4,101)	Environ-mentalists (*N* = 311)	EV owners (*N* = 84)	EV experts (*N* = 2,051)	First preference: At-home charging (*N* = 3,266)	Home owners (*N* = 1,736)
Charging duration (reduction by 1 min)	0.16	0.16	0.16	0.17	0.16	0.16
Waiting time (reduction by 1 min)	0.82	0.89	0.77[(a)]	0.79	0.82	0.82
Renewable share (increase by 1%)	0.42	0.93	0.60	0.50	0.41	0.38
Technology (inductive instead of cable)	8.38	9.36	9.68[(a)]	10.28	7.73	6.50
Charging location:						
At home	(base)	(base)	(base)	(base)	(base)	(base)
On the road (main goal)	-46.26	-34.63	-32.32[(a)]	-50.82	-50.93	-51.82
On the road (side goal)	-35.64	-29.10	-34.55[(a)]	-39.47	-40.60	-40.60
At work	-22.31	-21.71	-28.24[(a)]	-22.15	-28.85	-29.21

Note: WTP given in €/month. [(a)] marginal effects not statistically significant.

Those who gave as a first preference *charge at home* exhibit the second-highest WTP for not charging at the roadside (main or side goal) or at work but at home (50.93 €/month, 40.60 €/month, and 28.85 €/month, respectively). This matches with their reduced WTP for inductive charging as compared to the overall sample, i.e. in case they mostly charge at home, there is no need for this advanced charging technology. Only *home owners* exhibit higher values. Consistent with previous results, *at-home chargers* would be willing to pay less for an increase in RES.

Home owners would pay the highest amount to charge at home and not at the roadside (51.83 €/month). This again underlines their assumptions of charging at home anyhow. For charging and waiting time, *home owners'* priorities correspond to the sample (0.16 €/month and 0.82 €/month, respectively). They care less about the share of RES and inductive charging, their WTP are the lowest among all groups and are below the average (0.38 €/month and 6.50 €/month, respectively).

With these results at hand, we are able to answer research question (2): the WTP for certain attributes of the EV charging process given in Table 8 varies significantly across attributes as well as across certain subgroups.

3.4 Discussion

3.4.1 Place of Charging

Our results are congruent with those report in several studies listed in the review by Hardman et al. (2018). Charging at home and at work are the most important locations according to three methodological approaches: (1) for increasing EV purchase intentions, the offer of (public) charging spots (in residential areas and at work) is inevitable (Franke and Krems 2013a; Bailey et al. 2015). (2) choice experiments and surveys show that – hypothetically – EV users prefer charging at home or at work (Skippon and Garwood 2011). (3) field trials and data loggings indeed show that *at home* and *at work* are the most frequently used charging spots (Björnsson and Karlsson 2015; Franke and Krems 2013a). The decisions made by our participants for at-home charging could be biased because for at-home charging, waiting time is always set to 0 min. In literature, oftentimes, it is stated that public charging infrastructure would be important for a substantial market uptake of electric mobility (Globisch et al. 2018; Bailey et al. 2015; Axsen et al. 2016; Morrissey et al. 2016). Yet, we find that − hypothetically − charging at home and at work are preferred over charging on the road. Thus, according to our results, there is no need for a myriad of scattered public charging spots but primarily in residential areas and at the workplaces. However, these results might be biased by the mere (perceived) absence of public charging stations to date (Hardman et al. 2018). According to Yang et al. (2016), consumers select charging spots with shorter charging durations, with less distance from home, and shorter detours from the original route of travel, and shorter waiting periods. Thus, the uncertainty about the availability of public charging stations near home might influence the decisions made in our DCE. This argument might be justified by the evaluation given in the accompanying survey: 21% of our participants considered the possibility to reserve a charging spot as important (Table 5). And, as Wolbertus et al. (2018b) point out, creating certainty about the availability of charging spots increases EV purchase intention and thus should be a policy goal if the diffusion of EVs is a goal to be achieved.

This discrepancy gives room for further research. In the case that there are indeed charging spots near home, a possible charging point congestion and the associated waiting times seem to be crucial for the decision making process (see section 3.4.4 on *waiting time*). Among the five specific consumer categories (*environmentalists, EV owners, EV experts, at-home charger, and home owners*), we find that *environmentalists* place the smallest WTP (21.71 €/month) and home owners the highest WTP (51.83 €/month) on charging at home rather than anywhere else. *Home owners* would pay more to charge rather at home instead of at work or on the street even though they are more likely to be able to charge their car on their own property. To sum up, on the one hand, *environmentalists* do not care about charging location as long as they charge green electricity. On the other hand, *home owners* and *at-home chargers* highly appreciate at home charging while not considering the share of RES nor inductive charging.

3.4.2 Charging Duration

We calculated the WTP for a reduction of 1 min of charging duration (0.16 €/month) as an average across all four attribute levels (10 min, 30 min, 4 h, and 8 h). Our results correspond to Yang et al. (2016): consumers prefer shorter charging durations (in combination with charging spots closer to home or along the travel route). In addition, we show that participants value 1 min differently in the three time intervals (10-30 min, 30 min-4 h, 4-8 h) again stressing that according to respondents' preferences, the valuation of time differs. In Figure 3, we depict the WTP (red curve in terms of €/month depicted on the y-axis) and the respective charging typologies (blue bubbles) for each time interval depicted on the x-axis. Starting from the right-hand side with the longest charging interval of 4-8 h, for a reduction of 1 h in charging time (e.g. a reduction from 8 h at a 2.3 kW standard household socket to 7 h with an additionally installed wallbox at 3.6 kW), respondents are willing to pay 0.13 €/min per month, i.e. 60 min·0.13 €/min per month = 8.09 €/month. Proceeding from the right to the left in Figure 3, for a reduction of 1 h in charging time (e.g. a reduction from 2 h to 1 h with 22 kW either at a private or a public charging spot), respondents are willing to pay 0.17 €/min per month, i.e. 10.17 €/month. For a reduction of 20 min in charging time (from 30 min at a public fast-charging spot with 50 kW to 10 min at a Tesla Super-charger with 120 kW), participants are willing to pay 0.38 €/min per month, i.e. 7.64 €/month. Our participants allocate a higher monetary value on a one-minute reduction of charging duration within a twenty-minute gap than within a four-hour gap: monthly WTP of 0.38 €/min as opposed to 0.13 €/min per month, respectively. For a reduction from 8 h at a household socket with 2.3 kW to 10 min at a Tesla's Super-charger at 120 kW, respondents are willing to pay 8.09·4 h + 10.17·3.5 h + 7.64 €/month = 75.58 €/month for all charging processes. Among the five consumer groups, shorter charging durations are appreciated the most by *EV experts*, i.e. they would pay 0.17 €/month for a reduction by 1 min. This corresponds to findings of Sun et al. (2016): current EV users are willing to take a detour of up to 1,750 m on working days to reach a fast-charging station. Interestingly, all other four groups share the average WTP of 0.16 €/month, where the value for *EV owners* should be interpreted with caution due to the small sample size.

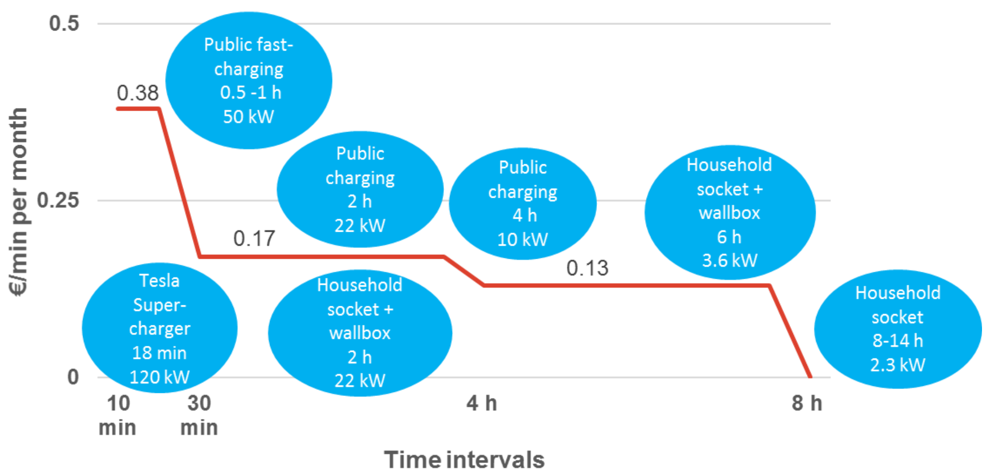

Figure 3: Change in WTP for lower charging duration at specific time intervals (€/min per month)

The popularity effects shown in Figure 1 indicate a 2% differentiation between charging durations of 10 min and 30 min. However, the WTP for reducing the charging duration from 30 min to 10 min is more than double than the WTP for reducing the charging duration from 4 h to 30 min: monthly WTP of 0.38 €/min compared to 0.17 €/min, respectively. In case participants want fast charging, they are willing to pay more for it. When aligning these results with the price premiums on electricity for fast charging in Germany calculated by Gnann et al. (2018, p. 327), we see that for covering the cost of a 50 kW fast-charging spot, the price premium on the German electricity price (0.29 €/kWh) ranges from 0.11-0.16 €/kWh depending on the range levels (100, 200, 300 km). For Tesla's Super-charger (120 kW), the authors deduce a premium of 0.04-0.07 €/kWh depending on the range levels (100, 200, 300 km). In order for the CPOs to operate profitably, the WTP for the reduction in charging duration should by higher than the price premiums. We report the WTP in €/month for all charging processes and the price premiums in

€/kWh. According to Gnann et al. (2018, p. 327), total costs including a price premium add up to: 0.29 €/kWh (household level electricity costs), + 0.11-0.16 €/kWh (50 kW fast-charging), and + 0.04-0.07 €/kWh (120 kW Tesla Super-charger).

3.4.3 Technology

Charging technology was said to have been disregarded during the decision process (Table 5) and was indeed most often ignored during the DCE (Figure 1, Table 6). Even though inductive charging is not yet a widespread technology, for the respondents the inductive charging process itself was comprehensible (see Table 5: only for 0.03% of the participants the attribute *technology* is not clear). The operators of inductive charging spots could charge between 6.60-10.15 €/month (on average 8.38 €/month). Among the five consumer groups, *EV experts* and *environmentalists* place the highest priority on inductive charging (WTP: 10.28 €/month and 9.36 €/month, respectively). Interpreting inductive charging as a matter of convenience, the preference of *EV experts* and *environmentalists* for charging inductively corresponds with their preference of shorter charging duration and shorter waiting times: Among the five groups, *EV experts* reveal the highest WTP for a reduction in charging duration, whereas *environmentalists* show the highest WTP for a reduction in waiting time. However, *EV experts* reveal the lowest WTP for a reduction in waiting time.

3.4.4 Waiting Time

Our total sample does not prefer to queue at charging spots, i.e. shorter waiting times for a charging spot to become available are preferred. Note that for at-home charging, waiting time is always set to 0 min. Thus, the decisions made for at-home charging could be biased.

The highest priority on waiting time is placed on by *environmentalists* and the lowest *by EV experts*. *At-home chargers* and *home owners* place the same priority on waiting time as the whole sample does (WTP: 0.82 €/month).

Waiting time, also termed charging spot congestion or queueing, is of essence when it comes to route planning. Gnann et al. (2018) set up a queueing model using Swedish and Norwegian charging data to assess the necessary number of fast-charging points and the transmitted power for a charging spot to be profitable, i.e. the faster the charge, the more EVs can be charged during the day. Thus charging data discloses that hardly no waiting times occur since the arrival times and plug-in times match. Therefore, the questions remains whether and how much waiting is to be expected in a more mature EV market in Germany. With the widespread offer of free public charging, Hardman et al. (2018) see the risk of charging point congestion. Hence, they suggest to foster policies that limit a possible shift of charging processes from fee-based at-home charging to cost-free public charging spots.

3.4.5 Share of RES

Higher shares of RES are preferred by all subsamples. On average, respondents would pay 42 €/month for filling up their EV with 100% RES instead of 0% RES. Placing this amount into relation to the relatively high electricity prices in the German residential sector (0.29 €/kWh), we find room for discussion of business ideas. For instance, two suggestions could be to install a PV system on the roof for the WTP of 42 €/month or to switch to a green electricity supplier and thus fill up the EV with 100% RES. *Environmentalists* place the highest priority on RES. Both, *at-home chargers* and *home owners* place smaller priority on RES than the other subgroups. Thus, *home owners* do not consider the suggestions made earlier: they might not consider the switch to greener electricity.

3.4.6 Cost

In general, lower costs are preferred by all subsamples. More specifically, *environmentalists* put the highest emphasis on lower costs and EV owners the least. This underlines *EV owners'* character of the *early adopters* in our sample, i.e. they do not care about the (initial) costs of innovations because they believe that the advantages outweigh the costs. *EV experts*, *at-home chargers,* and *home owners* state preferences equal to the overall sample.

3.5 Opinions on electric vehicle charging

A more precise picture of EV-related opinions was given in the survey. When asked for purchase intentions, 22% of the participants were keen on buying an EV in the next three years. When asked directly for their WTP, 58.1% of the respondents would not buy an EV regardless of its price. Further, 37.7% would not buy or lease an EV regardless of its range. We also asked for opinions on fast charging in combination with the tradeoff of a reduced battery lifetime: longer battery lifetimes are preferred.

With every additional km of average daily commuting distance, respondents are willing to pay €38 more for an EV. Regarding commuting and gender, an interaction term of gender and age regressing on commuting distance reveals that men drive, on average, 14.8 km more than women do. With every additional year in age, men drive 0.38 km less, women drive 0.30 km less.

3.6 Policy recommendations and future research

To answer research question (3), we draw several conclusions on policy implications for charging infrastructure planning and business models. It is still debatable whether extensive public infrastructure investments are needed in every part of the city, as e.g. Gnann et al. (2018) postulate. Our results suggest that consumers of privately-used passenger EVs would prefer charging spots in residential as well as in work areas offering green electricity, as suggested e.g. by Soylu et al. (2016). These authors also suggest solutions for the number of demand-driven (fast) charging stations, which could be a direction for further research. However, our results suggest that EV users hardly differentiate between a charging time of 10 min or 30 min, so that the question remains whether fast-charging stations offering a full charge within 10 min are really needed. And if EV drivers want to fast-charge in under 30 min, they would be willing to pay 0.38 €/month for reducing charging duration by 1 min as opposed to 0.17 €/month for reducing charging duration by 1 min within the time interval 30 min – 4h. We try to contribute to Madina et al. (2016), Soylu et al. (2016), Gnann et al. (2018), and Daina et al. (2017) who propose solutions to economize both EVs and charging points in the framework of a complex e-mobility ecosystem.

Avenues for future research of individual choice behavior could be the integration of vehicle-to-grid (Geske and Schumann 2018) and smart charging (Daina et al. 2017) into DCEs since respondents evaluated vehicle-to-grid (15%) and dynamic pricing (38%) as important (Table 5). Vehicle-to-grid and smart charging (ultimately contributing to the concept of a 'smart home') combined with the integration of renewable energies into EV charging, e.g. combining photovoltaic systems on households' roof tops with EVs, has been rarely looked at by literature. Also, future research could aim at scrutinizing regional and geographical differences of WTP and at formulating policy implications. The DCE and survey designed here can easily be transferred to other countries or other powertrain technologies as well. With the uptake of e-mobility, research can rely more and more on empirically revealed preferences rather than hypothetical stated choice data. Kühl et al. (2019) collected empirical consumer satisfaction data on Twitter, which could even be defined as real-time preference data.

Further important attributes that could not have been part of the DCE, i.e. range of the EV, dynamic pricing, compatibility of charging points of different providers, and the possibility to reserve a charging spot or to pay someone for charging the car, could be included in future analyses. From this, future EV charging business models as well as planning and policy insights could be derived.

4. Conclusion

In the DCE, we asked current and potential future drivers of privately-used passenger EVs to choose repeatedly between two hypothetical EV charging possibilities with varying attribute levels. We discern preferences and WTP for individual attributes of the charging process. To answer our three research questions, we can clearly conclude that (1) the respondents prefer charging at home to at work to roadside charging as a side activity to roadside charging as the main goal, inductively to cable-charging, with a higher share of renewable energies, with shorter waiting times and shorter charging durations, and the least cost. (2) Over the whole range of time intervals, for a reduction of 1 min in charging time, consumers are willing to pay 0.15 €/month. Our participants hardly differentiate between 10-30 min of charging duration. For a reduction of 1 min in waiting time, consumers are willing to pay 0.80 €/month. The respondents value a reduction in waiting time substantially more than a reduction in charging time: on average, respondents are willing to trade in between 4.49-5.87 min of charging time for 1 min of waiting time per charging process. Our findings indicate that for diminishing waiting time and thus the uncertainty of charging spot availability, respondents are willing to pay a substantial amount. And thus (3) the reservation of chargings spots could be a promising business case. With our DCE, we learn that certain consumer groups show varying degrees of WTP for specific attributes of the charging process, e.g., we find that the WTP for a higher share in RES increases more than twofold for *environmentalists*. *EV owners* exhibit advanced EV experience level by assigning less priority to waiting times and higher priority on inductive charging.

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Germany; the 42nd IAEE International Conference, May 29 - June 1, 2019, Montréal, Canada; and the International Conference on Operations Research 2019 (OR2019), September 3-6, 2019, Dresden, Germany.

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