32nd Electric Vehicle Symposium (EVS32)
Lyon, France, May 19 - 22, 2019

The City of Stockholm experiences with charging infrastructure for EVs

Eva Sunnerstedt[1], Maria Xylia[2], Anton Sjögren[2]

[1]*City of Stockholm, Fleminggatan 4, 112 26 Stockholm, eva.sunnerstedt@stockholm.se*

[2]*Sweco AB, Gjörwellsgatan 22, 100 26 Stockholm*

Summary

In this paper, practical experiences from establishing public charging in Stockholm are analysed. A combination of quantitative and qualitative methods is used in order to gain insight on who, where, and how public charging infrastructure is used. On-street normal and fast charging as well as charging at parking facilities are included. The results from a large-scale survey with users show that the main issues faced relate to the need for stricter control systems, improving information on charger types, signs and payment systems, increasing the number of public charging stations, integrating payment system, and improving maintenance and monitoring of the chargers.

Keywords: charging, infrastructure, municipal government, user behaviour, ZEV (zero emission vehicle)

1 Introduction

The City of Stockholm (Stockholms Stad) has put in place a charging master plan to oversee and facilitate public infrastructure development for EV-charging in order to ensure that it can effectively meet increasing user needs. The plan includes a publicly accessible dynamic map which shows existing as well as planned charging locations. This map assists private actors interested in providing public charging in the city to find suitable locations to establish infrastructure. As a result, 15 charging streets (6-8 charging units in a row along a street) with over 100 chargers in total were established in 2017. Furthermore, an additional 250 - 750 chargers are planned to be established in 2019. There are around 1200 off-street public charging units in Stockholm. The goal for 2022 is a total of 5000 public chargers, on and off street.

The City of Stockholm, therefore, provides an interesting case of a coordinated approach for public charging infrastructure in dialogue with private companies that is useful to analyze for further improving and expanding such services in the city, but also in order to replicate the approach in cities that are contemplating similar strategic plans for public charging infrastructure.

Establishing charging infrastructure (both public and private) is essential for motivating the transition to electric vehicles (EVs). Overnight charging (home charging) is the dominant charging type for individual owners. In order to facilitate the installation of chargers at residential properties, the City of Stockholm has an ongoing information campaign, which includes a short information film with know-how, evening seminars, a step-by-step guide with experiences and practical examples of how such chargers can be installed. The aim is to provide interested citizens, housing associations and single-family home owners with facts and

practical advice in order to introduce charging facilities at home, using the financing opportunities provided by the government.

In this paper, practical experiences from establishing public charging in Stockholm are analysed. The aim is to obtain insight to the following questions: (i) *who is using the public charging infrastructure? (ii) what are the experiences from public charging infrastructure?; (iii) where is public infrastructure used?; and (iv) how is public charging infrastructure used?*

According to the literature, there are three main factors that influence charging behaviors: time, cost, and convenience [1]. The interplay of these three factors influence charging decisions. Home charging is by far the preferred charging option most probably because it is the option that causes minimal influence on the users' daily routines and behavior [1].

In previous research a number of studies from different countries around the world has been compiled in order to study closer charging behaviors for pure electric and hybrid electric vehicle owners. The analysis showed that 50 to 80% of all charging occasions happen at home, followed by 15 to 25% at the working place (destination charging) and only around 5% of all charging occasions took place at public charging stations [2]. Similar trends has been observed in studies focused on Swedish users' charging behavior [3, 7].

Even though the share of public charging occasions does seem to be smaller compared to other alternatives, its importance should not be underestimated, as the presence of public charging offers the opportunity to realize longer trips with electric vehicles (especially pure electric ones with shorter ranges, but also hybrid electric vehicles so as to ensure that the vehicles run on electricity as much as possible). This can be of particular importance for addressing range anxiety issues and building higher confidence for purchasing an electric vehicle in the future [4]. Additionally, the fact that public charging is the only option for charging in some cases should not be disregarded. This is the case, for example, for private users that lack access to chargers at their property or lack private opportunities at all. The above are supported in recent research [1], [5].

A deeper understanding of user behavior is needed in order to specify optimal locations for charging. This does not only require analyzing the charging behavior at this early adoption stage, but also comparing current charging behavior with refueling behaviors, which would give indications of how further adoption will influence charging behavior trends. Real examples and analysis of experiences from implementation are valuable for planning ahead and adjusting city strategies for the roll-out of charging infrastructure. As the amount of EV users is increasing so are the system requirements changing. This study gives the opportunity of insight into detailed data on charging patterns, as well as qualitative perceptions on public charging with the help of a large-scale survey which is among the largest of its kind for a city.

Following the present introduction, Section 2 presents the methods used for the analysis, while Section 3 the results of the quantitative and qualitative analysis. Finally, conclusions and their policy implications are discussed.

2 Method

The approach used here is empirico-inductive, i.e. both quantitative and qualitative approaches are used for analysing the deployment of charging infrastructure in the city of Stockholm. With regards to the quantitative methods used, secondary data analysis is applied, using data delivered by charging service providers as input. Secondary data analysis is one of the most cost- and time-efficient methods for answering policy-related questions in research [6]. Document analysis, particularly the city's official documents, complements the data analysis when relevant.

The quantitative analysis shows how charging stations in Stockholm have been used under 2018. The data refer to the time period from 1 January to 31 December 2018 and include, among others, information on charging time and at what point through the day charging has started, the differences of charging on weekdays and weekends as well as monthly trends, the energy transferred per charging session, and differences on the trends for normal and fast charging. Normal and fast charging sessions at public stations are included, as well as charging in public parking spaces owned by Stockholm Parkering. The three private actors that operate chargers within Stockholm are EON, Fortum, and Vattenfall.

Survey research is the method are chosen for addressing the qualitative aspects addressed in this study. The survey was carried out in February 2019, with the use of an anonymous electronic questionnaire. The respondents were contacted via the three companies offering on-street charging services in the city of Stockholm. The respondents are customers that have used public on-street charging infrastructure via these companies. A total of 535 users responded to the survey.

The questionnaire was split in the following sections: (i) *background questions* (user demographics, electric vehicles types, vehicle ownership); (ii) *charging patterns* (charging frequency, charging location, charging methods - e.g. normal vs. fast charging[1]); (iii) *public charging alternatives* (public charging importance, preferred method for finding available chargers, preferred charging locations); and (iv) *public charging experiences* (perceived range anxiety and charger occupancy, opinions on charging time restrictions).

The survey was anonymous, unless the respondents specified otherwise. Out of 27 questions, 25 were closed-format. The purpose of including two open-format question is to give freedom to the respondents to address issues that they think are important for further improving public charging infrastructure in the city, as well as to gain a deeper insight into why users choose electric vehicles and public charging. The first reason is of particular importance for the thematic analysis proposed in this study, while the former gives a unique opportunity to understand the main drivers of electric vehicle ownership. The questionnaire's design was adjusted after a testing session with a user. Based on the feedback received, the questions were further refined before officially launching the survey.

3 Results

3.1 Quantitative analysis

The dominating share of charging sessions (49%) in the dataset was charging at 37 parking facilities/garages off-street. On-street normal charging represented 21% of the charging sessions and fast charging represented 29%. The charging sessions are almost split in half between Stockholm Parkering (51%) and the private actors offering charging services (fast or normal charging in the city (49%). This indicated the importance of normal charging at parking facilities, which offer the opportunity to charge while for example the user is at work (destination charging) instead of the time-limited (3 hours limit is applied), on-street charging.

While a decreasing trend can be observed between Q4 2017 and Q3 2018, the trend reverses and the number of charging sessions increase during Q4 2018, exceeding the total number of charging sessions for the same quarter in the previous year (see Figure 1). Another observation is that the number of fast charging sessions significantly decrease from Q2 2018. This can be attributed to the fact that one of the private actors started to require payment for fast charging in April 2018. The numbers for Q3 2018, however, include some uncertainty since there have been technical problems in registering the sessions from one actor which led to a linear adjustment of the dataset instead.

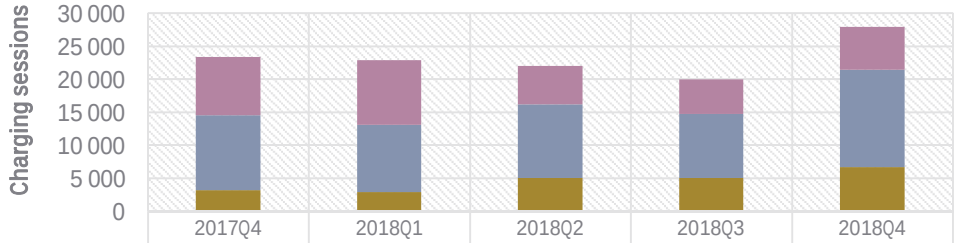
Charging activities are reduced considerably during the summer months, particularly in July. This is in line with the trends observed in all past reports of charging in Stockholm's region and can be attributed to the fact that most users are on vacation during that month. The trend resumes from august and increases gradually in the autumn of 2018, leading to the highest number of charging occasions for the whole year occurring in October and November 2018. Most charging occasions occur on weekdays.

Charging patterns for weekdays are shown in Figure 2. Normal charging at parking facilities starts most often between 5:00 and 7:00, while on-street charging sessions start most between around 8:00 and 9:00. Both parking facility and on-street charging session starts decline after around 16:00. Fast charging session most often start between 11:00 and 13:00. These patterns show that charging at parking facilities could be associated with destination charging, while the more evenly distributed patterns of on-street charging could

[1] **Normal charging:** Charging with a power output of maximum 22 kW, according to the definition in the EU Directive on the deployment of alternative fuels infrastructure. Most often this is 3,7 kW in Stockholm.

Fast charger: Charging with a power output of more than 22 kW, according to the definition in the EU Directive on the deployment of alternative fuels infrastructure. Most often this is 50 kW in Stockholm.

be associated to both destination and home charging (home charging meaning in this context on-street normal charging at the location where the car will be parked overnight). Another reason such patterns can be observed is that some parking facilities are not open during night time. Charging patterns for fast charging show that most users choose to use the infrastructure during lunch time.



	2017Q4	2018Q1	2018Q2	2018Q3	2018Q4
Fast charging, on-street	8 785	9 799	5 832	5 189	6 496
Normal charging, parking facilities	11 435	10 224	11 190	9 703	14 752
Normal charging, on-street	3 119	2 849	4 981	5 022	6 658

Figure 1: Charging sessions per type between Q4 2017 and Q4 2018 (linear adjustment for Q3 due to partial lack of data)

Charging patterns for weekdays are shown in Figure 3. The charging patterns here are a bit different than weekdays, with the peak being observed closer to noon, instead of early in the morning. On-street charging peaks in the afternoon in this case. Both figures indicate that parking facility charging is used for destination charging coinciding with activities of the users.

On weekdays the hourly pattern represents normal working hours, while in the weekends charging can be associated with free-time activities such as shopping etc., which would normally start at a later point during the day. The charger occupancy through the day is quite constant for on-street charging, in contrast to charging at parking facilities which shows a clear increase between 06:00 and 16:00, further enhancing the argument that such charging is used for destination charging and at high rates (see Figure 7).

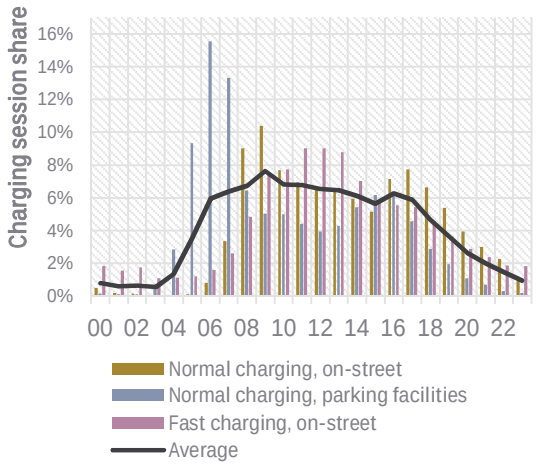


Figure 2: Charging sessions distributed per start time, weekdays 2018.

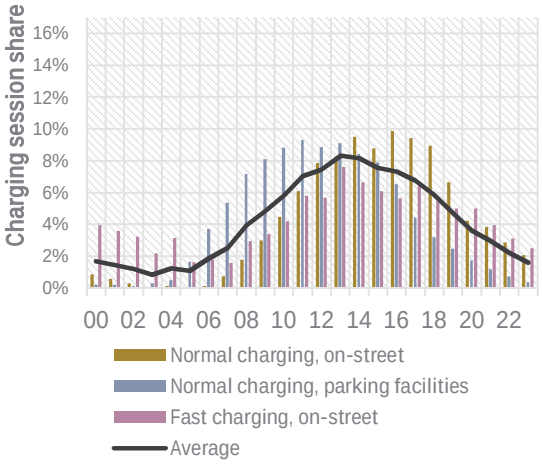


Figure 3: Charging sessions distributed per start time, weekends 2018.

The majority of charging sessions do not last more than 2 hours (42% - see Figure 4). This number should be assumed to be a result of the time limitations for public charging in the city of Stockholm. Fast charging is limited to 30 minutes, with 90% of fast charging sessions lasting less than 2 hours and 59% lasting less than 30 minutes (see Figure 5). A small increasing trend between 8 and 10 hours of charging duration for parking facilities could be attributed to destination charging during normal working hours (8 hours), which further enhances the notion that chargers at parking facilities are used for destination charging during the day.

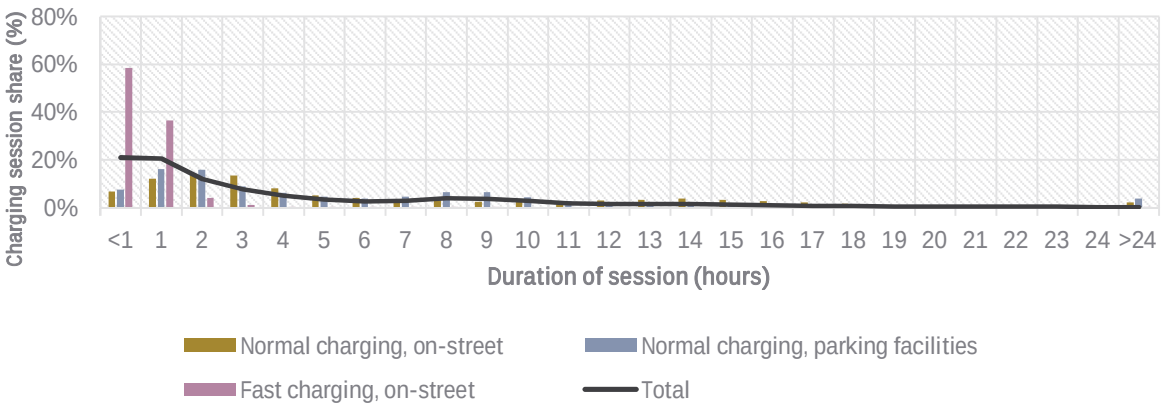


Figure 4: Charging time distribution per charging type, 2018.

Additionally, normal charging is limited to 3 hours, but 38% of charging sessions exceed this limit (see Figure 6) on weekdays and 14% of those exceed a charging time of 9 hours, which includes those that may park after 16:00 and stay over the evening but exceed the time limitation the following day. This indicated the need for stricter controls of the status of vehicles using the public charging infrastructure. This is with regards to both controlling whether the vehicle parked at the designated charging station is an electric vehicle or not, but also if the vehicle is still charging (within the time limits) or not. In 2018, 86 fines were issued for cars that stood longer on charging points and 1081 fines were issued for non-electric vehicles standing on designated charging points.

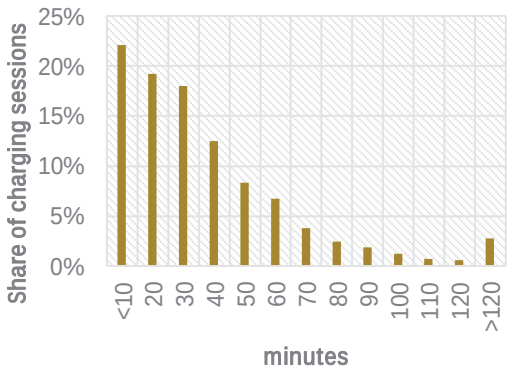


Figure 5: Fast charging session time distribution, 2018.

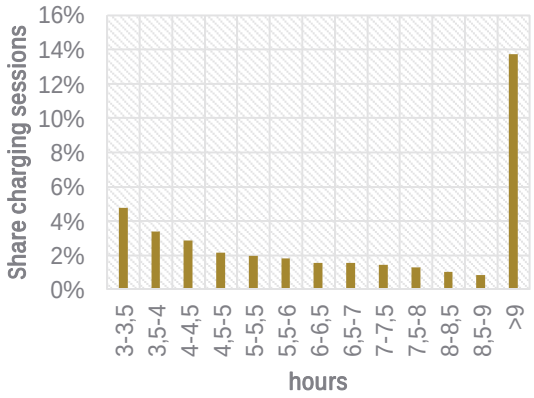


Figure 6: Normal charging sessions that exceed the 3-hour limit on weekdays, 2018.

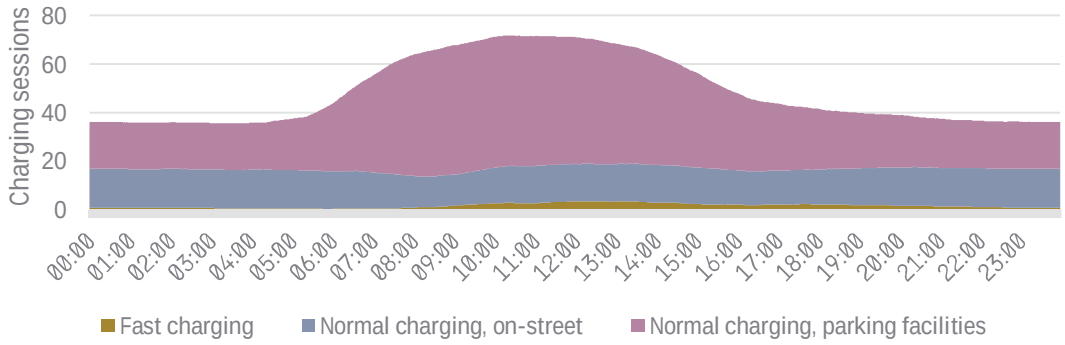


Figure 7: Charger occupancy for an average day in 2018.

Regarding the energy transferred per session, Figure 8 shows that 80% of normal charging sessions do not exceed 10 kWh of energy transferred. A large number of normal chargers offer a power at 3,7 kW, which with regards to the time limit of 3 hours leads to an energy transmission of approximately 10 kWh per session, which is in line with what is shown in Figure 8. Furthermore, 45% of fast charging sessions do not exceed 10 kWh of energy transferred. Depending on the battery capacity of the vehicle which is charging, this amount of energy could imply a smaller-scale top-up of battery capacity, and not a main charging event, i.e. the method of choice for charging the vehicle full.

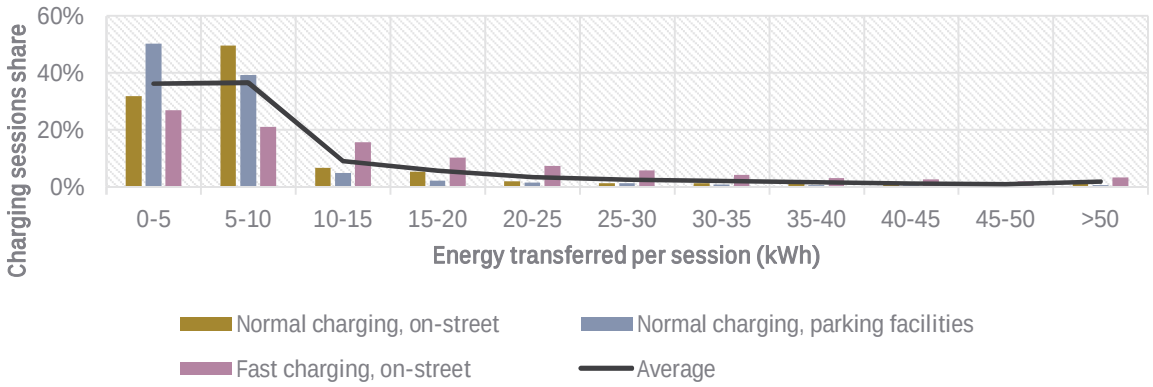


Figure 8: Charging sessions by charging type and the energy delivered per session, 2018.

3.2 Qualitative analysis

The demographics of the respondents' group are quite specific: the majority is men over 36, with the largest age group being over 55 (see Figure 9). The number of respondents that drive pure electric vehicles is slightly higher than those who drive hybrid electric vehicles (see Figure 10). The majority of BEV[2] users use both normal and fast charging, while the majority of PHEV users only use normal charging. This can be explained by the fact that much fewer PHEV[3] models give the opportunity to fast charge than BEV models.

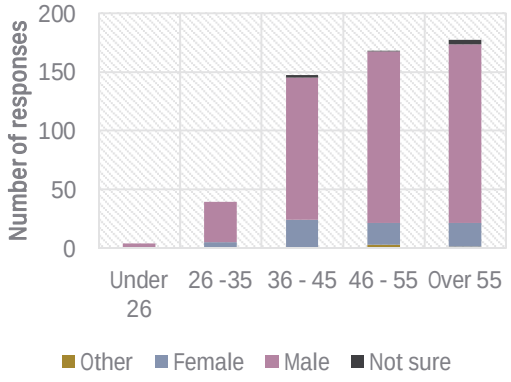


Figure 9: Age and sex distribution of survey respondents

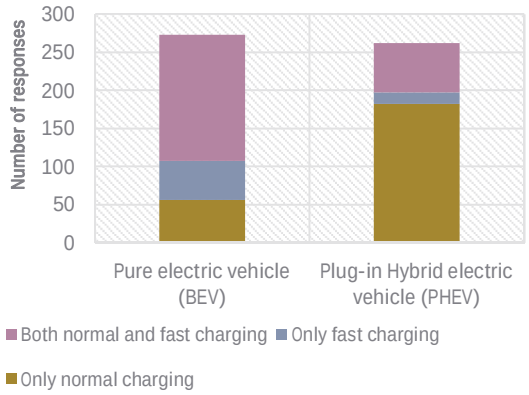


Figure 10: Preferred charging type (normal, fast, both) per electric vehicle type (BEV, PHEV)

Another interesting observation from the survey is the ownership of the vehicles. The majority of BEVs are purchased by the respondents themselves (46%), while the remaining vehicles are either leased (25%) or vehicles provided by companies to their employees (28%) (see Figure 11). A very small share (1 %) is

[2] **Battery Electric Vehicle (BEV):** Vehicle powered only by an electric motor.

[3] **(Plug-in) Hybrid Electric Vehicle Vehicle (PHEV):** Vehicle equipped with two different types of engines, of which one is an electric motor. The two power sources can drive the car separately, or they can work together. The electric motor in a plug-in hybrid is powered by a battery that is charged externally.

carpools. For PHEVs the majority is company cars (51%), while 30% is purchased by the respondents and 19% is leased. These results show that leasing is not as dominant as previously thought, particularly for BEVs, and almost 40% of the total number of respondents indicate that they have bought the vehicles themselves.

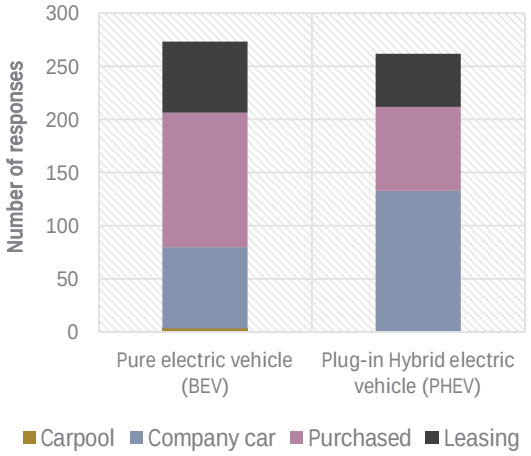


Figure 11: Ownership per vehicle type

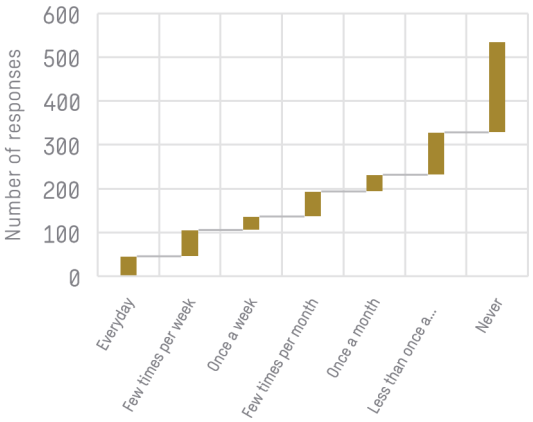


Figure 12: Frequency of range anxiety perception

Another issue worth discussing is that of range anxiety perceptions (see Figure 12), with 57% of the respondents experiencing range anxiety less than once a month or never (39% mentioning that they never experience range anxiety). On the other hand, 26% in total experience range anxiety at least once a week. It can be concluded, therefore, that the majority of respondents do not see range anxiety as an issue, but the number of the respondents that do frequently experience range anxiety is significant and should be further investigated. It should be noted that this result should not be perceived as representative for all EV users, because as previously stated, the majority of EV users do not charge public. It can be assumed that users that do not charge public could have lower rates of range anxiety, although this needs to be confirmed through further research.

The respondents were also asked to provide their opinion on the time limits for normal and fast charging on-street. The largest share (32%) thinks that the 3-hour limit for normal charging should not change (see Figure 13), while 10% thinks that the charging time should be unlimited. The results show that in general a slightly higher number of BEV users request longer time limits, except for the 4-hour limit recommendation, which is chosen by mostly PHEV users. For the case of fast charging, the majority thinks that 30 minutes are not enough (41%), but the difference to those who think the time limitation is appropriate to be 30 minutes is not very large. As previously seen, most respondents for fast charging use BEVs, and this connects to the limited number of PHEV models with possibility to fast charge. 26% of the respondents do not use fast charging.

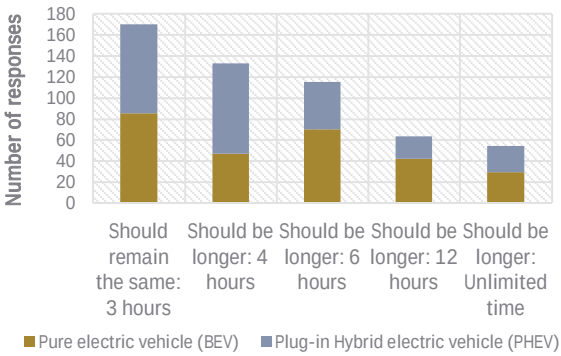


Figure 13: Survey results regarding the respondents' opinion on the normal charging time limitation (currently limited to 3 hours during daytime)

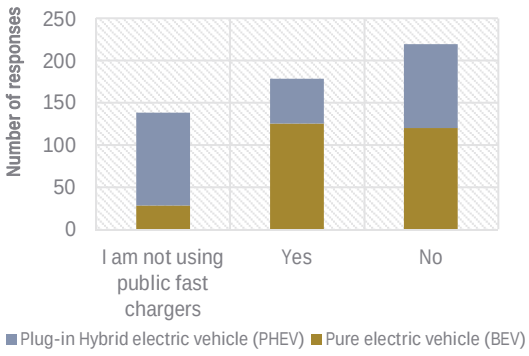


Figure 14: Survey results regarding whether the time limitation of 30 minutes for public fast charging is perceived as enough for charging

Similarly, the difference regarding which type of public charging is most important is not very large, with 52% responding that fast charging is most important (see Figure 15). The largest share of respondents (20%) indicate that they would like to see more charging stations installed at shopping centers (18%), while parking facilities (17%) and highways (13%) follow (see Figure 16). Other suggestions include fuel stations, city streets (12%) (and more specifically streets in Stockholm's inner city – 11%), and lastly transport hubs (9%).

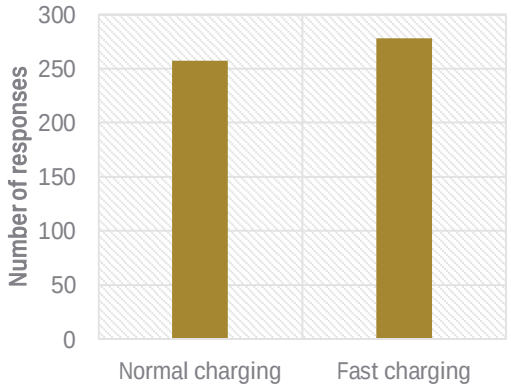


Figure 15: Survey results regarding what type of charging is perceived as most important from the respondents

Figure 16: Survey results regarding where the respondents wish to see more public fast chargers installed (showing categories with most responses)

Figure 17 visualizes the open answers of the survey respondents to the last question of the survey regarding issues that they would like to see addressed in the future (see Table *2* in the for a complete list) Most open answers refer to the issue of improved controls for vehicles parked at charged stations, i.e. whether the vehicles are electric or not, and whether the vehicles are actually charging or not. Additionally, the need to improve the systems' user-friendliness for facilitating everyday charging needs is discussed. Table 1 shows the main themes that can be identified from the answers shown in Figure 17, as well as examples of answers and recommended actions.

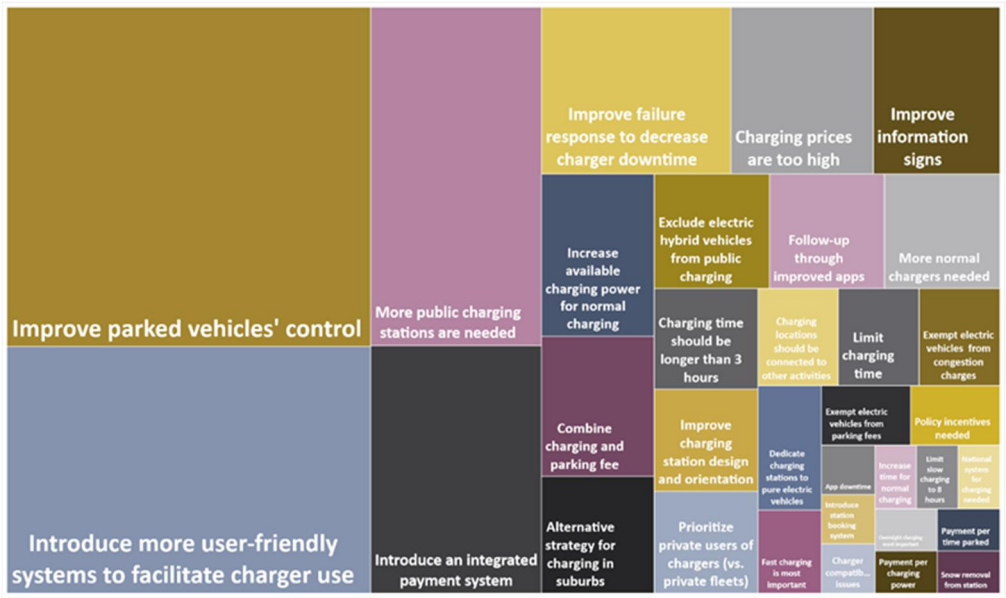


Figure 17: Overview of the thematic analysis of the respondents' answers (244 in total) to the open question "Is there anything you would like to add which has not been yet addressed in the survey?" (see full list of answers in Appendix)

Table 1: Recommended actions to address the main challenges identified from the survey

Theme	Example of survey answer	Recommendation
Better control systems for parked cars	*"It is important to control that EVs connected to the charger are actually charging. It should be a high priority to place fines on fossil fuel-driven vehicles parked at charging stations."*	Within the city's jurisdiction to increase checks throughout the day for whether the parked vehicles are electric, and the time limitations are followed. Outside the city's jurisdiction to control and fine an electric car parked at the charging station but not charging. Dialogue regarding the regulation should continue nationally.
Improve information (charger types, signs, payment)	*"High engagement is required for keeping up with the various charger types, payment systems and different plugs used for charging."*	City of Stockholm coordinates information campaigns. A strategy for simplifying sign systems should be developed and applied. The Swedish Transport Agency (Transportstyrelsen) is responsible for these signs. Dialogue between private actors with coordination from the City of Stockholm could help identify additional improvements needed.
Increase number of public charging stations	*"Install more chargers so that more can purchase EVs."*	Identify and allocate more streets where chargers can be installed and increase chargers at parking facilities. Prioritize locations that can be connected to other activities, such as shopping centers.
Integrate payment systems	*"There should be an integrated payment system and a common charging station database."*	Information campaigns on existing solutions in order to increase user awareness.
Charger maintenance and monitoring	*"Since one plans the day with regards to the charging needs, it is a big discomfort if the charger does not work – bigger than the case of a fuel station not working. Improved quality, monitoring, and operation is needed, as well as better service."*	Real-time notifications to user via app on when a charger is not working. Dialogue with stakeholders on strategies for decreasing downtime.

3.3 Information campaigns

The City of Stockholm adopts a holistic approach when it comes to strategies for further expanding charging infrastructure. Understanding the importance and promoting establishment of public infrastructure is one part of this approach. The other part is the facilitation and support for establishing charging infrastructure at private properties. This gives the opportunity to spread the charging loads in various locations and prioritizing home charging at night, avoiding power peaks in the inner city where the grid is most loaded. Additionally, the presence of such infrastructure at home decreases the need for an unnecessary high number of public charging infrastructure for fulfilling basic charging needs, therefore, making public charging a "top-up" option, which essentially implies that less energy should be transferred per session as it is not the primary charging choice for users. This leads to further reduction in power peaks, as well as shorter parking times for the charging cars.

In order to facilitate the installation of chargers at residential properties, the City of Stockholm has an ongoing information campaign, which includes a short information film with know-how, experiences and practical

examples of how such chargers can be installed. The aim is to provide interested citizens and housing associations with facts and practical advice in order to introduce charging facilities at home, using the financing opportunities provided by the government. Throughout 2017 and 2018 twenty seminars with 1 800 participants were held. The interest has been very large and over 4 000 private charging units have already been installed as a direct result of the campaign so far. The replicability potential of this strategy is high, as it is an easy-to-implement, yet meaningful, option for a large number of other cities around the world that contemplate strategic actions within the field of charging infrastructure. Four city-regions in Sweden have already implemented the campaign concept inspired by Stockholm's example.

4 Conclusions and policy implications

The quantitative analysis of the data collected from Stockholm's public charging infrastructure shows that use has in general increased in comparison to 2017, in line with the increase in number of EVs in Stockholm region. A difference compared to 2017 is that the share of fast charging in the total number of charging sessions has decreased, while shares for normal charging on-street and at parking facilities has increased. Fast charging might have decreased due to one of the actors introducing fees for fast charging in April 2018.The analysis of the distribution of charging events throughout the day shows that destination charging during working hours is the most popular option, while fast charging peaks at around noon and in coincidence with lunch breaks.

In total, most charging sessions do not last more than 2 hours. Despite though the time limits set for on-street charging (3 hours for normal charging and 30 minutes for fast charging), 38% of normal charging sessions and 41% of fast charging session still exceed the limits on weekdays. This indicates the need for stricter controls of the vehicles using the public charging infrastructure. Another alternative would be to increase the charging power available per charger, however, the analysis of the energy transferred per session indicates that this should not be a priority. The majority of charging sessions transfer on average up to 10 kWh, which would require approximately 3 hours with the usual charging power of 3,7kW. A potential alternative to this could be the introduction of more chargers at the (already popular) parking facilities where the infrastructure can be used for destination charging. Nevertheless, the energy transfer numbers mentioned above should be further investigated.

The above can also be confirmed from the large-scale survey (535 respondents) performed. The respondents seem to prioritize the improvement of vehicle control at charging stations, referring to both control of whether the vehicle is electric or not as well as whether this vehicle is charging or not. Additionally, improving the user experience and user friendliness of the systems accompanying the infrastructure itself is necessary. Many of the respondents indicate that it is difficult to keep up with different payment systems and would like to have smarter information systems for finding available chargers in the city. Sign systems could also be improved according to the survey answers, and this is a measure that the Swedish Transport Agency is responsible for administering. The survey indicates that the main issues that should be addressed from the user's perspective can be aggregated as follows: (i) improving control, information, and payment systems; (ii) increase the number of public charging stations; (iii) improve maintenance and monitoring of charging stations.

The City of Stockholm has succeeded in designing a strategy that combines the exploitation of the potential for public charging in synergy with the promotion of home charging through information campaigns which are discussed in this paper. The City of Stockholm can with regards to the above continue with the existing information campaigns, as well as initiate a wider stakeholder dialogue for improving and setting minimum requirements for the services. Allocating more spaces where infrastructure can be established should be made with regards to where the chargers are most needed. According to the survey, shopping centers come first, followed by parking facilities. Creating a wider network of chargers at these locations can be beneficial for decreasing traffic in the inner city, as users can choose to leave their vehicle to charge while using other transport means to move in the inner city.

Acknowledgments

The authors thank the 535 respondents of the survey for their engagement and insightful answers. Additionally, we would like to thank EON, Fortum, and Vattenfall for providing data for the quantitative analysis of charging behaviour in Stockholm as well as spreading information regarding the survey. We also would like to thank Stockholm Parkering for the data concerning the normal chargers off-street. The work with the charging map, the information campaign and the compiling of this data has been possible with the support of CIVITAS Eccentric, which received funding from the European Union´s Horizon 2020 research and innovation programme under grant agreement No 690699.

References

[1] M. Spöttle *et al.*, "Research for TRAN Committee – Charging infrastructure for electric road vehicles," Brussels, 2018.
[2] S. Hardman *et al.*, "A review of consumer preferences of and interactions with electric vehicle charging infrastructure," *Transp. Res. Part D Transp. Environ.*, vol. 62, pp. 508–523, 2018.
[3] R. Granström, K. Hillman, A. Nordlund, and K. Zampoukos, "Användarnas beteende och syn på laddbara bilar," Umeå, 2017.
[4] I. Vassileva and J. Campillo, "Adoption barriers for electric vehicles: Experiences from early adopters in Sweden," *Energy*, vol. 120, pp. 632–641, Feb. 2017.
[5] D. Hall and N. Lutsey, "Emerging best practices for electric vehicle charging infrastructure," Washington D.C., 2017.
[6] A. Majchrzak, *Methods for Policy Research*. Thousand Oaks: SAGE Publications Ltd., 1984.
[7] E. Sunnerstedt, H. Hedenquist, *På väg mot fler elbilar i Sverige. Slutrapport från Elbilsupphandlingen*. 2015.
[8] Trivector Traffic, *Analysis of Stockholm´s publicly acessible charging infratructure for elelctric cars*. April 2018

Authors

Eva Sunnerstedt works for the Environment and Health Administration within the City of Stockholm, is appointed as head of unit for the clean vehicles and fuels program within the city. Eva is currently in charge of the City of Stockholms EV strategy including the establishing of on-street charging. Eva has been involved in many public procurements of clean vehicles and fuels and she managed the nationwide procurement of electric cars and vans in Sweden a few years ago. Eva is a Civil Engineer from the Royal Institute of Technology in Stockholm.

Dr. Maria Xylia is a senior energy systems consultant at Sweco with a specialization in transport electrification. Maria has a PhD in energy technology from KTH Royal Institute of Technology. Her research addressed optimal placement of charging infrastructure for electric buses. Maria has investigated the techno-economic, environmental, and social effects of the transition to sustainable transport systems in a variety of contexts in collaboration with public and private actors.

Anton Sjögren is an energy systems consultant at Sweco with experience in transport electrification. Anton has a Master of Sciences in energy systems from Linköping university and École Polytechnique Fédérale de Lausanne (EPFL). Anton has worked with electrification in public transport and energy supply to charging infrastructure in areas with limited available electrical capacity, as well as the integration between energy generation, storage solutions, city blocks and the transportation sector.

Appendix

Table 2: Complete list of open survey responses regarding what should be improved with regards to public charging

Survey answer	Number of responses
Improve parked vehicles' control	47
Introduce more user-friendly systems to facilitate charger use	34
More public charging stations are needed	22
Introduce an integrated payment system	16
Improve failure response to decrease charger downtime	12
Charging prices are too high	9
Improve information signs	8
Increase available charging power for normal charging	7
Combine charging and parking fee	6
Alternative strategy for charging in suburbs	5
Exclude electric hybrid vehicles from public charging	5
Charging time should be longer than 3 hours	4
Improve charging station design and orientation	4
Prioritize private users of chargers (vs. private fleets)	4
Follow-up through improved apps	5
Limit charging time	3
Charging locations should be connected to other activities	3
More normal chargers needed	5
Exempt electric vehicles from congestion charges	3
Dedicate charging stations to pure electric vehicles	3
Fast charging is most important	2
Exempt electric vehicles from parking fees	2
Policy incentives needed	2
App downtime	1
Introduce station booking system	1
Charger compatibility issues	1
Increase time for normal charging	1
Limit normal charging to 8 hours	1
National system for charging needed	1
Overnight charging most important	1
Payment per charging power	1
Payment per time parked	1
Snow removal from station	1