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Electric Vehicle Drivers' Search for Charging Convenience

The Role of Pricing and Paths to Effective Segmentation

Electric vehicle (EV) drivers currently encounter a multitude of tariffs and providers when charging at public stations. This study examines the impact of this situation on EV drivers' satisfaction in Switzerland and finds a strong focus of the drivers on convenience and a lack of loyalty. The proximity and availability of charging stations are identified as key priorities. Furthermore, the study reveals the emergence of different driver segments, suggesting the need for tailored strategies.

Thibault Buraglio, Malte Bleeker, Prof. Dr. Sven Reinecke

The automobile industry is currently experiencing one of the most substantial transformations in its history. Due to increasing pressure to reduce CO_2 emissions, car manufacturers have been compelled to shift their focus from internal combustion engines (ICEs) to electric vehicles (EVs). In less than a decade, global electric car sales skyrocketed from only 120,000 EVs worldwide in 2012 to a staggering 6.6 million in 2021 (International Energy Agency, 2022) and 10.8 million in 2022 (Statista, 2023). However, several obstacles are currently slowing down the transition to EVs. Notably, the customer experience of public charging lags significantly behind ICE fueling standards (International Energy Agency, 2022). In Switzerland, the public charging structure plays a decisive role in this, given that around 60% of all Swiss residents live in rented dwellings and are thus most likely to rely on it primarily (Federal Statistical Office, 2023).

Prices are often considered a driving factor in achieving carbon neutrality in transportation. Among the components that influence the public charging experience, they are one of the most significant. The relevance of these "refilling costs" is expected to increase even further with a decrease in EV prices (Lanz et al., 2022). However, EV drivers currently encounter a multitude of pricing mechanisms, tariffs, and providers when charging electric vehicles at public stations (Potoglou et al., 2023). This set of factors potentially hindering the charging experience might lead to lower EV adoption in general (Krishna, 2021). The present research aims to provide tangible insights to electro-mobility providers, EV manufacturers, and policymakers to ease the transition of drivers from ICEs to EVs.

Research Questions and Hypotheses

The research hypotheses were developed based on the existing literature and indications from four preliminary semi-structured interviews with experts from the public charging industry.

The first hypothesis states that the charging price is not the main criterion for EV drivers when selecting a public charging station. According to two experts, users are more likely to prioritize reliability, location, and availability – i.e., charging convenience – over price. This is in line with the established importance of charging convenience when it comes to EV adoption by ICE drivers (Mandys, 2021). Furthermore, charging convenience has also been identified as a decisive factor in the decision of plug-in hybrid drivers to either switch back to ICEs or transition to fully electric vehicles (Lee et al., 2023). Additionally, it has been suggested that EV drivers are unwilling to take a detour to benefit from lower charging prices (Philipsen et al., 2015). Therefore, hypothesis 1 stipulates that:

Thibault Buraglio, M.A.
Business Analyst, Deloitte Digital,
Zurich, Switzerland
Tel.: +41 (0) 79 8466742
tburaglio@deloitte.ch

Malte Bleeker, M.Sc.
Research Associate & Doctoral Student,
Institute for Marketing and Customer Insight,
University of St. Gallen (HSG), St. Gallen, Switzerland
Tel.: +41 (0) 71 2242834
malte.bleeker@unisg.ch

Prof. Dr. Sven Reinecke
Executive Director, Institute for Marketing
and Customer Insight, University of St. Gallen (HSG),
St. Gallen, Switzerland
Tel.: +41 (0) 71 2242873
sven.reinecke@unisg.ch

H1: The selection of a public charging station is not primarily influenced by the charging prices.

Pischalnikov et al. (2022) note that "the decentralization of charging providers has hindered the driver's discovery of and routing to a charger, impacting ease of use and customer experience." In line with H1, this conflicts with the desire for charging convenience and the low willingness to make detours (Philipsen et al., 2015). Combining this with the high fragmentation of the charging provider landscape, the second hypothesis concerning the loyalty of EV drivers is derived (Hoess et al., 2022):

H2: The level of customer loyalty in public EV charging is low.

The third hypothesis considers the tariff structure used by charging providers. The most common tariffs for EV charging are flat fees (i.e., subscriptions for unlimited usage), volumetric fees (paying per each consumed kWh), or time-based fees (paying per time spent charging) (LaMonaca & Ryan, 2022). Previous research has shown that consumers tend to have a preference for flatrate pricing, i.e. subscription fees, over usage-dependent pricing (Gerpott, 2009; Nunes, 2000), even if the latter is cheaper on average (Kienzler et al., 2021; Lambrecht & Skiera, 2006). A prior study in Denmark and expert opinion suggest that time-based prices are usually not favored by EV

drivers (Visaria et al., 2022). It therefore appears likely that EV drivers would also prefer the ease of flat-rate tariffs over volumetric or time-based fees. Hypothesis 3 thus implies that:

H3: Drivers prefer flat-rate tariffs when charging their EVs at public stations.

Treating customers as a homogenous group would neglect the complexity of the market landscape and impede firms' ability to make effective marketing decisions.

The second objective of the present research was to move beyond the positivistic approach of assessing assumptions towards an explorative approach without any preconceptions. This involved the identification of distinct customer segments within the EV charging landscape who have homogenous attitudes towards public charging prices to allow for effective segmentation by public charging providers. During the expert interviews, it became clear that treating the customers as a homogenous group would neglect the complexity of the market landscape and impede firms' ability to make effective customer-centric product and marketing decisions.

Methodology

The research design consisted of two parts: preliminary qualitative expert interviews and a quantitative survey. Between December 2022 and January 2023, four semi-structured interviews were conducted with industry experts to support the development of research questions. The central part of the research involved a quantitative survey to evaluate the hypotheses on EV driving experience, charging priorities, reliance on public charging infrastructure, and attitudes towards different pricing schemes.

Before the survey's main distribution, a pretest was conducted with 15 EV drivers. The survey was distributed in collaboration with swisscharge.ch (an EMP), resulting in 135 complete responses from active EV users. An active user was defined as someone who had used at least one public charge in the last three months.

For the second objective of the research, a latent factor-cluster analysis was conducted to segment EV drivers based on their pricing-related perceptions and attitudes. The analysis utilized perceived complexity, fairness, transparency, and sensitivity, which had been identified as the most crucial pricing aspects by prior research (Homburg et al., 2014; Ramirez & Goldsmith, 2009). In addition, the study included environmental attitudes, as prior research on decision processes regarding EV adoption had shown this factor to be highly predictive (Mandys, 2021; Morton et al., 2017). All factors were captured as robust latent variables on 7-point Likert scales with at least three items and were included only if the scales showed high reliability (KMO > 0.6, Bartlett's Test < 0.01, and MSA > 0.5). In the second stage, hierarchical clustering and Ward's method were used to determine the optimal number of customer segments (Ward, 1963). Ward's method was chosen due to its empirically demonstrated ability to identify homogenous clusters of approximately equal sizes (Ferreira & Hitchcock, 2009).

Results and Discussion

To address the first hypothesis, EV drivers were asked to rank various aspects according to their relevance when selecting a public charging station (Table 1). As mobile apps are the pre-dominant method for selecting charging stations, respondents were also asked to identify their primary purpose in using such apps.

Two key observations can be made regarding H1: EV drivers prioritize the location, charger availability, and charging speed when selecting a charging station. Charging prices come in fourth place, indicating that other factors are more important. Additionally, EV drivers exhibit a low willingness to make significant detours to benefit from lower prices. This is reflected in the usage of mobile apps, with 51% using them to find the nearest available charging stations and only 13% using them to compare prices. Therefore, it is reasonable to conclude that H1 is verified and that prices only play a minor role in EV drivers' selection of public charging stations.

Management Summary

In the current market landscape, charging convenience is critical for EV drivers. They pay little attention to price and show low loyalty to any provider. Additionally, there are distinct segments of EV drivers. For example, one segment relies on public charging for long trips only, while another segment depends on it exclusively for everyday use. Providers need to consider such diverse needs and offer tailored services to effectively capture market share in today's and tomorrow's market.

Table 1: Preferences for Charging Stations

Ranking	Selection Factor	Median	Mode	Bowley's Coeff.
1st	Station's location	2	1	0.0
2nd	Charger availability	2	2	0.3
3rd	Charging speed	3	4	0.0
4th	Charging price	4	4	–0.3
5th	Station's additional amenities	5	5	0.0
6th	Charging network	6	7	–0.3
7th	Safety of the location	6	7	0.0

Note: Respondents ranked the factors according to their relevance, from the highest (1) to the lowest (7). Source: Own illustration.

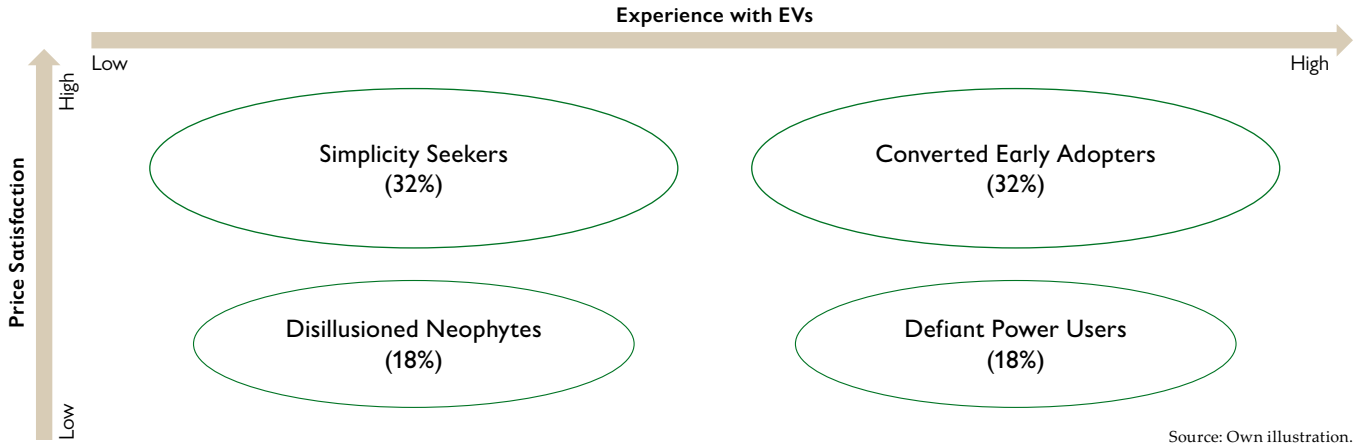
To address the second hypothesis, respondents were asked to indicate the number of charging networks they typically use and the number of network cards and apps they utilize, assuming that this indicates, to a certain degree, their loyalty to specific charging providers. The data analysis reveals that 30% of drivers do not have any or only one network app and almost one-third of EV drivers use four or more network apps. The numbers were only slightly lower for network cards. Network apps and cards are crucial requirements for public charging and have been widely adopted by EV drivers. Furthermore, 70% of drivers consider more than one provider when selecting a charging station, with only 24% relying exclusively on one provider. This is also reflected by the fact that 70% of drivers have more than one network application on their mobile phone, and 53% have more than one charging card. This lack of commitment is also reflected by the small share of drivers (25%) that have a subscription to a specific provider.

Possessing multiple cards and applications also serves to give EV drivers a sense of security, reducing their charging anxiety. Relying on several charging providers provides them with the certainty that they can charge whenever needed. Hence, the results suggest that customer loyalty in public charging is relatively low, thus confirming H2.

The third hypothesis was assessed by asking respondents to rank the most common pricing schemes (kWh-based, time-based, mixed rates, and flat rates) according to their preferences. Additionally, the survey identified the main reasons why users are hesitant to subscribe. The volume-based scheme was ranked as the most preferred one (median and mode: 1), followed by mixed rates (median and mode: 2) and time-based schemes (median and mode: 3). The flat rate scheme was ranked as the least preferred option. This contradicts the stipulated hypothesis and shows that EV drivers exhibit a strong preference for usage-dependent pricing (kWh-based) and a strong aversion towards flat rates, leading to the rejection of H3.

This is inconsistent with previous findings in other industries (Lambrecht & Skiera, 2006) and goes against the expectations of one of the interviewed experts. However, the fragmented landscape of service providers in this industry means that relying on multiple providers is often a necessity rather than a choice. Indeed, EV drivers cite the low return on in-

Figure 1: Market Segments Derived from Cluster Analysis



Source: Own illustration.

Main Propositions

1. EV drivers prioritize charging convenience and location availability over price.
2. Customer loyalty to public EV charging providers is low.
3. The market is heterogeneous, but driver segmentation offers valuable insights.
4. Tailored strategies based on segmentation are crucial for effectively capturing market share.

vestment as a key reason for not subscribing to any specific charging provider's plan. Considering the unique nature of this industry, the perception of a 'good deal' through flat-rate pricing does not seem to play a significant role in EV drivers' decision-making process when selecting between charging options.

In combination, the results demonstrate that EV drivers prioritize convenience and security, as shown by their focus on charging station proximity and availability. The price of this convenience does not seem to be a significant concern. Customers prefer having a free choice of provider at any time.

Clustering EV drivers according to their attitudes and price perceptions resulted in four distinct market segments. Figure 1 visually represents the four distinct segments based on their satisfaction with charging prices and overall experience with EVs.

While figure 1 provides a two-dimensional overview of the segments, it is also essential to examine the detailed description of each segment, considering the differences between segments across various dimensions (e.g. price sensitivity, environmental attitude; see Table 2). Figure 2 provides a characterization of the four customer segments through prototypical descriptions, which are expanded upon in the subsequent paragraphs. The interpretation is based on the differences between the factor means of each cluster (Table 2).

Segment #1 – The Disillusioned Neophytes

The disillusioned neophytes make up 18% of the market. As the name implies, this segment includes drivers with the least EV ownership experience. They mostly live in urban regions (50%) and have the highest share of public charging for work commuting (17%) and on business trips (17%) across all segments. They report the lowest levels of price satisfaction when charging their vehicles at public stations due to complex and unclear pricing structures that they perceive as unfair (i.e., prices do not match the value they expect to get). Additionally,

Table 2: Descriptives of the Market Segments

Dimensions	Disillusioned Neophytes Mean (S.D)	Converted Early Adopters Mean (S.D)	Defiant Power Users Mean (S.D)	Simplicity Seekers Mean (S.D)
Price Complexity	↑ 5,6 (1,1)	↓ 2,9 (0,9)	→ 3,9 (1,3)	↑ 5,8 (0,8)
Price Fairness	↓ 2,7 (1,0)	↑ 4,8 (1,2)	↓ 2,0 (0,8)	→ 4,3 (0,8)
Price Transparency	→ 3,6 (1,4)	↑ 5,4 (0,9)	↓ 3,1 (1,4)	→ 3,4 (1,1)
Price Sensitivity	↑ 4,6 (1,3)	↓ 3,5 (1,2)	↓ 3,5 (1,2)	→ 4,1 (1,3)
Price Comparison	↑ 5,0 (2,1)	↓ 3,7 (1,9)	→ 4,5 (2,1)	→ 4,3 (1,9)
WTP (Premium Services)	↓ 3,5 (1,7)	↑ 4,9 (1,4)	→ 4,4 (1,3)	↑ 5,0 (1,3)
Environmental Attitude	↓ 4,0 (1,0)	↑ 6,0 (0,8)	↑ 6,2 (0,8)	↑ 6,2 (0,6)
Charging Satisfaction	↓ 4,7 (1,6)	↑ 5,4 (1,3)	↓ 4,8 (1,9)	→ 5,0 (1,5)
Charging Frequency	↓ 2,9 (1,5)	→ 3,3 (1,2)	↓ 2,8 (0,9)	↑ 3,6 (1,5)
EV Experience (in years)	↓ 3,8 (1,7)	↑ 4,8 (3,0)	→ 4,4 (2,0)	↓ 4,1 (2,6)
Share of EV Drivers	↓ *18%*	*32%*	*18%*	*32%*

Notes: n = 135, Dimensions are based on 7-point Likert scales (1: Low – 7: High), WTP = Willingness to pay. Source: Own illustration.

Figure 2: EV Driver Personas for Each Segment

Simplicity Seekers

I seldom use public charging networks, but the few times I did, I was quite satisfied with the experience. I still find it challenging to understand the charging prices and find them slightly opaque. However, I trust that they are fair. I especially enjoy the superior services provided by some charging stations and am more than willing to pay for them.

Converted Early Adopters

I used to be an EV driver before they became popular, and I usually charge my car at home or work. I only use public charging stations when I go on vacation. Overall, I find the charging process to be convenient, and the pricing is easy to understand, fair, and transparent. However, I am aware that I am fortunate not to have to count every penny and compare prices in advance.

Disillusioned Neophytes

I recently bought an EV, primarily for the low ownership costs rather than the environmental benefits. I frequently use public charging stations, but despite my attempts to compare prices and find good deals, I find the process to be highly complex and unfair. I do not enjoy the charging experience and believe that improvements are necessary.

Defiant Power Users

I have owned an EV for quite some time now and got one because of my environmental concerns. I have no access to private charging stations at home or work, so I rely heavily on public charging I am dissatisfied with the overall charging experience as it lacks fairness and transparency on the different tariffs. I do compare prices before charging, but mostly just out of curiosity.

Source: Own illustration.

they have the lowest environmental score, suggesting that sustainability is not one of their top priorities. They are also the most price-sensitive segment, regularly comparing prices, and are the least willing to pay extra at charging stations.

Segment #2 – The Converted Early Adopters

The converted early adopters make up a significant portion of the market (32%). This group has the highest average age and the most extensive experience with electro-mobility. However, these drivers tend to charge their vehicles less frequently at public stations, relying more on home and workplace charging. This segment has the highest share of wall box owners (79%). Public charging stations are typically used only for longer trips during their free time (77%). This low dependence on public charging at specific locations may also explain why they are most satisfied with the overall experience and prices. They find prices easy to understand and perceive them to be fair and transparent. However, they also exhibit the lowest price sensitivity and rarely compare prices before charging, two factors that may also contribute to the high satisfaction scores. The converted early adopters are concerned about the environment but are not necessarily the most active segment in this regard.

Segment #3 – The Defiant Power Users

This segment accounts for 18% of the market. The defiant power users have the lowest access to home and workplace chargers, with 32% and 68% access, respectively, and therefore rely heavily on public charging. Despite their lack of access to private charging, the defiant power users are the second most experienced segment in electro-mobility. This segment is dissatisfied with public charging and perceives prices as understandable, but unfair and opaque. At the same time, they demonstrate one of the highest environmental scores, indicating that protecting the environment is one of their main concerns. Their price sensitivity is as low as that of the converted early adopters. Despite their low price sensitivity, defiant power users are interested in comparing prices before charging.

Segment #4 – The Simplicity Seekers

The segment of the simplicity seekers accounts for 32% of the market. This segment has only limited experience with electro-mobility and charging frequency, which suggests that they are not the most knowledgeable about EVs and

public charging. While simplicity seekers show high charging satisfaction and find charging prices to be fair, they criticize charging providers for their somewhat opaque pricing. This paradoxical result may be due to their lack of understanding or disinterest in the pricing structure. Individuals who prioritize simplicity may not have a strong interest in understanding the intricacies of the charging process, particularly as they do not use it frequently. Their lack of knowledge may lead them to perceive charging prices as reasonable. They display high environmental scores, do not tend to compare prices, and have the highest willingness to pay a premium for additional services. Their low price sensitivity may thus indicate that prices are no significant factor in their decision-making process.

Implications

The results of this research are relevant to professionals in the public charging industry as they provide insights into EV drivers' behaviors and preferences, which can help shape future pricing strategies. The study's findings suggest three critical areas for consideration.

Firstly, when planning new public charging infrastructures, charging providers should prioritize the stations' location, availability, and charging speed over attractive charging prices to attract and retain EV drivers. It is recommended to construct charging hubs at strategic locations with multiple charging points to ensure availability in the event of high demand, even if this results in higher operating expenses.

Lessons Learned

1. Charging providers should prioritize convenience over price by focusing on strategic location and availability to attract and retain EV drivers.
2. Providers could benefit from forging partnerships with navigation and complementary service providers to enhance convenience.
3. It is important to embrace customer segmentation for tailored services, as a one-size-fits-all approach neglects the diverse needs of EV drivers.
4. Charging providers must be prepared for a more mature EV market with new segments and higher reliance upon their infrastructure.

Secondly, charging providers might be able to gain a competitive advantage by offering enhanced convenience. This might increase the currently low loyalty of drivers. To achieve this, charging providers should integrate their services with most charging and navigation apps and platforms to enhance the user experience by offering seamless integration and reducing the number of apps needed. Additionally, providers might benefit from strategic partnerships with other providers, which would allow for access to multiple stations via a single interface.

Lastly, the present research indicates that a uniform approach is inadequate for the public charging market. It identifies four customer segments, each displaying distinct behaviors, particularly concerning their perception of charging prices. Therefore, charging providers should customize their strategies to meet the specific needs of each segment, thereby increasing customer satisfaction levels, loyalty, and ultimately profits. For instance, subscription plans are generally unpopular due to variations in charging frequency among EV drivers. However, adjusting these plans and targeting specific use cases, such as high-frequency users, could increase their perceived benefits and attractiveness.

Thus, the converted early adopters might benefit from a vacation scheme, which could offer additional services during journey days based on the number of charges at the provider stations. The defiant power users, who mostly rely on public charging, might be interested in reduced offers or low-cost subscriptions for their home and work surrounding area. Automatic suggestions of the charging station with the lowest current price in the surrounding area may best serve the disillusioned neophytes, who are highly price-sensitive and tend to compare prices. In contrast, the simplicity seekers could benefit from cooperations with restaurant chains, as they are willing to pay for additional amenities at the charging location. These recommendations should only be considered as examples, but they highlight the need for effective segmentation to address the diverse customer needs.

Limitations and Outlook

The present study focused on a few hypotheses and was limited to Switzerland, a country with low customer price sensitivity. The cooperation with only one provider means that the results cannot be assumed to be representative of the entire market, even though customers cooperate with many providers anyway. The segmentation was based on an explorative cluster analysis, which provided relevant preliminary results that should be confirmed by a larger quantitative study.

It is also essential to consider the current maturity of the EV (charging) industry. With the number of drivers and stations rapidly expanding, the paradigm may change in the future, and it remains to be seen whether prices will continue to be trivial when drivers have multiple charging providers to choose from at the same location (Yang et al., 2023). While it is possible that the cost of electric vehicles might decrease in the future, the recent sharp rise in electricity costs in Switzerland is likely to result in a significantly higher price sensitivity among EV drivers (Statista, 2023). As EV adoption increases across all social segments, it is expected that new and probably more price-sensitive segments will emerge. Segments that will be even more reliant on public charging should be expected, considering the higher rate of home ownership in the underlying sample of EV drivers (68%) compared to the whole population (40%) (Lee et al., 2019; Zarazua de Rubens, 2019). Current providers need to be prepared for new and more price-sensitive customer segments that will arise in the coming years.

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