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How should we develop the charging network? User and industry expectations

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Abstract

This study attempts to clarify expectations for electric vehicle (EV) users and the charging providers to provide information relevant for the development of the charging network. The study is based on a new and large-scale data collection among electric and conventional car users in collaboration with IDA, FDM, and FDEL as well as expert interviews with key players in the automotive and charging industry. The user survey gives relevant information on the satisfaction and expectations of both electric and conventional car users when it comes to electric cars and the charging infrastructure. We compare the results with data collected on the same indicators in a previous DTU project five years ago in order to analyse how these have developed. We find that the satisfaction with the EV charging infrastructure is not very good but has increased for all types of chargers, except for fast charging. Furthermore, our results suggests that the importance level of some EV attributes (e.g., price, range, environmental performance) have remained very high in the last years, both for EV users and non-users. Finally, we compare this development with results from a series of expert interviews with key players in the automotive and charging industry.

Background

In recent years, there has been a significant increase in sales of electric cars in Denmark. According to Dansk E-mobilitet, in the second half of 2022, the share of electric cars and charging hybrids thus accounted for more than 40% of new car sales. Although data from the Danish National Transport Survey (TU, Baescu, O., & Christiansen, H. (2020)) shows that around 75% of households with a car have the opportunity to park on their own property and thereby set up a private charging station, there is a need for a charging network that can service drivers who cannot charge at home as well as drivers who need to drive further from home

than the range allows (Spottle et al., 2018; Springel, 2021; Rich et al., 2022). A comprehensive network with easy access to charging, which does not require major changes in the user's transport habits, is for most people a requirement to purchase an electric car because it provides a reassurance that situations with unnecessary extra waiting time or cancelled trips do not arise (Coffman et al., 2016).

In Denmark, the charging network has developed as more electric cars have appeared, and according to elbilviden.d (accessed 27. March 2023), there are currently 2019 locations with a total of 8549 destination charging outlets that enable charging when the electric car is parked at a location for a longer period of time. If you need to charge faster, electric drivers can use 1123 outlets in 353 locations, of which there are 147 locations with the so-called super fast chargers (lynladere), which allow even electric cars with the largest batteries to charge the batteries within 30-45 minutes. Currently, several actors in the charging market are expanding their charging networks greatly, both in city centers, along major highway corridors, at fuel stations and next to e.g., grocery shopping locations. While there have been several analyses looking into the need for charging based on current transport behaviour, there is little knowledge about where electric car users prefer to charge and how this is aligned with the current development in charging infrastructure. It is also relevant to follow how these expectations change as both the electric car performance (e.g. driving range) and the development of the charging network has increased greatly within just a few years.

Based on expert interviews and data on the perceptions of both EV and non-EV users of charging infrastructure, this analysis seeks to inform policy makers and charging providers about future customer's expectations. We utilize survey data about electric car users' view on charging infrastructure both when it comes to how they rate importance and their satisfaction collected in two periods, namely during 2017-2019 and more recently in the fall of 2022. We analyse how electric and conventional car users have adjusted both their (expected) satisfaction and importance level related to electric cars and put the results in perspective of the results of the expert interviews.

Data and Methods

Data was collected in different periods of time and in different settings. The first user survey on EV and conventional car users was conducted during 2017-2019 by DTU in relation to the EU project "GREAT" conducted as part of the Trans-European Transport Network (TEN-T). This survey was target at a representative group of car owners and customers at E.ON. In the autumn of 2022, The Danish Association of Engineers (Ingeniørforeningen IDA) conducted a survey among The Danish Car Owners Association (FDM) and The Danish Association of Electric Car owners (FDEL)'s members in collaboration with FDM, FDEL and the Technical University of Denmark (DTU) where the latter organization worked on the survey in relation to a project called "FUZE", financed by EUDP. This second survey included questions about expectations and satisfaction with electric cars in general and the charging network. Several questions were asked in the same way as the first previous DTU survey.

Despite differences in user groups and sampling methodology, the data collected to some extent allows us to examine the evolution of expectations and satisfaction. While the sample of conventional car users might differ to a greater extent (online user panel vs. members of a car organisation), we argue that the sample of electric car users is more alike (E.ON customers vs. FDEL members). Table 1 provides an overview of the observations included in each dataset:

Finally, several interviews with key stakeholders have been conducted during Spring of 2023 in relation to a B.Sc project conducted at DTU. These stakeholders cover charging point operators, Electric Mobility Service Providers, and universities. Stakeholder interviews are crucial in understanding industry actors' short-term plans for the charging infrastructure in Denmark. By understanding how different actors have decided to respond in the context of the user data, the analysis provides a comprehensive view of the development of charging stations and potential challenges.

Table 1 provides the characteristics of the respondents in the GREAT and FUSE data and a comparison with the Danish population in households with cars. It is seen that the sample of Non-EV sample from the GREAT survey represents the individuals in car households the best, except that it seems to overrepresent individuals in the Capital region of Copenhagen. As the literature also shows, EV users tend to be older and more often male which is also clearly the case in our sample. 2022 data is skewed towards higher age and male for both EV and non-EV users which likely is typical for members of a car-owners organization. Surprisingly, we find little difference in the 2022 sample across EV and non-EV users.

Table 1: Characteristics of the samples and comparison with The Danish Transport Survey (TU). For TU, only individuals of at least 18 years of age in households with at least one car are included. 2017-2019 data is based on data from GREAT while 2022 is based on data from the IDA survey.

		2017-2019			2022		
		TU	EV	Non-EV	TU	EV	Non-EV
Age	18-29	16%	3%	15%	17%	1%	1%
	30-49	33%	50%	37%	33%	18%	11%
	50-69	35%	41%	37%	35%	58%	56%
	70+	15%	6%	11%	16%	23%	32%
Gender	Male	51%	90%	57%	51%	92%	94%
	Female	49%	10%	43%	49%	7%	5%
	Other	0%	0%	0%	0%	1%	1%
Postal code	< 3000	18%	36%	45%	18%	22%	21%
	≥ 3000	82%	64%	55%	82%	78%	79%
Private parking	Yes	76%	82%	48%	74%	54%	58%
	No	24%	18%	52%	26%	46%	42%
<i>Number of observations in the sample:</i>			1658	1564		516	1276

Results and discussion

The planned development of the charging infrastructure was investigated through interviews conducted with relevant industry stakeholders such as the charge point operators, electric mobility service providers (EMSPs) and their representing industry organisations. The general sentiment is that a big rollout of charging stations is happening all around Denmark. However, multiple actors identify different EV users' needs that are not being met. These groups are primarily EV-users without access to home-charging who must depend on the public charging infrastructure. Reasons being housing associations making it difficult to implement the charging stations at the shared parking spaces. Some EV-users can't depend on semi-public chargers such as at the workplace or other trivial locations. These are salespeople and external consultants that drive around the country to meet people out of the current reach of the charging infrastructure. Moreover, EV users in towns that have no public charging infrastructure depend on their own home-charging possibilities. Thus, EV-user visitors in these towns have difficulties charging for those without any relations to residents in the town. Finally, EV-users who cover many kilometers pr. year need consistent charging possibilities on their long-trips.

When asked about people who are not able to charge at home, it was stated that current EV-users or people who intend to buy an EV are expected to wait for the closest gas-stations to appear with charging stations. These gas stations are expected to have a mix of fast and normal chargers. Whereas parking for longer times will be sufficient with slow charging.

In the survey data, we have explored tendencies in the development of important and satisfying users ranked different aspects of the charging infrastructure, and compared those with the stakeholder interviews. Figure 1 describes the development in the level of importance and satisfaction as indicated by

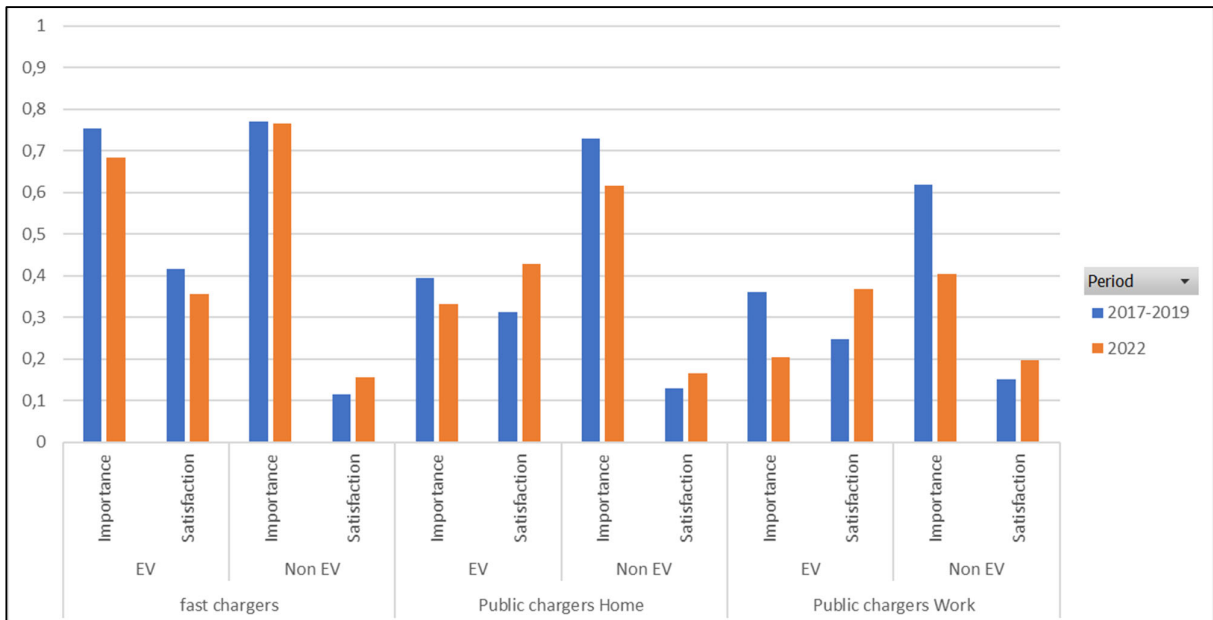


Figure 1: Development in level of satisfaction and importance for different charging aspects of charging infrastructure for EV and non-EV users. The graphs present the share of respondents who indicated high or very high importance or satisfaction level.

both EV and non-EV users since 2017-2019. In general, the level of satisfaction is very low for non-EV users across all aspects, which likely reflect a selection bias, i.e. they did not chose the EV because they are not satisfied with the performance of the charging infrastructure. For both segments, the highest importance level is indicated for fast charging but non-EV users indicate high importance on all aspects except for workplace charging that seems to be declining in 2022 from a very high level. The importance of workplace charging is also declining for EV users but from a much lower level. In general the satisfaction level is increasing across both segments for all aspects, except for fast charging, where the rating is declining for EV users. This might be due to a period with a high increase in the number of EVs while the fast charging network has not followed the same pace.

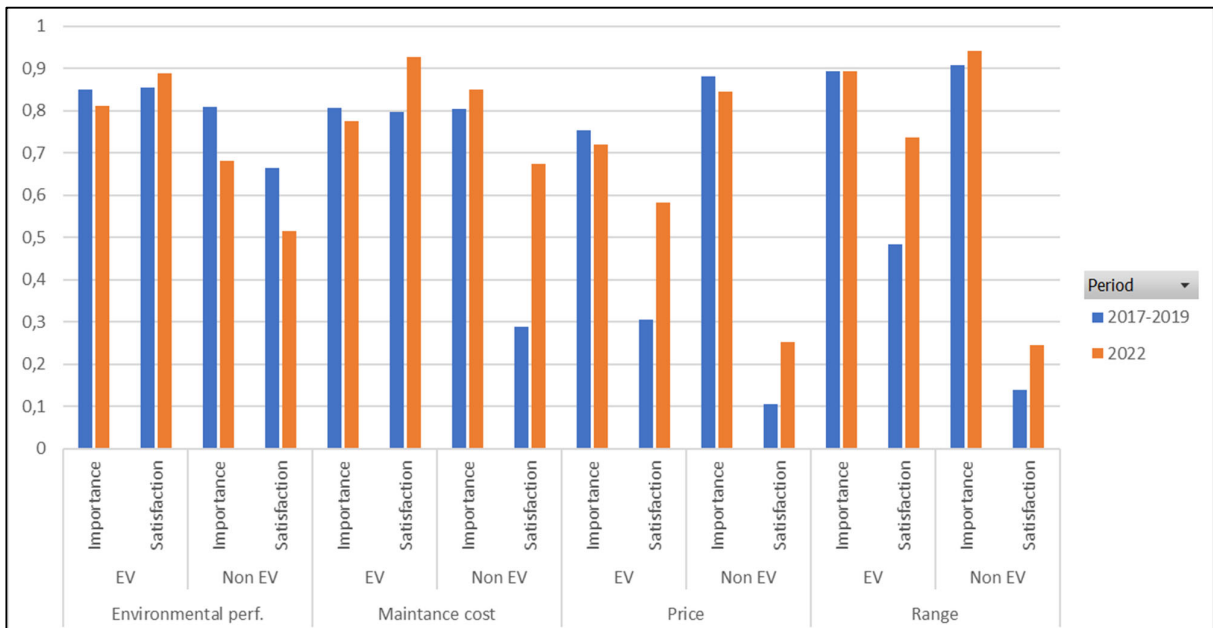


Figure 2: Development in level of satisfaction and importance for different electric car aspects for EV and non-EV users. The graphs present the share of respondents who indicated high or very high importance or satisfaction level.

Figure 2 presents the development in the level of satisfaction and importance for different electric car aspects for EV and non-EV users. For EV users the importance levels seem to be rather stable, while we see an increase in satisfaction for maintenance costs, purchase price and driving range. For non-EV users the importance is also rather stable but, surprisingly environmental performance seems to be declining. Also for non-EV users the satisfaction level for maintenance, purchase price and driving range is increasing with the highest increase for maintenance cost. This tendency might be due to information from e.g. the car owners' association about the lower relative maintenance cost that electric car users experience.

Finally, Figure 3 presents the importance and satisfaction levels indicated by the 2022 sample for different charging locations specific for the parking conditions of the respondent. We see that the importance level of being able to charge at home is high for those with access to private parking and these are also very satisfied. On the other hand, people without access to private parking seems to put higher importance on public charging facilities, workplace charging and fast daily charging which could e.g. be a fast charger located at a fuel station or next to a grocery store. Overall, there is a low satisfaction level for public charging facilities and charging options during daily routines while the satisfaction level for work charging is slightly higher. The most important charging aspect, beside home charging, is fast charging during long trips, but only 4 out of 10 are satisfied or very satisfied with the current conditions.

SATISFACTION		Charging Locations								
		at home private place	at home shared place	Curbside Away from Home	Curbside Near Home	Major public facilities	at work or educ. place	Fast station for daily	Fast station for long trips	Errands or Shopping
Parking Place	Front garden at house	92%	10%	6%	7%	18%	37%	15%	38%	15%
	Garage inside house	90%	13%	5%	5%	16%	31%	16%	35%	13%
	Park space near property	35%	24%	6%	9%	23%	22%	14%	39%	14%
	On street or road	n.a.	n.a.	6%	19%	15%	29%	6%	35%	5%

IMPORTANCE		Charging Locations								
		at home private place	at home shared place	Curbside Away from Home	Curbside Near Home	Major public facilities	at work or educ. place	Fast station for daily	Fast station for long trips	Errands or Shopping
Parking Place	Front garden at house	97%	36%	23%	19%	65%	59%	48%	94%	39%
	Garage inside house	95%	35%	25%	18%	69%	57%	46%	87%	45%
	Park space near property	80%	76%	34%	32%	67%	56%	51%	89%	49%
	On street or road	82%	94%	50%	89%	83%	73%	70%	95%	50%

Figure 3: Development in level of satisfaction and importance for specific charging type and charging locations based on 2022 data. The values present the share of respondents who indicated high or very high importance or satisfaction level.

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