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The potential for community financed electric vehicle charging infrastructure

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Abstract

Charging infrastructure is one of the key ingredients necessary to further increase the market uptake of personal electric vehicles (PEVs). Limiting the growth of charging infrastructure in Europe are the facts that most public charging infrastructure is not profitable, and 42% of European households reside in dwellings with no possibility to install a private charger. Hence, this work presents and analyzes an alternative business model for 'community-owned charge points' that combines the convenience advantages of private charging with the cost savings of a joint purchase. Such a model would allow households who cannot install a private charger to more comfortably adopt PEVs, and may benefit the electricity system due to load smoothing from scheduled charge times. Survey data from 3,131 households in Austria is used to identify barriers to PEV charging and charging infrastructure usage, as well as investigate consumers' preferences with respect to community-owned charging points.

Keywords: electric vehicles, charging points, charging infrastructure, energy transition, community finance, social innovation

1 Introduction

Despite the potential benefits of personal electric vehicle (PEV) usage including reduced GHG emissions and noise pollution, and the existence of subsidy schemes across much of Europe, PEVs, including battery-electrics, and plug-in hybrids, enjoy a market share of only about 1% of vehicle purchases in Europe (ICCT, 2017). This level of market uptake lags significantly behind EU objectives (Biresselioglu et al., 2018).

Recent reviews of the literature regarding PEV market uptake have identified numerous barriers to consumer adoption of PEVs that explain the observed low levels of adoption. Among these barriers to adoption, charging-related issues and a lack of charging infrastructure are considered as the leading challenges that need to be solved to substantially increase PEV adoption rates and the pace of electrification in the road transport sector (Funke et al., 2019; Shen et al., 2019; Anderson et al., 2018; Biresselioglu et al., 2018; Hardman et al., 2018; Soylu et al., 2016). Moreover, current market-based business models for charging stations do not provide the level of service that consumers expect (Madina et al., 2016). Public charging infrastructure is still in the early market phase and requires significant investments in order to become profitable. At the same time nearly half Europeans reside in the dwellings without a possibility to install their own private charger, which means their participation in the adoption of PEVs is restricted. In this paper, we discuss a novel business model of a semi-public charging station which can support further diffusion of PEVs by allowing to include households who do not have a possibility to install their own private charging station and offer a better level of service and reliability compared to currently available public charging stations.

We contribute to current literature by using survey data from 3,131 Austrian households to investigate the concept of community-owned PEV charging points. The concept of a charging station owned by several households, located in a close proximity and using it together based on an agreed upon schedule could improve PEV users' experience with charging and offer a solution to charging-related issues including the low level of satisfaction with the service, long-waiting times, and absence of real-time information about free charging spots and the lack of sufficient charging infrastructure when/where it is needed (Madina et al., 2016). The parameters that have an impact on the consumer decisions to invest in such a charging station are analyzed through econometric models. The parameters that are specifically relevant for four types of potential key customers, namely, PEV owners, PV owners, high income households, and strongly environmental households, are identified.

In the following section the suggested business model is described in detail, and discussed in the context of currently available types of charging stations. In Section 2, the procedures for data collection and analysis are discussed. Section 3.2 reflects on the main findings of our analysis and Section 4 gives policy relevant insights for a way forward to an increased diffusion of PEVs through targeted campaigns taking into account the identified preferences of different types of consumers with respect to the investigated charging model.

1.1 Business models for PEV charging points

Past literature has identified charging-related issues as one of the leading challenges, or perhaps the leading challenge, that needs to be solved to increase PEV adoption rates. For one, the shortage of charging facilities is an important factor that reduces the purchase interests of prospective PEV adopters. The literature review paper of Biresselioglu et al. (2018) finds that "[...] lack of charging infrastructure is considered one of the main barriers to PEV market diffusion" across a multitude of studies. A further major barrier to uptake are technical restrictions also related to charging, such as charging time requirements, battery range, and battery lifetimes (Biresselioglu et al., 2018). Another review paper from Hardman et al. (2018) identifies five key insights on consumer preferences for PEVs. Four of the five key insights directly relate to consumer access to charging points and related costs. These insights are: "[...] (1) the importance of [charging] infrastructure at home, work, and public locations, (2) consumers access to charging infrastructure, (3) the cost to charge a PEV, (4) how many charge points are needed to support the introduction of PEVs [...]" (Hardman et al., 2018). The authors go on to identify the existence and quality of home charging points as the most important infrastructure-related factor in consumer adoption of PEVs (Hardman et al., 2018). This is upheld in an Austrian study, which estimates that 88% of PEV charges take place in private residences (Baresch and Moser, 2019). Yet, 42% Europeans live in multi-family buildings with no easy possibility to install a home charging point, which means that under the currently available charging point business models if these households choose to adopt a PEV they would have to rely mainly on public charging station.

In order to increase the market acceptance of PEVs previous studies have focused on modeling the optimal number of charging stations that are needed in order to increase the diffusion of PEVs and improve the inclusion of households residing in multi-family buildings in the e-mobility transition (Funke et al., 2019). While others investigated the optimal location strategy of the future charging stations (Shahraki et al., 2015), which could also help to increase the adoption of PEVs, taking into account the necessity to reflect on the impact of the charging infrastructure on the grid (Roni et al., 2019; Yang et al., 2016). Such studies offer one approach of the development of the charging infrastructure by optimizing location and number of charging stations according to available insights on PEV owners and assumptions on consumers decisions and behavior, while another possibility would be to investigate alternative business models which require lower investments and where consumers can decide for themselves about the potential location of the charging station. Thus, in this paper we focus on the latter by analyzing a novel business model of the charging stations operation and as well as the preferences of customers in terms of key parameters of the charging station.

Recent studies (Hardman et al., 2018; Serradilla et al., 2017; Madina et al., 2016) distinguish between several currently available business models of charging stations based on the level of their accessibility:

- private charging in private domain, also called residential or domestic charging that are owned and used by one household;

- public charging in private domain, which is represented by chargers located in commercial areas or hotels;

- public stations in public domain, which include chargers situated by the roadside, sidewalk, or in other generally accessible parking lots.

Another model mentioned in the literature includes so-called semi-public charging stations which could be located in both private or public domains and have restricted access to only a specific group of customers, for instance, employees of a business park or members of a fitness studio.

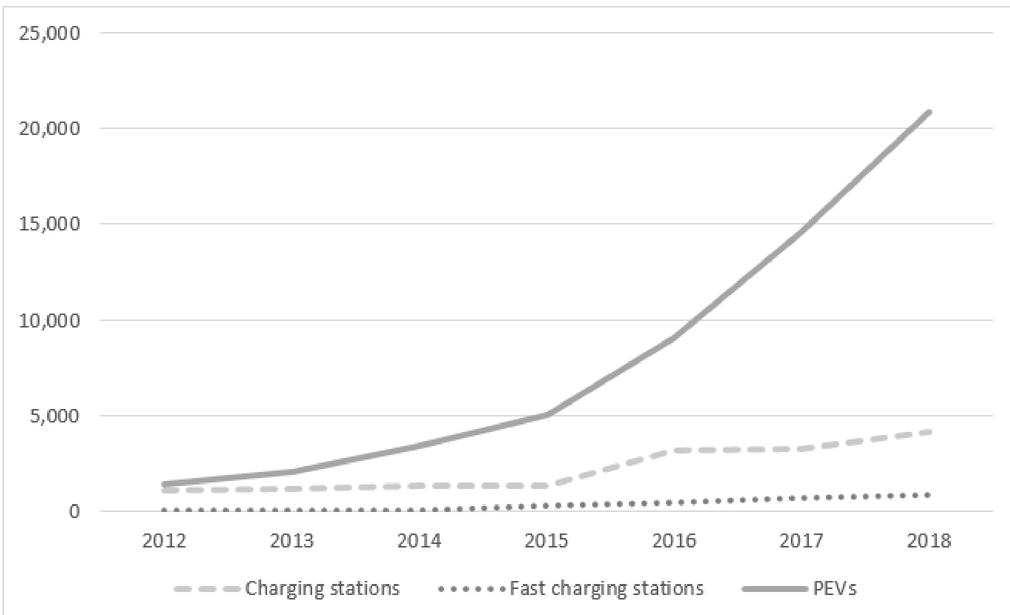
Construction of a public charging station requires large investments and is relatively expensive in daily maintenance (Lopez-Behar et al., 2019; Schroeder and Traber, 2012). This causes the current situation wherein the majority of the public charging stations are not profitable and underused, which can be partially explained by infrequent charging operations (Zhang et al., 2018; Schroeder and Traber, 2012). The low and infrequent flow of customers is, in its turn, related to issues like long waiting times, inability to reserve a place or get live information about the availability of an open charge point, which can significantly increase the time spent on charging a PEV (Zhang et al., 2018). Thus, charging infrastructure and PEV uptake currently suffer from a 'chicken or the egg' type problem whereby there are often too few charge points to allow for quick PEV market uptake but also too few PEV users to stimulate a profit-motivated deployment of new charging infrastructure. This issue is evident in Figure 1, which shows the development of public charging infrastructure in our case-study country of Austria, where the rate of charging infrastructure growth lags behind PEV uptake - likely creating a barrier for further PEV adoption in Austria.

One way to solve this is to follow the Norwegian model where charging points have been aggressively subsidized since 2009, including Tesla superchargers that allow for long-distance road travel to be feasible via PEV Figenbaum (2017); Ingeborgrud and Ryghaug (2019). At least in part due to the build-up of charging infrastructure, Norway had achieved a PEV market share of 17.2% by 2015 (Figenbaum, 2017). However, for many nations and regions strong subsidy programs for charging may be financially or politically infeasible.

Another potential option to crack the 'chicken or the egg' nature of charge points and PEV adoption is to develop business models that allow PEV owners or would-be adopters to co-own or co-develop charging infrastructure. Such schemes would ideally make charge point and PEV market uptake simultaneous to alleviate both infrastructure profitability and availability concerns. However, the currently applied public/private business models for charging stations are unable to provide the level of service required to contribute to further growth of PEV fleet (Zhang et al., 2018; Schroeder and Traber, 2012). Thus, we consider alternative novel business models and social innovations that have the potential to alleviate the charging infrastructure barrier to PEV adoption.

One of such models is analyzed in the German "CrowdStrom" research project, which assessed the potential for a new business model of peer-provider PEV charging stations. The designed business

Figure 1: Public charging infrastructure and PEVs in Austria.



Sources: statista.de on the number of publicly accessible charging stations in Austria. Fast charging stations are identified as the ones that allow for a transfer of electricity to an electric vehicle with a power of more than 22 kW. The data on the number of electric vehicles is sourced from Statistik Austria.

model follows the template of Uber and other ICT-enabled platforms for fostering peer-to-peer markets. Specifically, in the CrowdStrom model a citizen would purchase and install an PEV charging station on their property and then would offer use of their charging station to other PEV owners via CrowdStrom app and receive a compensation when their charging station is used. The CrowdStrom project included a feasibility assessment of the business model in the form of a survey effort within a German city that asked respondents about their willingness and ability to become peer-providers within the CrowdStrom system. A surprisingly high-number of survey respondents (25%) expressed an intention to provide charging services within the hypothetical CrowdStrom marketplace, though avidity bias, where those interested in the topic are more likely to complete the survey, cannot be ruled out as a possible cause for this result. With regard to the ability to provide charging services, 14% of respondents reported that they would have the correct infrastructure (parking space, money, installation point, etc.) to do so. It should be noted that the ability to provide these services did not include the current ownership of a PEV charging station, and that this was a self-assessment on the part of respondents, without any follow-up technical assessments by professionals. Nevertheless, the authors estimate that 4.5% of the city's population are potential providers of PEV charging services (Plenter et al., 2018).

While the CrowdStrom business model is one alternative solution to charging-related challenges we put forth herein the complementary possibility of joint- or community-owned charging stations, which are collectively owned by several households within a geographic proximity based on agreed usage and contractual parameters. This business model is fully compatible with the CrowdStrom idea of sharing your charging stations with peers through an app, but is less sensitive in terms of potential privacy and security issues related to usage of a charging station located on your property, as well as less complicated with respect to billing. The community-based business model combines many of the conveniences of a privately owned charging point while sharing the cost burdens. Such stations will allow a group of co-owners to reduce fixed costs and avoid the pitfalls of public charging stations by planning charging schedules in advance or through ICT systems, such as the CrowdStrom app. The community-based model has the additional potential benefits of fostering communication and joint-learning within the group about PEV usership, charging, and energy topics. The idea for such a business model is rooted in the social innovation of community financed energy installations, which have been successful at developing renewable energy generation and improving consumer outcomes (Sagebiel et al., 2014; Sperling, 2017).

Considering the grid perspective, community financed charging stations can also reduce potential risks to the electricity grid from increased peak loads due to simultaneous PEV charging. The community model could improve the temporal distribution of electricity demand and smooth peak loads. As an example, instead of having several households located in a close geographic proximity each using their own charging station and potentially charging their vehicles simultaneously creating a peak in electricity demand (Azadfar et al., 2015; Babrowski et al., 2014), e.g. when they get home from work, they could use one community-owned charging station and apply a charging schedule.

For PEV owners who do not have a possibility to install a charging point in their dwelling such a business model would allow them to experience some of the convenience benefits of a private charge point while also splitting the costs with their neighbors. Even for PEV owners who have the ability to charge at home, usually through a normal electricity outlet, the possibility of a nearby faster charging infrastructure may be worthwhile. As elicited in Hidrue et al. (2011), consumers are willing to pay between $425 and $3,250 for an hour reduction in charge time. In this regard, it is interesting to investigate the other factors that can be driving consumer decisions to participate in a communally owned charging station and how these interests differ across types of consumers.

2 Survey design

A large-scale survey was conducted in the three Austrian federal states, Salzburg, Styria, and Upper Austria, to gain a deeper understanding of households' perspectives on novel products, services and business models related to energy consumption. This survey was conducted online in partnership with utility providers in each of the three federal states. In total, 171,971 emails were sent out by utility companies to customers who agreed to be solicited by email[1]. The emails included a link to an online survey developed by the authors.

A total of 13,450 households completed the survey, giving an overall response rate of 7.8%. All participating customers were informed about the aim of the survey as well as about the organizations involved in the survey and related data collection activities. Thereby, full transparency was ensured. The participation in the survey was voluntary. In order to ensure that not only households with interest in energy-related topics participated in the survey, a lottery with various prizes was organized

[1] Due to new data protection and anti-spam regulations customers must explicitly agree to solicitation via email, with the default status that solicitation is not allowed. Thus only about 10% of customers are able to be contacted in this manner. All other relevant data protection and privacy aspects arising from online data collection were appropriately taken care of by legal council.

in which a randomly chosen 1% of respondents received a prize, such as gift vouchers. The survey contained questions in three main categories:

1. Socio-demographic indicators and household equipment ownership: including a wide range of questions targeting household composition, living situation as well as their equipment with large, high electricity consuming devices, and their heating system.

2. Ownership and interest in purchase as well as level of awareness and general attitude to PEVs, as well as photovoltaic (PV) and battery storage.

3. A ranking analysis aiming to investigate the importance of factors determining consumers' decision to participate in a communally-owned charging point. The analysis was conducted only with the households who reported to own a PEV or were planning to buy one in the next five years, as only these households may hold a relevant and informed view on PEV charging issues. The respondents were offered six attributes of the charging station that they could rank as the most important and second most important as well as least important for their decision to participate in a community-owned charging station.

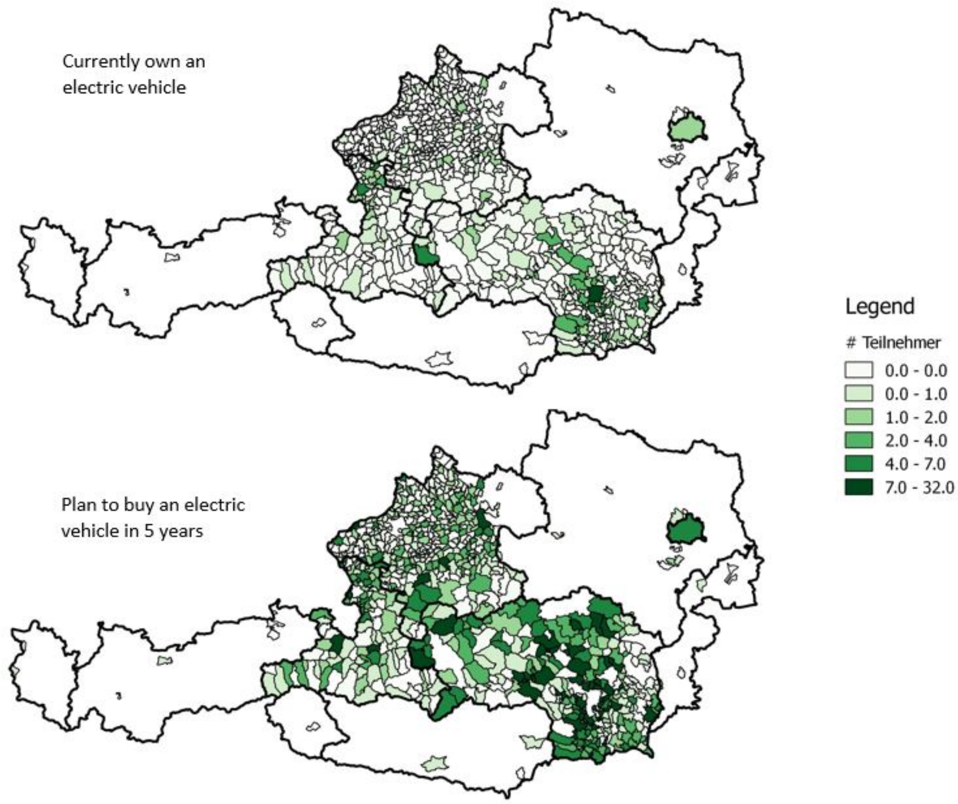
2.1 Sample composition and representativeness

In Table 1 we provide main socio-demographic characteristics of our full sample in the first column and compare it to the observed average characteristics of the whole population in Austria, given in the second column. While some parameters, for instance, households size, share of single family households and share of PEV owners is quite comparable with the Austrian average, for other factors such as living space size or average income we observe some differences: average living space size in our sample is larger than the one observed in Austria, same tendency is observed with the average income which is considerably higher in our sample.

Considering that our main research goal is to investigate consumers' preferences with regards to a novel business model for a charging station, we focus on the group of consumers, which represent the key target audience for it. Based on the questions included in the survey we identified respondents who already own a PEV and the ones who plan to buy one in five years.

According to the data observed in our survey 3% of respondents own a PEV (comparable to Austrian statistics of 2.4%) and 23% of the respondents consider buying a PEV within the next 5

Figure 2: Development of PEV ownership in Austria

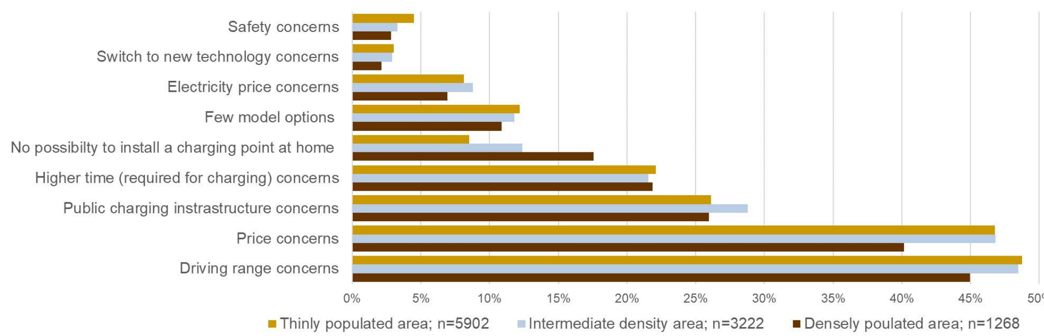


years. In Figure 2, we show the distribution of answers with respect to actual and future PEV owners based on their geographic location. These 23% of the households could be potentially interested in the described in this paper business model and availability of such a solution for the charging related issues could be the tipping point for their decision to adopt a PEV for at least some of those households.

The households who do not own a PEV and do not intend to buy one within five years were not asked to answer the questions about the suggested charging business model due to assumed lower level of knowledge and interest in such topics. While we exclude the households that did not own and were not planning to buy a PEV in the next five years, we collected information on the reasons why they are not willing to buy an electric car (see Figure 3). According to the results the top three factors that are still considered as barriers to wider e-mobility development are driving range concerns, price concerns, and public charging infrastructure concerns. The business model of community-owned charging stations offers one potential solution to range and charging related barriers.

As a further step, in order to avoid including in the analysis respondents that provided protest

Figure 3: Barriers to PEV adoption (from full survey sample,excluding current PEV owners and those who plan to buy a PEV, N=9,997)



answers, we excluded the observations where the answers for all the three ranking questions were identical as well as those observations where one of the two most important factors was identical with the least important. 322 protest answers were excluded, as a result of this cleaning procedure 3,131 households represent the main sample of this study.

In the third column of Table 1 we show how our main sample compares to average households in Austria and full sample respectively. We observe a higher share of single family households, with higher than average income level, bigger size of living space and slightly larger household size. Further on, in our main sample we observe 12% of PEV owners, which is higher than on average in Austria, but is specifically relevant for our study. Thus, as expected our main sample of interest is not representative of the whole Austrian population, yet this statistic provides insights on the characteristics of the subpopluation of households which include early PEV adopters as well households which are currently already considering buying a PEV in the nearest future.

Table 1: Comparison of Austrian national and sample statistics

	Full sample	**Austria**	**Main Sample**
owns_home	83%	47.80%	87%
livingspace (sq.meters)	134.09	101.1	146.79
singlefamily	58%	47.30%	79%
PV_ownership	17%	NA	30%
PEV_ownership	3%	2.40%	12%
income (€)	3,105	2,188	3,469
household_size (persons)	2.7	2.26	2.9

Austrian statistic is based on data from Statistik Austria for 2017, except the share of single family homes for which the data is available only for 2011. No information on share of PV owners among Austrians has been found.
Full sample values are based on 13,450 observations.
Main sample values are based on 3,131 observations.

In a separate analysis we focus on a subsample of current PEV owners. For these 380 respondents a set of additional variables including the reason for buying a PEV as well as set of variables describing their charging behaviors is available. Considering that owning a PEV has been shown to have an effect on driving range anxiety, the analysis of this specific subsample provides additional evidence on the differences between current and future PEV owners, as well as their preferences with respect to a suggested business model. The full set of variables for both samples used in this paper is given in Table 2.

Table 2: Descriptive statistics

Variable	Description	Mean	Std. Dev.
Full sample			
owns_home	=1 if HH owns their residence	0.87	0.33
living space	sq. meters of indoor living space	146.79	81.35
single family	=1 if the HH lives in a detached home or duplex	0.79	0.41
PV_ownership	=1 if HH owns a PV system	0.30	0.46
PEV_ownership	=1 if HH owns an PEV	0.12	0.33
income	monthly HH net income in €	3469.51	1344.32
residents	Number of persons in HH	2.91	1.26
environmentalism	=1 if HH believes climate/environmental issues are highly important	0.60	0.49
UpperAT	=1 if HH resides in Upper Austria	0.16	0.36
Salzburg	=1 if HH resides in Salzburg	0.10	0.30
Styria	=1 if HH resides in Styria	0.75	0.44
Subsample of PEV owners			
second_car	=1 if HH owns an additional car to PEV	0.88	0.33
charge_home	=1 if HH mostly charges PEV at home	0.43	0.50
charge_work	=1 if HH mostly charges PEV at work	0.35	0.48
charge_public	=1 if HH mostly charges PEV on public charging station	0.39	0.49
charge_wallbox	=1 if HH mostly charges PEV at home using wallbox	0.42	0.49
charge_always	=1 if HH always charges PEV given a possibility	0.44	0.50
charge_50%	=1 if HH always charges PEV when battery is below 50% charged	0.29	0.46
charge_warninglight	=1 if HH always charges PEV when warning sigh is on	0.06	0.23
charge_alwayshome	=1 if HH always charges PEV when at home	0.21	0.41
PEV_status	=1 if HH bought PEV for status reasons	0.28	0.45
PEV_driving	=1 if HH bought PEV for better driving experience	0.40	0.49
PEV_environment	=1 if HH bought PEV for environmental reasons	0.78	0.41
PEV_funding	=1 if HH bought PEV because of offered funding	0.43	0.50
PEV_noise	=1 if HH bought PEV for reduced noise	0.48	0.50
PEV_independence	=1 if HH bought PEV for independence from gas stations	0.44	0.50

“HH”=households
Main sample includes 3,131 households, PEV subsample includes 380 households.

2.2 Data collection methodology

Stated preference survey methods are used to investigate consumers’ preferences in the of absence of revealed preferences and have been used in transportation research since the 1980’s (Louviere, 1988). This method is especially relevant in the context of new services, products or business models research, which is the case of communally-owned charging points, as this business model is not yet widely applied.

Also no empirical data on consumers' revealed preferences are collected in this regard so far, so a stated preference approach is a suitable method to investigate consumers' preferences and fill in the gap in the available literature.

Specifically, we follow a subset of the questions used in (Balcombe et al., 2012) and in analysing the preferred attributes of PEVs in Egbue and Long (2012), and ask respondents to rank the importance of attributes. This puts our study in the framework of an attribute ranking analysis and the resulting data should be viewed as judgment data, as opposed to choice data, as respondents are asked only to give their evaluative ranking of different attributes of community-charging schemes (Louviere, 1988). Our data generation method is similar to choice-based conjoint analysis but does not constitute a full conjoint method as we do not vary the attributes shown to respondents or the experimental design of the question, and thus do not estimate utility part worths or willingness to pay. This simple attribute ranking method was chosen over a conjoint approach due to the novelty of the community-owned charging point topic. At this stage in the investigation we attempt to show merely how such a business model could be set up and what limitations or key factors can be identified. Whereas a full conjoint analysis would require the respondents to make tradeoffs between different attributes or attribute levels, which is thought to be a stretch in terms of cognitive ability to imagine oneself inside an unfamiliar community ownership setting.

The attributes each respondent was asked to rank are:

- distance to home
- freedom of charging times
- speed/power of charger
- total investment cost
- cost per charging cycle
- possibility to leave the car overnight at the charge point

The attributes can be divided in two groups, covering the financial aspects of the arrangement and the convenience aspects of the charging point configuration. For the attributes, we selected factors mentioned in the literature in the context of PEV charging transactions. For instance, Yang et al. (2016) in their survey of preferences of drivers in China find that charging time and charging station's location have a significant impact on PEV drivers' decision to charge their vehicles at the respective stations. The importance of location of the charging station is suggested by Nicholas et al. (2017) who examine a dataset from the charging provider EVgo operating in the US, and find that many consumers are charging close to home with more than half of the paid sessions made less than 16.6 kilometers distance from home. Based on these findings we include "distance to home" and "speed/power of charger" (which determine charging time) as the attributes to be tested in the analysis of the preferences for the suggested community-owned charging station business model. While examining PEV owners attitudes with respect to charging Globisch et al. (2019) mention that comfort and flexibility of charging operations are key attributes defining experience of the consumers and consumers demand. A similar idea is brought up by Madina et al. (2016) who state that the possibility to charge their vehicles at any time and avoid waiting times is of high importance for PEV user satisfaction. Following these findings we include the attribute "flexibility to charge your PEV at anytime" in our survey. Another comfort and flexibility aspect of a private charging station is a possibility to leave the car overnight, which is then also included in our analysis.

Looking at the financial attributes, the total cost of investment is an important factor influencing consumers' decisions. Even if a parking place for installation of a private charging point is available, some households might still not be able to install one due to financial limitations. As mentioned by several previous studies (Hardman et al., 2018; Guo et al., 2016; Madina et al., 2016) the investments required for charging station installation and operation are still high and considered as barriers to further deployment of PEVs. Community-owned charging station business model offers a potential solution for high investment barriers by allowing owners to share the installation and operation costs amongst several participants. Also cost per charge, based on the analysis by Hardman et al. (2018) and Chakraborty et al. (2019), can be an important driver of PEV owners' decisions to charge their vehicles at a specific charging station. Accordingly, we included both financial attributes - total investment cost and cost per charge - in our analysis.

Survey respondents were also offered an opportunity to indicate other factors or attributes, that they consider as highly important in the context of their participation in such a business model. We provide a brief overview of the most-frequently mentioned factors as these might be important drivers of consumers' decisions to invest in a charging community project that are not yet well-represented by the current literature.

2.3 Econometric models

There are several key attributes of a community-owned charging station identified. When choosing how to rank the attributes households are assumed to consider all of the attributes; an assumption that is bolstered by the fact that respondents ranked three of the six attributes, choosing a most important, second most important, and least important factor. With the econometric exercise we seek to go beyond descriptive results to examine the socio-demographic and attitudinal factors that correlate with a respondent choosing a specific attribute as one of the most important or the least important element in a hypothetical community charge point. As such we employ a standard choice modeling approach that can give interpretations and insights into the data, the multinomial logit model.

Multinomial logit models can deal with multiple unordered choice options where a choice is observed from among these options. In our multiple attributes model, the dependent variables are the attributes ranked as the most important factor or the single least important factor. For any choice, the multinomial logit model is expressed as in (1).

$$\ln\left[\frac{P(Y_i = j)}{P(Y_i = J)}\right] = \alpha + \beta \mathbf{X}_i + \epsilon \tag{1}$$

where $P(Y_i = j)$ represents the probability that the household i chooses attribute j as the most important factor, and $\mathbf{X}$ represents the vector of explanatory variables that may influence the choice. The explanatory variables include household socioeconomic status, housing conditions, and federal state dummy variables, as described in Table 2. The federal state fixed effects are included to account for unobserved differences on the state level which could be relevant in terms of having an impact on the consumers' ranking of the respective attribute of the charging station, for instance, differences in the landscape or density of the available public charging infrastructure. The regression coefficient β reflects the effect of the explanatory variable on the logarithm of the probability ratio between the j attribute and J attribute, where J is the baseline comparison group. We use cost per charging cycle at the community-owned charging point as the baseline category in all multinomial logit analyses.

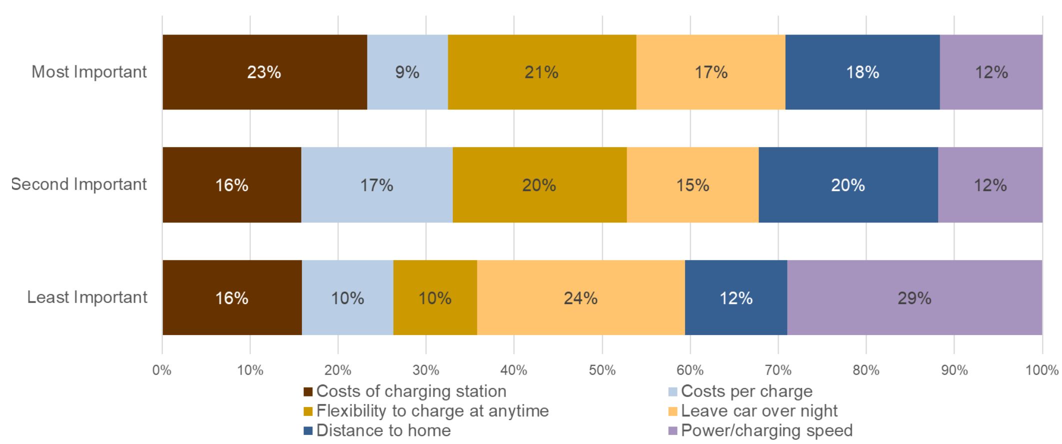
As suggested by (1), the coefficient estimates of the multinomial logit models are interpreted in relation to the probability of choosing attribute j as a most important, or the least important, factor over the probability of choosing attribute J as a most important or least important factor. Thus, by choosing the cost per charging cycle attribute we can interpret the multinomial logit output as the effect of an explanatory variable on choosing another attribute as more/less important over the marginal usage cost.

3 Analyses of the attribute ranking task

3.1 Descriptive analysis

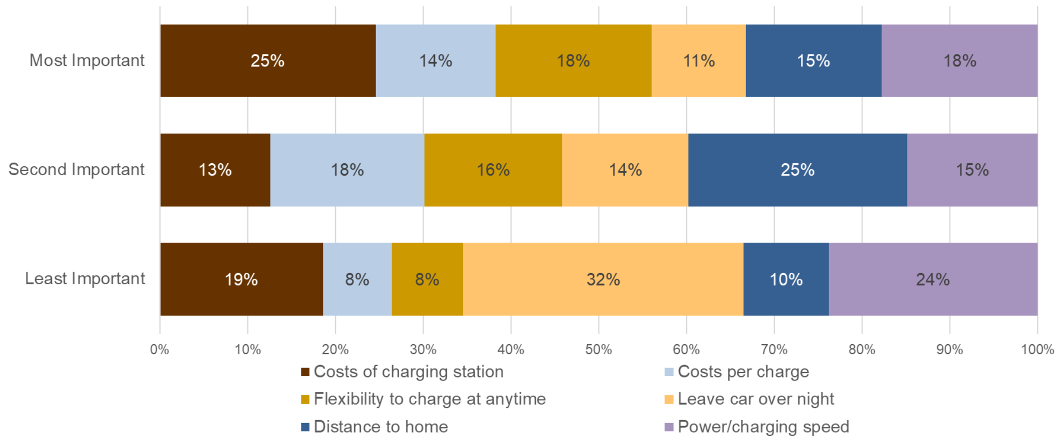
Figure 4 shows the distribution of answers according to the attached importance of the six attributes of a communally-owned charging point offered in the survey. As discussed above, the households were asked to rank six attributes and choose the most important one, the second most important and the least important that would influence their decision to participate in such a project. Looking at the results, we find that the costs of the charging station (total investment cost) were ranked by the majority of households as the most important factor (23%), the second most important factors were distance to home and flexibility to charge the car at any time (both 20%). This corresponds to PEV adoption literature that generally shows high initial cost as the first barrier to adoption followed by convenience and security concerns (Biresselioglu et al., 2018). The least important factor chosen by the majority of the respondents was the power of the charging station or the speed of charging (29%) followed by the possibility to leave the car over night at the charging station (24%).

Figure 4: Descriptive results of attribute ranking task: PEV owners and those who plan to adopt within 5 years



Based on 3,131 responses representing the full sample

Figure 5: Descriptive results of the choice experiment: PEV owners only



Based on 380 responses of PEV owners

Comparing Figure 4 to the corresponding Figure 5 for PEV owners only, we note differences in the distribution of the attributes' importance between PEV owners and the main sample. Although in general the distribution of answers looks somewhat similar, upon a deeper look some obvious differences are reflected. Compared to households without electric vehicles, households that already own a PEV attach a higher importance to the power of the charging station, but less importance to the possibility to leave the car overnight. For the second most important factor, we also observe differences in distribution of ranks of the attributes, but most interestingly in the least important attributes PEV owners opted for a possibility to leave the car overnight, while the majority of non-owners chose the charging speed as the least important attribute.

Such differences in the distribution of choices can be interpreted as empirical evidence of differences in preferences between the two groups of consumers. These differences can be explained by socio-demographics partially: early adopters are mainly residing in single-family houses and have higher than average income (de Rubens, 2019; Hardman et al., 2018), however the majority of our sample is represented by households residing in single-family homes, which usually all have a possibility to leave the car near their home overnight. The fact that power of the charging station is considered important by PEV owners shows that actual experience of owning an PEV and regularly charging it changes the perception of time invested in these daily activities and plays a role in considering an investment in new charging infrastructure.

3.1.1 Further factors suggested by respondents

As explained in Section 2, we offered respondents a possibility to express their opinion on the other factors that are important for them and can increase the probability that they will participate in a collective charging business model. 86 respondents provided their answers to this question and suggested additional attributes. We analyzed their answers, and grouped the responses according to the key factors mentioned by the respondent in the comment. Among the provided answers we identified the top three which were mentioned with the highest frequency and which we denote as:

1. The relations and communication within the group, as well the size of the group.
2. The source of electricity. Several respondents expressed that they would prefer to have such a charging station either built with a PV unit or using the electricity from an already available PV unit.
3. Legal aspects and responsibilities within the group.

Further factors suggested by respondents included safety of the charging point and security of the cars. In our initial exploration of the collective charging business models we did not include these factors. The elements listed above should be considered in future research or empirical tests of collective charging, and could be applied more broadly to community-schemes for other energy goods, such as a community renewable energy installations.

3.2 Econometric results

3.2.1 Results of main sample estimations

The results of the multinomial logit models are given in Table 3. The results of the first model (Model A) give estimates of the variables' effects on the probability to choose the respective factor as the most important one compared to the baseline attribute - the cost per charging transaction. The second model (Model B) gives estimates of the variables' effects on the probability to choose the respective attribute as the least important, compared to the baseline. We begin by considering the attribute specific constants which show, in Model A, that compared to cost per charge total investment cost, flexibility and possibility to leave car overnight have all higher probability to be ranked as the most important for the consumers' decision to invest.

Looking next at the results of appliance ownership, we can see that households owning a PV are distinct in their ranking of attributes of a community-charging station to a statistically significant degree in many cases. For instance, compared to cost per charge they have lower probability of ranking total costs or freedom of charging times or possibility to leave the car overnight as the most important attribute of a community charging. Such effects might be explained by the fact that households that already own a PV have a higher level of awareness about current price per kWh on the one hand, and on the other are already used to adjust their electricity consumption behavior to specific times (e.g. when the sun is shining), which could contribute to the fact that they attach higher importance to the cost per charge and care less about the possibility to leave the car overnight or have a flexibility to charge their car at anytime. Households that already own a PEV also show different preferences for the attributes of the communally-owned charging stations. Such households attach less importance to the possibility to leave their car overnight at the charging station, as well as distance to their house and flexibility to charge at any time compared to cost per charge.

Among the socio-demographic factors that play a role in the respondents ranking of the attributes, we identify income level as well as geographical location as key drivers. For instance, households with lower income have a higher probability of choosing speed and wattage of the charger as the most important factor compared to the cost per charging transaction. Also lower income respondents attach higher importance to the distance from their house to the community-owned charging station, which could be possibly explained by the potential additional costs related to commute from the charging station to their house, which respondents estimated to be more substantial than a cost per charge. Another explanation for such preferences could be related to the the fact that both attributes speed of the charge and distance to house are related to additional time expenses, yet according to (Bick et al., 2018) low income households work substantially more hours compared to higher income households, so their willingness to spend additional time to wait longer for a slower charge and spend additional commuting time might be lower compared to higher income households. Taking into account that they have less leisure time due to more working hours, they attach higher values to attributes which allow them to save more time in terms of PEV charging.

We also observe statistically significant differences on the federal state level fixed effects, where the survey sample from Styria is the omitted and baseline comparison group for this set of indicator variables. The regional differences are especially pronounced for Upper Austrians where households have a lower probability of ranking possibility to leave the car overnight or distance to their house as the most important attributes, while households from Salzburg have a higher probability to rank their total investment cost as the most important factor compared to Styrian households.

Table 3: Factors affecting consumers' decision to invest in a communally-owned charging point

	Model A		Model B	
	Coef.	*Robust Std. Err.*	*Coef.*	*Robust Std. Err.*
Total investment cost				
PEV ownership	-0.299	-0.197	0.411*	-0.235
owns_home	0.098	-0.244	0.248	-0.248
living space	-0.001	-0.001	-0.002	-0.001
income low	0.139	-0.297	-0.340	-0.289
income high	-0.147	-0.194	0.092	-0.174
environmentalism	- 0.448*	0.229	0.0920	0.217
PV ownership	-0.428***	-0.160	0.204	-0.169
residents	0.050	-0.065	0.095	-0.067
single family	0.067	-0.158	-0.014	-0.157
Salzburg	0.455*	-0.250	-0.253	-0.244
Upper Austria	-0.267	-0.184	-0.100	-0.201
Cons	0.942***	-0.266	0.094	-0.285
Freedom of charging times				
PEV ownership	-0.540***	-0.206	0.117	-0.281
owns_home	-0.063	-0.245	0.165	-0.274
living space	0.000	-0.001	-0.001	-0.001
income low	0.097	-0.303	0.212	-0.287
income high	0.033	-0.193	-0.627***	-0.221
environmentalism	0.074	-0.145	-0.038	-0.167
PV ownership	-0.534***	-0.164	0.193	-0.192
residents	0.043	-0.066	0.136*	-0.073
single family	0.090	-0.160	0.141	-0.176
Salzburg	0.242	-0.259	-0.730**	-0.311
Upper Austria	-0.190	-0.186	-0.373	-0.233
Cons	0.982***	-0.265	-0.414	-0.317
Possibility to leave your car overnight				
PEV ownership	-0.771***	-0.232	0.659***	-0.223
owns_home	0.100	-0.253	0.336	-0.232
living space	-0.002	-0.001	-0.002	-0.001
income low	0.247	-0.310	-0.065	-0.251
income high	0.072	-0.201	-0.568***	-0.174
environmentalism	-0.095	-0.151	0.018	-0.139
PV ownership	-0.666***	-0.175	0.185	-0.162
residents	0.114*	-0.068	0.062	-0.063
single family	-0.037	-0.165	0.250*	-0.150
Salzburg	0.115	-0.273	-0.040	-0.226
Upper Austria	-0.405**	-0.201	-0.134	-0.190
Cons	0.886***	-0.278	0.414	-0.262
Distance to your house				
PEV ownership	-0.562***	-0.215	0.24	-0.264
owns_home	0.384	-0.264	-0.140	-0.247
living space	0.000	-0.001	0.000	-0.001
income low	0.683**	-0.299	-0.098	-0.272
income high	0.252	-0.195	-0.717***	-0.214
environmentalism	0.035	-0.150	0.221	-0.161
PV ownership	-0.327*	-0.169	-0.248	-0.192
residents	0.111*	-0.067	-0.126*	-0.075
single family	0.128	-0.164	0.193	-0.173
Salzburg	0.037	-0.271	0.061	-0.264
Upper Austria	-0.486**	-0.199	0.117	-0.213
Cons	0.127	-0.290	0.490*	-0.279
Speed and wattage of charger				
PEV ownership	0.059	-0.213	0.144	-0.227
owns_home	0.145	-0.292	0.016	-0.216
living space	0.001	-0.001	-0.003***	-0.001
income low	0.607*	-0.322	-0.409*	-0.248
income high	0.059	-0.213	-0.383**	-0.166
environmentalism	0.234	-0.165	-0.151	-0.134
PV ownership	-0.384**	-0.183	0.126	-0.159
residents	-0.006	-0.073	0.132**	-0.061
single family	0.340*	-0.182	0.110	-0.144
Salzburg	0.324	-0.284	-0.191	-0.222
Upper Austria	-0.229	-0.208	-0.184	-0.186
Cons	-0.397	-0.317	1.239***	-0.247

* p<0.1, ** p<0.05, *** p<0.01
Number of observations: 3,131
Model A: dependent variable is a binary which equals to one if the respective attribute was ranked as the most important factor.
Model B: dependent variable is a binary which equals to one if the respective attribute was ranked as the least important factor.

Looking at the results of Model B, where we explore the probability of a specific attribute being chosen as the least important, we find that distance to house as well as speed and wattage of charger have higher probabilities to be chosen as least important attributes for a community-owned charging station. We observe that while PV ownership is not a critical factor defining preferences of users with respect to community-owned charging station in Model B, PEV ownership, income and number of residents are. PEV owners have a higher probability to rank total investment cost and the possibility to leave the car overnight as the least important attributes compared to potential future PEV owners. This result shows how the preferences of current PEV owners differ when compared to non PEV owners, especially considering that 35% of PEV users in our sample frequently use public charging stations. High income households have lower probability to rank freedom of charging times, possibility to leave their car overnight, distance to their house, as well as speed and wattage of the charger as least important attributes compared to the cost per charge, which we can interpret as having a higher preference for comfort and flexibility for such households as opposed to cost per charging transaction. Looking at the number of people in a household, another factor which turned out to be a driver of consumers ranking judgements in Model B, we find that for bigger households the distance of the charging station is less likely to be chosen as the least important attribute compared to the cost per charge, yet they care less about the speed and time of the charger as well as flexibility to charge their vehicle at any time. The relevance of distance to their house from the charging point for households with more residents could be related to additional costs related to this commute which are higher if multiple members of the households have to make it. Additionally if multi-family households have children longer commutes might be more complicated for them to manage.

3.2.2 Analysis of current PEV owners

In both models we observed that PEV owners have different preferences with respect to attributes of the community-charging business model. Considering that a set of additional information is available for PEV owners, we extend the models shown above with additional variables describing PEV users charging behaviors as well as reasoning for buying a PEV.

In this section, the same estimation strategy is applied to a sub-sample of respondents that already own an electric vehicle. We first compare the two samples in terms of their socio-demographic characteristics. Looking at Table 4, we can conclude that while the samples are in general quite similar there are some parameters with significant differences. For instance, a considerably higher share of households owns a PV among PEV owners, possible due to the complimentary nature of these two goods (Cohen et al., 2019). More PEV owners also tend to own their dwelling, reside larger dwellings, and have higher reported net incomes, on average. Mostly the differences in socio-demographics are in line with the findings in the literature describing typical current PEV owners or early adopters as high income households, usually owning their dwelling and residing in a single family house (de Rubens, 2019; Vassileva and Campillo, 2017; Plötz et al., 2014).

Table 4: Comparison of the current PEV owners with the main sample

Variable	Description	Main sample Mean	Main sample Std. Dev.	PEV subsample Mean	PEV subsample Std. Dev.
owns_home	=1 if HH owns their residence	0.87	0.33	0.94	0.24
living space	sq. meters of indoor living space	146.79	81.35	165.29	85.63
single family	=1 if the HH lives in a detached home or duplex	0.79	0.41	0.86	0.35
PV_ownership	=1 if HH owns a PV system	0.30	0.46	0.53	0.50
income	monthly HH net income in €	3469.51	1344.32	3864.61	1396.51
residents	Number of persons in HH	2.91	1.26	3.08	1.24
environmentalism	=1 if HH believes climate/environmental issues are highly important	0.60	0.49	0.68	0.47
Upper	=1 if HH resides in Upper Austria	0.16	0.36	0.18	0.39
Salzburg	=1 if HH resides in Salzburg	0.10	0.30	0.12	0.32
Styria	=1 if HH resides in Styria	0.75	0.44	0.70	0.46

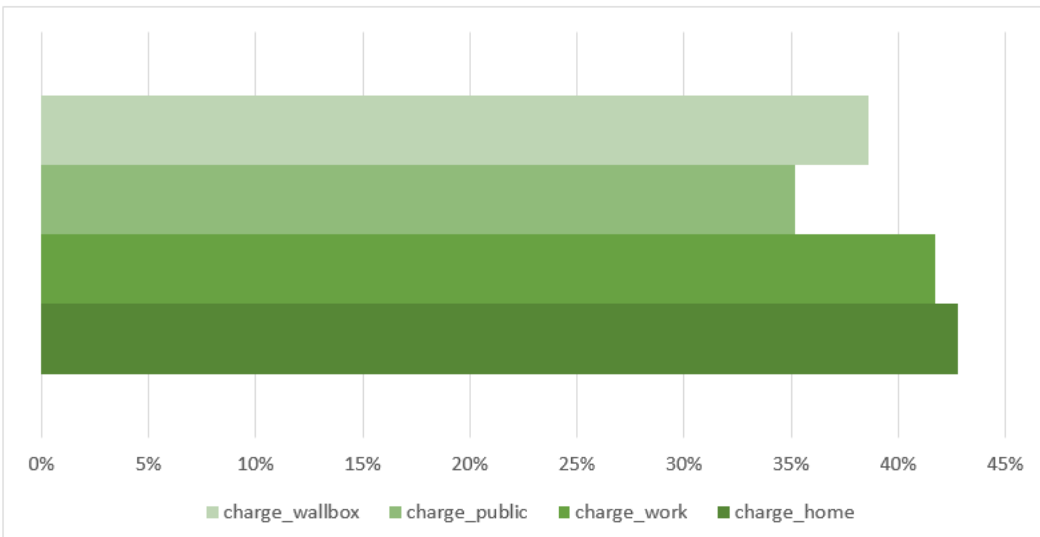
Main sample includes 3,131 respondents; PEV sample includes 380 respondents.

We continue by exploring charging behaviors of these respondents. Previous studies show the majority of charging operations are committed at private charging stations (Chakraborty et al., 2019; Hardman et al., 2018). Baresch and Moser (2019) suggest that 88% of all charges happen at home in Austria, and according to Chakraborty et al. (2019) only 5% of charges are made at the public charging stations. Similar patterns are confirmed in our data. We asked consumers where they most frequently charged their PEV and allowed multiple selections of the suggested locations. Most of the households in the sample (43%) most frequently charge their vehicles at home using a normal charger, followed by 42% who usually charge at work, 39% charge at home using wallbox charger and 35% claim to be using public charging stations.

Looking at Figure 7 which gives the share of users that only chose one respective location as the one they most frequently use for charging, we find that only 4% of the sample solely rely on public charging stations, while 8% rely solely on charging stations at their workplace. Thus, only a relatively low share of consumers currently adopts a PEV when solely relying on public charging infrastructure.

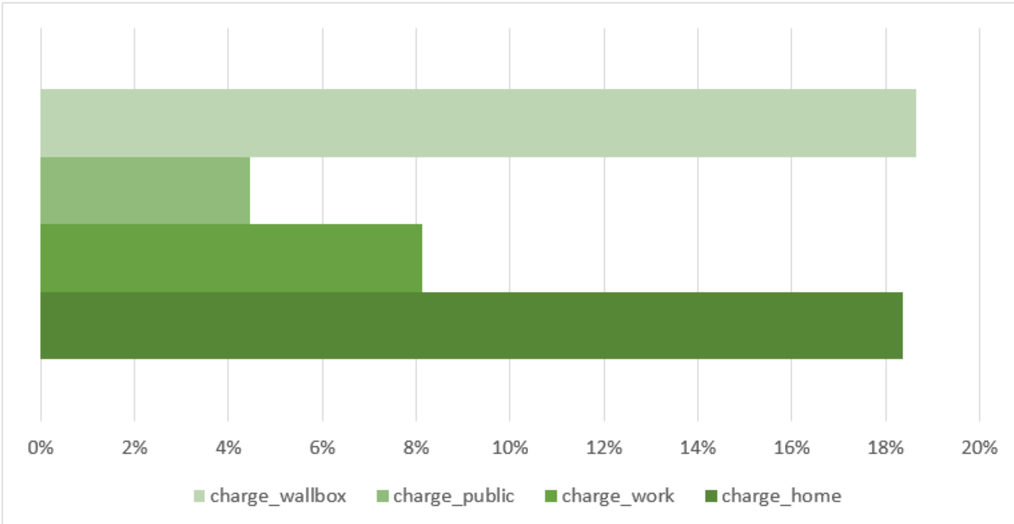
Of the households owning a charging wallbox at home, we find that 60 (33% of this group) also frequently use public charging stations. These findings show that even households that own a wallbox charger at home often use public charging stations, thus, we assume the community charging model could be of interest to a significant share of PEV drivers, not only the ones that are currently solely relying on public and work located charging stations. For these PEV owners community-owned charging station concept could offer an increase in the level of service and reliability which is currently not achieved with the public stations, but also the ones who already own a charger at home as there is a significant share of PEV owners who while owning a charger at home also frequently use public chargers.

Figure 6: Charging locations. Multiple selection allowed



Based on 380 responses, multiple selection was allowed

Figure 7: Charging locations. Share of households using exclusively one type of charging stations



Based on 380 responses

We further investigate the charging behavior of electric vehicles' owners by looking at their preferred times of charging. The time of charge is important considering that community owned charging station business model involves coordination of the charging times of co-owners possibly involving a special ICT system facilitating communication within a group an allowing to check the live status of the charging station. Philipsen et al. (2018) stated that unlike conventional car drivers PEV users tend to recharge the consumed quantities of power immediately. The results of our survey confirm this option as being the most popular among PEV users, followed by 29% of users charging their vehicle as soon as the level of battery charge drops lower than 50%, and 6% of the sample usually charges their vehicles when the warning sign is on. Such distribution of charging times among PEV owners might be explained by a certain level of range anxiety and risk aversion. We include the set of variables describing PEV owners charging as well as reasons to buy a PEV in the estimation of the model shown in the previous section.

The results of the estimation are given in Table 5. In the results we find a different preference expressed through the attribute specific constants than for the full sample. For instance, compared to cost per charge total cost of investment is most likely to be chosen as the most important factor, while all the other attributes are not. In the main sample the attributes related to flexibility and possibility to leave the car overnight were perceived as more important compared to cost per charge. We assume that such results might be due to experience of charging the vehicles that PEV have, which also changes the preferences with respect to certain comfort-related attributes of the charging station and puts costs on the first place instead. Interestingly, PV ownership does not play a role in the rank of the attributes, unlike in the main results. However, ownership of the dwelling does. Respondents that own a PEV and own their dwelling have higher probability to rank total cost of investments and possibility to leave their car overnight as the most important factor compared to cost per transaction. As owning a dwelling does not necessarily mean owning a parking space for the car, for such households possibility to leave the car overnight could be an important factor for their decision to participate in a community-owned charging station.

Turning to the respondent-specific factors, we find that PEV user specific characteristics are more pronounced. If respondents bought their PEV for environmental reasons they attach a lower importance to the total cost of investment in the charging station as well as the possibility to leave the car overnight, while in general respondents that consider themselves as environmentally conscious have a lower probability to choose distance to their house as the most important factor compared to cost per charging transaction similar as in the main estimations. From the policy perspective, the fact that consumers care less about the total cost of investment as well as attributes of a charging station related to comfort like possibility to leave their car overnight or commute distance, if they bought a PEV for environmental reasons or in general have high environmental concerns underline the importance of advocating for the advantages of PEV adoption for the environment on the one hand, and importance of raising awareness about environmental issues in general.

Looking at the charging behavior related variables, we observe that PEV users frequently using public charging stations care less about distance of the charging point to their house compared to cost per charge. Looking at Model B, we find that PEV owners who charge their vehicles after the warning light turns own have higher probability of ranking total investment cost, freedom of charging times, possibility to leave car overnight, distance to their house and speed and wattage of the charger as the least important factor compared to cost per charge and to PEV users that charge their vehicles more frequently. Looking at these results for PEV sample we can conclude that PEV owners attach higher importance to cost per charge and less importance to distance of the charging station to their home. We no longer detect significant differences in choice probabilities across the three Austrian states in the analysis.

Table 5: Factors affecting PEV owners' decision to invest in a communally-owned charging point

	Coef.	*Robust Std. Err.*	*Coef.*	*Robust Std. Err.*
Total investment cost				
owns_home	1.631*	-0.875	-13.85***	-0.676
living space	0.003	-0.003	-0.002	-0.003
residents	-0.434***	-0.168	0.110	-0.219
income low	1.078	-1.320	-1.384	-1.126
income high	-0.170	-0.461	0.274	-0.513
environmentalism	0.175	-0.436	-0.095	-0.551
PV_ownership	-0.122	-0.386	0.811	-0.528
PEV_environment	-1.109**	-0.558	1.329**	-0.641
PEV_funding	-0.824**	-0.388	0.216	-0.508
PEV_noise	0.649	-0.477	-0.094	-0.672
charge_work	-0.192	-0.407	-0.114	-0.481
charge_public	0.007	-0.392	-0.043	-0.464
charge_warning	-0.290	-0.921	14.22***	-0.531
second car	0.080	-0.462	-0.177	-0.677
cons	1.542*	-0.923	13.56***	-1.025
Freedom of charging times				
owns_home	0.814	-0.915	-12.97***	-0.852
living space	0.004	-0.003	-0.002	-0.003
residents	-0.147	-0.161	0.099	-0.258
income low	1.380	-1.266	-0.872	-0.939
income high	0.466	-0.452	-0.459	-0.677
environmentalism	-0.107	-0.451	-0.666	-0.631
PV_ownership	0.283	-0.413	0.156	-0.596
PEV_environment	-0.915	-0.583	2.035**	-0.822
PEV_funding	-0.210	-0.420	-0.030	-0.580
PEV_noise	0.831*	-0.503	-0.499	-0.724
charge_work	0.166	-0.421	0.278	-0.546
charge_public	0.182	-0.405	-0.373	-0.590
charge_warning	0.065	-0.916	14.42***	-0.678
second car	0.279	-0.476	-0.479	-0.765
cons	-0.331	-1.022	13.23***	-1.120
Possibilty to leave your car overnight				
owns_home	1.880*	-1.045	-12.41***	-0.713
living space	-0.002	-0.004	-0.004	-0.003
residents	-0.232	-0.173	0.021	-0.216
income low	2.132*	-1.230	-0.969	-0.859
income high	-0.127	-0.559	-0.245	-0.495
environmentalism	-0.163	-0.499	-0.283	-0.520
PV_ownership	-0.594	-0.493	0.191	-0.491
PEV_environment	-1.259**	-0.640	1.350**	-0.591
PEV_funding	-0.028	-0.510	0.415	-0.469
PEV_noise	0.962*	-0.542	-0.441	-0.649
charge_work	-0.146	-0.482	-0.190	-0.451
charge_public	0.220	-0.429	-0.183	-0.434
charge_warning	0.444	-0.980	12.19***	-0.801
second car	0.404	-0.570	-0.443	-0.614
cons	0.249	-1.156	14.27***	-0.959
Distance to your house				
owns_home	-0.280	-0.834	-13.17***	-0.981
living space	0.002	-0.003	-0.002	-0.003
residents	0.188	-0.174	-0.402	-0.259
income low	1.303	-1.201	-0.815	-0.906
income high	0.687	-0.480	0.062	-0.597
environmentalism	-0.800*	-0.441	0.601	-0.612
PV_ownership	-0.124	-0.430	0.549	-0.588
PEV_environment	-0.261	-0.622	0.127	-0.652
PEV_funding	-0.842**	-0.429	0.378	-0.558
PEV_noise	0.713	-0.514	-0.304	-0.732
charge_work	-0.816*	-0.456	-1.084*	-0.582
charge_public	-0.223	-0.417	0.144	-0.542
charge_warning	1.312	-0.970	13.61***	-0.735
second car	0.686	-0.549	-0.609	-0.719
cons	0.128	-1.082	15.24***	-1.168
Speed and wattage of charger				
owns_home	1.455	-1.044	-13.71***	-0.600
living space	0.006**	-0.003	-0.006**	-0.003
residents	-0.296*	-0.160	0.130	-0.225
income low	1.853	-1.254	-1.283	-1.017
income high	-0.142	-0.472	0.207	-0.512
environmentalism	-0.301	-0.431	-0.254	-0.540
PV_ownership	-0.046	-0.415	0.124	-0.510
PEV_environment	-0.904	-0.566	0.811	-0.623
PEV_funding	-0.273	-0.408	0.143	-0.495
PEV_noise	0.532	-0.511	-0.061	-0.664
charge_work	0.186	-0.416	-0.211	-0.477
charge_public	0.312	-0.406	-0.423	-0.454
charge_warning	0.167	-1.045	13.81***	-0.568
second car	1.191**	-0.548	-1.211*	-0.625
cons	-1.378	-1.169	16.00***	-0.837

* p<0.1, ** p<0.05, *** p<0.01

Number of observations: 380

Model A: dependent variable is a binary which equals to one if the respective attribute was ranked as the most important factor.

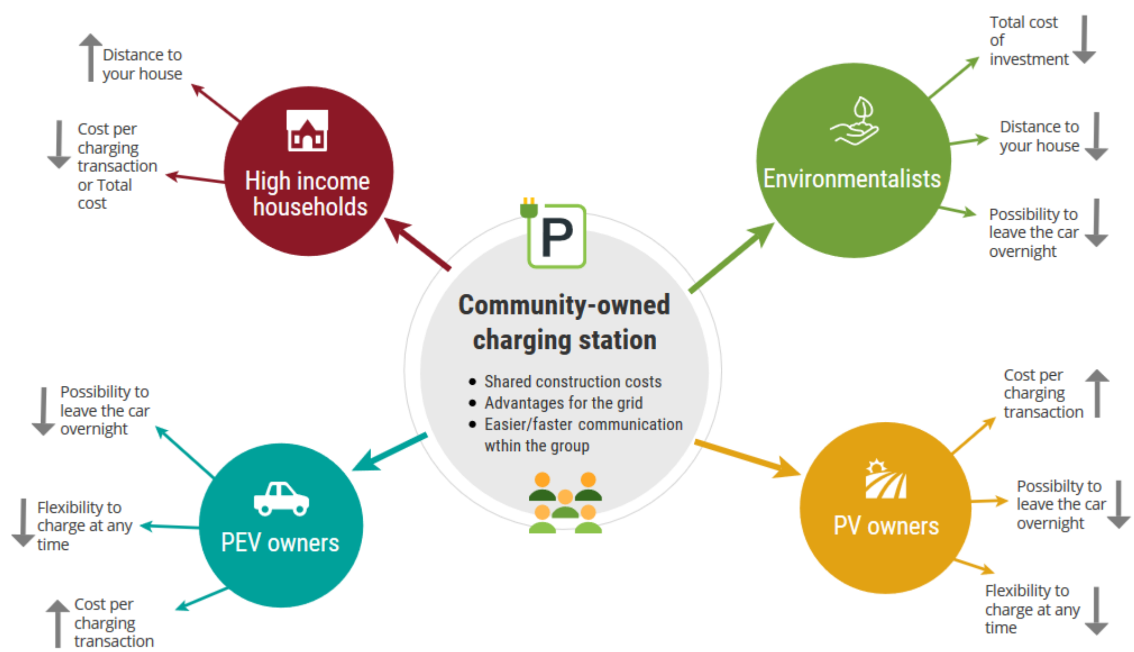
Model B: dependent variable is a binary which equals to one if the respective attribute was ranked as the least important factor.

Selected coefficients are shown

3.3 Clustering potential participants in community charging

Based on the respondent socio-demographic information and ownership of appliances, we identified clusters of respondents who have markedly different preferences for the attributes of a community charge point. These groups and their preferences are summarized graphically in Figure 8. The groups are identified as the following: high income households, if the reported level of income was higher that €4.401; PV owners, if households reported owning a PV, PEV owners if households reported owning a PEV, and environmentalists, who expressed high level of concern for environmental or climate issues.

Figure 8: Key potential customers and their preferences with respect to community-owned charging station



We provide a concise summary of the main results of our estimations for four potential clusters of customers. We focus on current PEV owners as they are the most obvious target audience for such a charging station business model. PV owners are suggested as another cluster, as PV and PEV adoption have been shown to be structurally linked Cohen et al. (2019). Another group of customers that we point to in this summary are those with high levels of environmental concerns, because such households represent another target group which based on their expressed attitude to environment might be willing to switch to electric mobility, if a suitable business model for charging is available. Another cluster of households that we highlight are the high income households, as they represent a target audience for electric vehicles, considering that current average price of an PEV is at least 40% higher than a comparable conventional car (Joint Research Centre, 2018). At the same time, such households can also be interested in co-investing in a community-owned charging station and further adopting a PEV.

4 Conclusions

In this paper we present and discuss a novel business model of community-owned charging stations, collectively owned and used by several people living in a close proximity. Such a concept may allow for further growth of electric mobility by removing a major barrier to PEV uptake that is the lack of available charging infrastructure Biresselioglu et al. (2018). If such models are widely applied additionally to private single-owner charging points, a greater number of consumers could be empowered to participate in the e-mobility market. Those who could otherwise not afford a charge point due to high costs under the single-owner model, or unavailability of a suitable installation space would also be able to enjoy some of the conveniences of a private charge point by using the community-based model. Also, the system as whole might benefit due to scheduled and diffused charging times instead of simultaneous charging across multiple individual residences. While the discussed model is new, there are some first efforts to spread this concept, for instance, according to State of the Sector 2018 report which gives Annual Review of Community Energy in England, Wales and Northern Ireland, 20 community-owned PEV charging points were constructed in 2017. Yet to speed up the development and adoption of this business model local authorities have a key role to play not only in creating opportunities to invest or offering suitable location for a charging point, but also engaging in campaigns informing about the advantages of this business model for consumers and community as a whole. The later requires a good understanding of the target customers types and their preferences with respect to attributes of the suggested business model.

In our analysis, we identify key target customers for a community-owned charging station and differentiate between potential PEV owners, who consider buying an electric vehicle in the near future, and actual PEV owners. Using the data from a survey in three Austrian federal states of 3,313 consumers, we investigate the relative importance of six chosen characteristics of a community-owned charging scheme in a respondent's hypothetical decision to join such an arrangement. Respondents were asked to complete an attribute ranking task where they indicated their top two most important and single least important considerations from among the six attributes. According to our analysis, the total cost of investment in the co-owned charging stations is considered as the most important factor. However, there are differences across the identified groups based on their socio-economic characteristics and revealed purchase history. We cluster respondents based their income level as well as ownership of PEV, PV and expressed level of environmental concerns to show distinct preferences for the configuration of a collective charging station amongst these groups. PEV owners attach lower importance to flexibility of charging times or possibility to leave the car overnight, while PV owners demonstrated to be sensitive to the cost per charge, and high income households expressed higher preference for flexibility to charge their vehicle at any point in time, while consumers with high environmental concerns expressed lower sensitivity to total cost of investment. Understanding the preferences of potential customers with respect to community-owned charging station attributes can help build targeted campaigns promoting the advantages of such a business model, including the impact on the environment, and in this sense contribute to further diffusion of PEVs.

Further important factors in setting up a collective charging station were given by respondents to the survey. These include the relationship within a group as well as the number of participants, well defined legal aspects and responsibilities in the group, and the source of electricity including a possibility to use PV. The later could be especially interesting to be promoted as a package for community-owned investment potentially together with an ICT which could not only help co-owners schedule the charging times but also include the overview of PV produced electricity. While the analysis conducted in this paper serves as a first exploratory attempt to investigate the consumers preferences with respect to community-owned charging station business model, further research or field tests of the collective charging business model would do well to consider these factors explicitly together with estimations of willingness to pay for participation.

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