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Evaluation of public charging in Stockholm.

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Executive Summary

The City of Stockholm is working to improve charging options for chargeable vehicles in the city. In cooperation with various charging infrastructure operators, an increasing number of charging points have been installed in the municipality in recent years. The City of Stockholm annually compiles data from the different public charging points in Stockholm; to date, data is available for the years 2017 to 2023. The aim is to get an overall picture of how public charging points have been used, information that is valuable for the work to expand the charging infrastructure in Stockholm.

The majority of all charging sessions for all charging categories take place during the day on weekdays. Normal charging in car parks off-street continues to be important to charge, while the car owner is at work, with an occupancy peak in the middle of the day. The usage of normal charging on-street follows the same pattern as in previous years, where more people use the charging infrastructure from the afternoon to the night, which indicates home charging. On-street fast charging shows increasing occupancy during the night and early morning on weekends and around the clock on weekdays. The occupancy peak is still in the middle of the day, indicating destination charging both weekdays and weekends.

The number of registered charging sessions at the public charging infrastructure has increased between 2022 and 2023 (+45%) at a faster rate than the number of chargeable vehicles (+28%) during the same time period. The statistics indicate that the public charging infrastructure remains important and attractive for a large proportion of chargeable vehicle owners in Stockholm. This is in line with previous years' results from statistics and surveys.

All categories, except for fast charging, have declined in the number of charging sessions per charging point compared to the previous year. This indicates that the usage has not increased at the same rate as the expansion. The rapid increase in charging points is probably the biggest reason why occupancy has dropped from the previous year.

In 2023, the logged energy transfer from public charging points in Stockholm was approximately 12 GWh, which is a 61 percent increase from 2022.

Cities play an important role in the strategic planning work to enable public charging. When municipalities have strategies and methods in place to promote charging infrastructure they can act as an enabler, this is shown by the actions taken by the City of Stockholm.

1 Combat climate change and achieve better air quality

Emissions from road traffic cause negative health effects to people living and visiting areas with poor air quality. Increased sickness, lung disease, and heart issues are some effects that are linked to poor air quality. The City of Stockholm has been working for better air quality for several decades. The need to combat climate change is also of great importance for the City. Electrification of the transport sector and making it easy to charge electric vehicles has been a focus since 2011 when the first Electric Vehicle Strategy was implemented.

The number of rechargeable cars (BEV and PHEV) in the City of Stockholm is almost 125,000 which is about 30 % of the total car fleet in the city. That is half of the electric vehicle fleet in the Stockholm County and a fifth of the entire electric vehicle fleet in the country of Sweden. The number of rechargeable vehicles in the City of Stockholm increased by approximately 28 percent from 2022 to 2023.

Gathering data from public on- and off-street chargers in Stockholm

The City of Stockholm has a business model for on street charging. Private operators may sign access right agreements with the City to provide public charging on street. A map with available locations is presented on-line and applications can be submitted at all times with a come first, served first system. The City is responsible for putting up street signs, cleaning and sweeping the area and for parking control. All other expenses for installation and equipment etc are covered by the operators. The parking fee goes to the city and the cost for charging goes to the operator. The operators are responsible for keeping the equipment in operation for at least 95 % of the time, they also need to compile with the City´s specified colour scheme and certain measurements with the regard of the size of the chargers. The access right agreements are valid for 10 years and can be prolonged for 5 years at the time. The business model have been in place since 2014.

The public normal and fast charging stations on-street that are available in Stockholm and included in the analysis are operated by E.ON, Recharge, Mer, Vattenfall, Milepost, VCG, Qwello, JB Charge and Chargey. Also normal charging off-street in parking garages in Stockholm Parkering AB's facilities are included in this evaluation. Stockholm Parkering AB is a parking company fully owned by the City of Stockholm; the company provides a lot of public parking and charging off-street in Stockholm. Stockholm Parkering AB is the operator that offers the most public charging points and has the most annually registered charging sessions.

The data available for analysis has increased a lot since 2018 because the number of public charging stations and the number of vehicles needing charging has increased as well. The analysis for 2023 is based on just over 760,000 charging sessions (424,000 sessions in 2022) that took place during the period 1 January – 31 December 2023, taken from a total of almost 7,000 charging points (appr. 4,000 in 2022). The 7 000 charging points represent 20 percent of all the public charging points in Sweden at the time. See figure 1 & 2.

	Normal charging, street	**Normal charging, parking garage**	**Fast charging, street**	**Total**
2018	84	279	26	389
2019	131	507	35	673
2020	169	864	44	1077
2021	190	1761	47	1998
2022	590	3489	56	4135
2023	1160	5746	58	6964

Figure 1: Number of charging units that provided data for this study between 2018 -2023

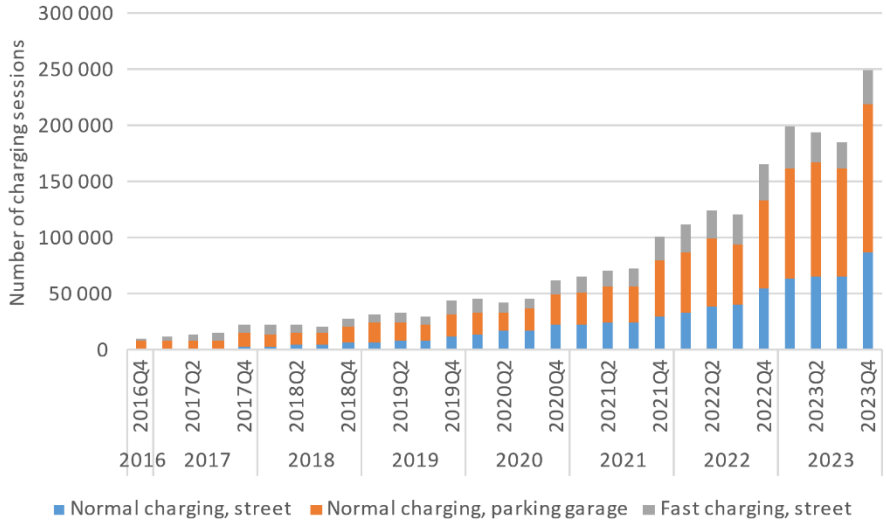

Figure 1: Number of charging sessions per charging category from Q4 2016 to Q4

2 Public off-street charging is more used than public on street charging

Of the total number of charging sessions registered in 2023, off-street normal charging in parking garage accounts for 48 percent of the sessions, normal charging on-street for 37 percent and fast charging on-street for 15 percent. The usage pattern between weekdays and weekends varies, both in start time and in the lengths of the session (5.2 hours on average for normal on-street charging, 10.2 hours for normal charging in a parking garage and 0.6 hours for fast charging on-street). The majority of all charging sessions for all charging categories take place during the day on weekdays.

A majority of the charging sessions take place during the day

The majority of all charging sessions for all charging categories take place during the day on weekdays (see figure 3). That a majority of the charging sessions take place during the day and within the framework of established time limitations for parking.

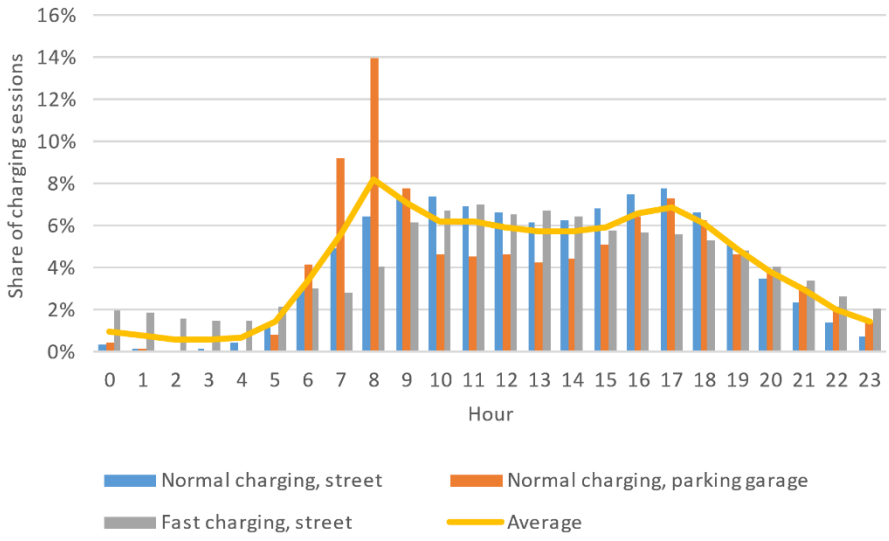

Figure 3: Share of charging sessions in 2023 that started at a specific time of day on weekdays for each charging category.

Normal charging in car parks off-street continues to be an important and in use while the car owner is at work, with an occupancy peak in the middle of the day. The general usages of the chargers has rebounded after the dip in 2022 and is now in line with 2021 levels.

The usage of normal charging on-street follows the same pattern as in previous years, where more people use the charging infrastructure from the afternoon to the night, which indicates home charging. However, a trend seen is that the occupancy is evened out over the day compared to previous years. The average occupancy has also decreased. This may be due to several reasons, one of which may be that a greater number of those who charge at home might have gained access to other options for home charging, such as apartment buildings in the city that have installed their own, private, charging facilities. However, the increase in charging stations is probably the biggest reason why occupancy on weekdays has fallen from the previous year.

On-street fast charging shows increasing occupancy between 2022 and 2023, particularly during the night and early morning on weekends and around the clock on weekdays. The occupancy peak is still in the middle of the day, indicating destination charging both weekdays and weekends (see figure 3 and 4).

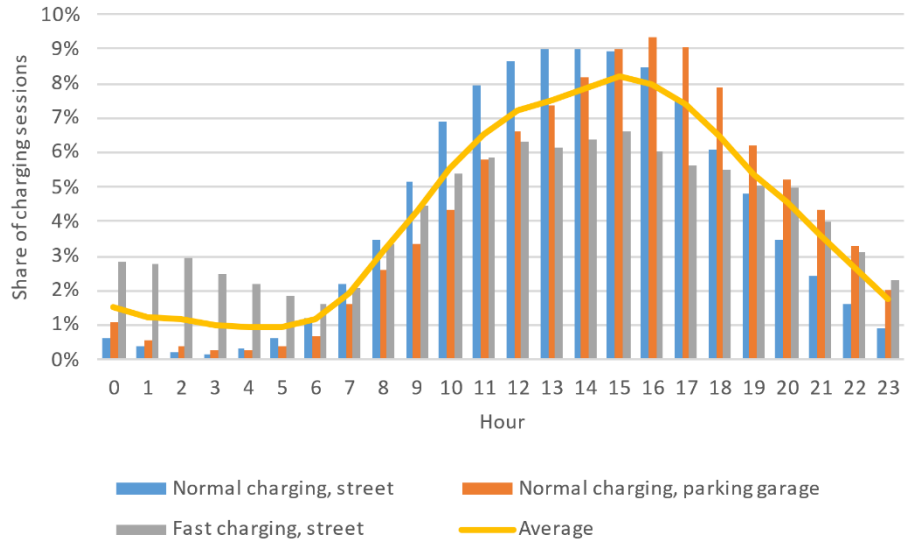

Figure 4: Share of charging sessions in 2023 that started at a specific time of day on weekends for each charging category.

As in previous years, the use of public charging stations does not seem to have any geographical connection to whether it is located in the inner city, as Stockholm Parkering's facilities both in and outside of central Stockholm are used frequently. Instead, it is likely to be linked to the activities that are nearby, such as home, work or places of trade. During the summer the number of charging sessions are reduced. This has been the case for several years.

Charging time

The fast charging points have continued to have the highest average number of charging sessions per day, while also transferring the largest amount of energy per charging session.

A majority of the charging sessions are under 3 hours. This is due to the fact that almost all normal charging on street is restricted to 3 hours in between 7 in the morning and 19 in the evening (on exception is Vallhallavägen where 24 hours parking/charging is allowed). The longest charging times are in the parking garages where the average charging time varies from 2 hours to 17 hours depending on the location.

The average normal charging time is 5 hours on street. The average normal charging time in the parking garages is 10 hours and 45 minutes. The fact that EVs on street are connected for a shorter period of time is due to the 3 hour parking restrictions during daytime.

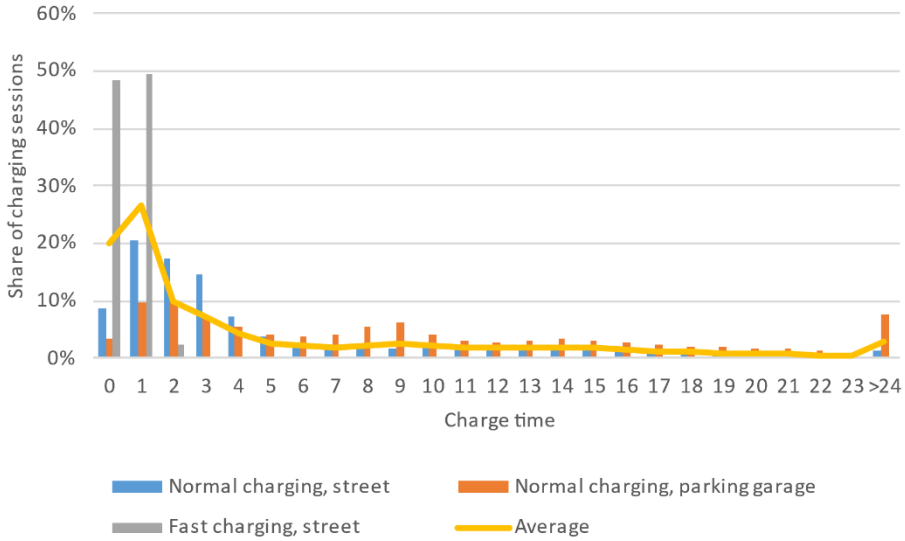

Figure 5: Share of charging sessions distributed by the duration of the charging session in hours for each charging category, on both weekdays and weekends. Note that the data shows the time from when the charging plug is connected until it is unplugged.

Occupancy

During the year 2023, occupancy at all charging points during an average day was a maximum of around 725 vehicles (which corresponds to 10 percent of the number of charging points) between 10-12, see figure 6. Around 600 vehicles were charging at the same time at all times. In December 2023, 20 percent of the chargers where used at the same time. The normal chargers on street had an average of 0,6 charging sessions per day and the most popular spots had 2,3 charging sessions per day. The most popular fast charger on street had 14,5 charging sessions per day.

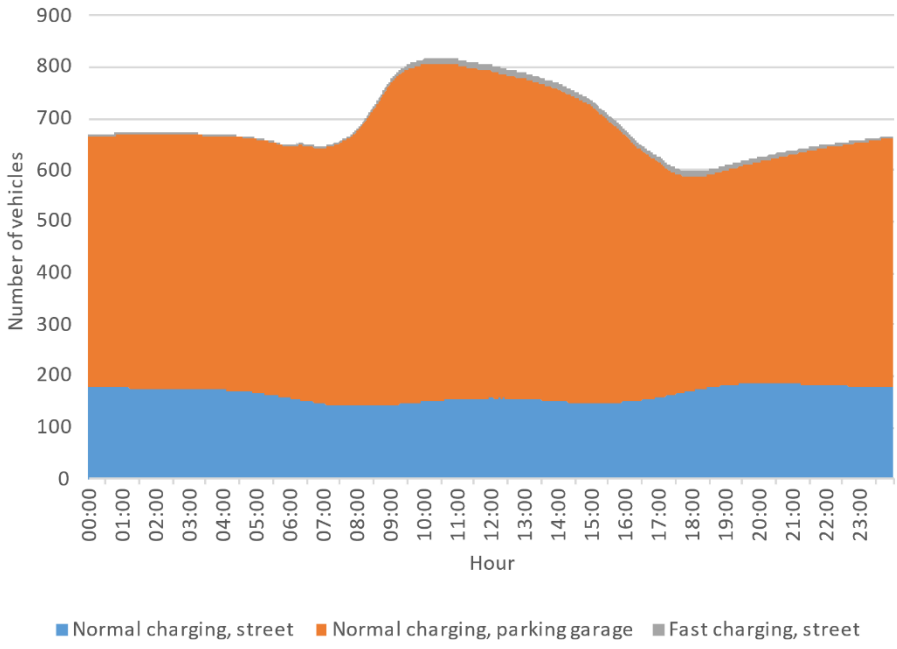

Figure 2: Number of electric vehicles simultaneously connected to charging points distributed by the different charging categories during an average day. The resolution is per minute.

During the summer of 2022 the occupancy level of the on-street charging units were investigated through visual inspections. This showed that the charging places were occupied around 50 percent of the time, since EVs are allowed to park without charging (se figure 7). In the inner city an occupancy rate of 85 percent for the on street parking is desired (over 85 % causes extra search traffic which should be avoided)

Summer 2022	**Normal charging, street**	**Fast charging, street**	**Total**
Parked cars	56 %	31 %	53%
Parked cars that were also charging	42 %	22 %	39 %

Figure 7: Occupancy level for on street charging in the summer of 2022 in Stockholm

Energy transfer has increased during recent years

In 2023, the logged energy transfer from public charging points in Stockholm was approximately 12,100,000 kWh (12 GWh), which corresponds to a mileage for an electric car of approximately 48,900,000 km or approximately 1,220 revolutions around Earth. It is also an increase of 61 percent in the amount of energy that was transferred at public charging points compared to the year 2022, when the amount of energy transferred was 7.5 GWh. Transferred amount of energy distributed quarterly per year can be seen in Figure 8 below. Note that the total energy transfer increased significantly during the last quarter of the year, as in previous years. This can be due to a variety of factors, such as an increase in the size of the electric car fleet, and more completed charging sessions at the same time as battery capacity increases in the cars. The increase should also be due to the large amount public charging points added during the year. Also driving behavior and a lower temperature can affect this peak of transmitted energy during the winter months.

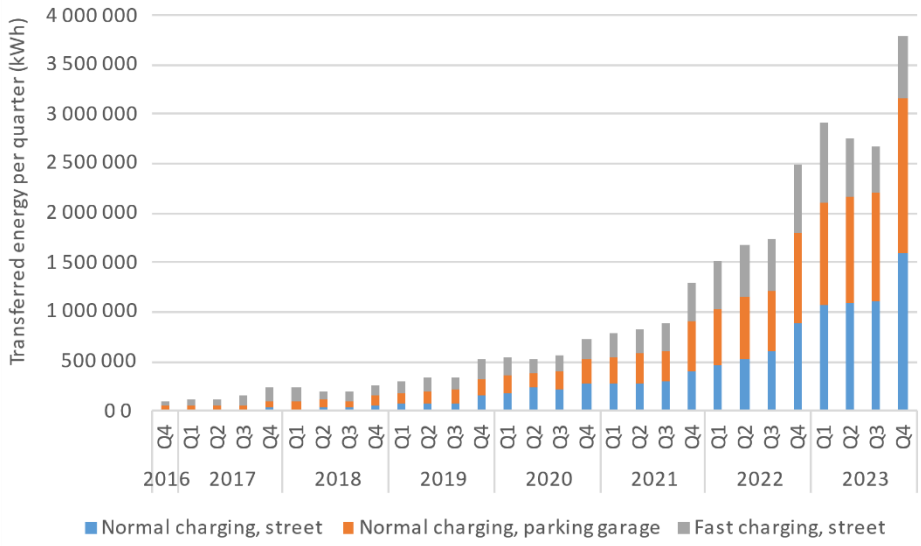

Figure 3: Total energy transfer from Stockholm's public charging stations per quarter.

Most energy is transferred in the morning and in the evening. During the weekdays two distinct peaks are shown in figure 9 when demands are high. During the weekend the peak is in the late afternoon and not as high as during the weekdays. Over half of the normal charging sessions on street have less than 10 kWh transmitted energy. The average energy transition is 15,9 kWh in the parking garages and 17,2 on street. The amount of energy transferred is slightly higher on street level, despite a shorter connection time. This may be due in part to a higher maximum charging speed for the charging points on street level so that a larger amount of energy can be transferred even for the shorter charging sessions. Another reason could be a lower battery level for the vehicles that connect.

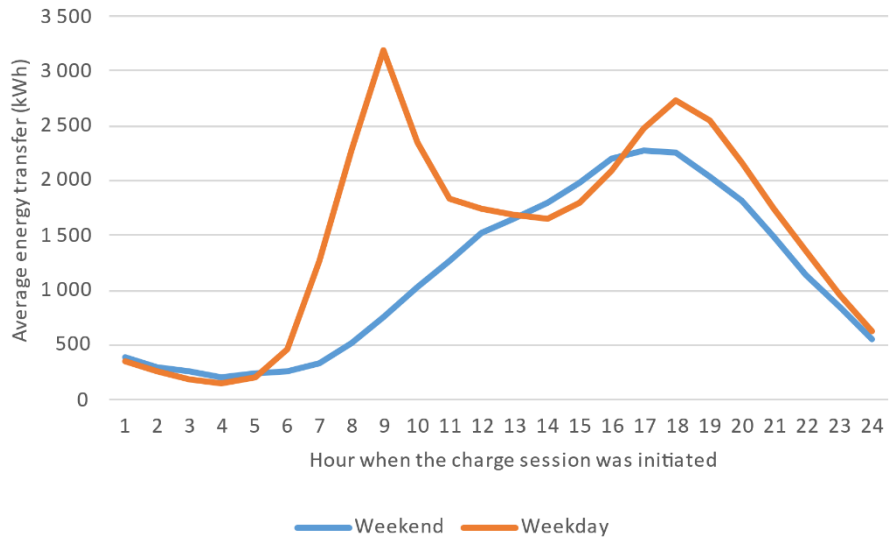

Figure 4: Average energy transfer over a day from all charging types at Stockholm's public charging stations, distributed by the time of charging initiation on both weekdays and weekends during 2023.

Discussion

Different types of charging infrastructure serve different functions and needs. The function of charging infrastructure is defined by its charging characteristics, accessibility and geographic location. Several different types of charging infrastructure can provide public home charging and meet residents' everyday charging needs, especially in apartment buildings, that do not have access to parking or charging space within its premises. There is an entire ecosystem of actors in the value chain for charging infrastructure. In order to enable public home charging, charging operators, municipalities and electricity grid companies have a particularly important role.

Data on the utilization of public charging stations in Stockholm shows user patterns that indicate that they are currently used by many for public home charging. User patterns can be similar to how non-public charging points are used, with long connection times during evenings and nights, but with the difference that the connection time is somewhat shorter. Compared to non-public charging in Norway, Stockholm's data shows a more varied usage pattern, where public chargers fulfil several functions, from public home charging to destination and workplace charging.

Cities play an important role in the strategic planning work to enable public charging. When municipalities have strategies and methods in place to promote charging infrastructure they can act as an enabler, while in cases where it does not exist, it risks to delay and increase the cost of charging infrastructure.

3 References

A full report in Swedish is available here: publ-laddinfr-23.pdf (stockholm.se)

Utvärdering av publik laddning för elbilar I Stockholms stad under 2022, April 2023.

Publik hemmaladdning ger el för ännu fler, Januari 2025, Power Circle

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5 Presenter Biography

Eva Sunnerstedt is Head of the Clean Vehicles and Sustainable Transport unit within the City of Stockholm's Environment and Health Administration. Eva Sunnerstedt has extensive knowledge within the fields of clean vehicles and fuels and has worked with electric vehicles and charging infrastructure since the late 1990s. The Stockholm EV Strategy, a nationwide procurement of electric cars and vans, and the business model for on-street charging in Stockholm are examples of her previous responsibilities. Eva initiated and is responsible for the evaluation of public charging infrastructure in Stockholm and are part of the team responsible for introducing the Zero Emission Zone in down town Stockholm. Eva has presented at many international conferences including a few EVS events. Education: Civil Engineer from the Royal Institute of Technology (KTH), Stockholm, Sweden.

Erik von Essen from Sweco Sverige AB is working as an energy system analyst at the group Advisory Services within Sweco where he has been involved in the fields of energy, sustainability, and e-mobility for almost 3 years. Before Sweco he held a position at Scania where he was overseeing the charging infrastructure development for electric buses and trucks. Erik's experiences include various aspects of electric vehicle charging projects where he has assisted municipalities, energy companies, and ports in developing strategies for charging of both passenger cars and heavy transport vehicles. His work has helped clients with decisions regarding the placement, power, and number of chargers as well as business models and costs related to the investments and operation of charging stations.