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Evaluation of home charging in Stockholm, Sweden

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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 and therefore has good knowledge of the usage. At the end of 2024, the City was able to access data from five operators providing home and office charging encompassing over 4,000 charging points and over 390,000 charging sessions during 2023 and 2024. This data has been compiled and is presented in this paper.

The typical non-public charging session in Stockholm during 2023 and 2024 provides insights as to the use of charging infrastructure and its utilization. Since the majority of parking spaces fitted with chargers in this analysis are rented by one person, the analysis primarily describes how the charging infrastructure is used, not the utilization of the parking space. The parking space is most often used by the tenant for parking, even when the vehicle is not connected to charger There is no information on the occupancy rate of the parking space. The statistics show an average for started charging sessions for all categories of 0.2 per charging point and day, meaning that on average one charge is started every five days. The in-depth analysis from Stockholm Parkering AB in 2024 contains statistics that show a more than twice as high utilization rate with 0.5 charging sessions/day.

The number of charging sessions per charging point has been stable for most location categories over the two years, but slightly less during the summer months. Variations in charging behavior depending on the day of the week and time of day indicate that most charging sessions occur on weekdays, with a peak on Wednesdays for offices.

In 2023, the total energy transfer for the charging sessions amounted to approx. 1.7 GWh, excluding two actors with incomplete data for 2023 (3 GWh including all actors). The majority of the charging sessions transfer less than 10 kWh, which indicates shorter trips and that charging occurs relatively frequently.

The non-public charging infrastructure in Stockholm contributes to reducing emissions and also plays an important role in meeting the increasing demand for charging electric cars. The insights gained about usage patterns, occupancy and energy transfer provide a basis for the City's continued work to develop an efficient and accessible charging infrastructure.

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 adopted.

The number of rechargeable cars (BEV and PHEV) in the City of Stockholm is over 140,000 (Marsh 2024) which is about 37 % of the total car fleet in the city. That is a fifth of the entire electric vehicle fleet in the country of Sweden. The number of rechargeable vehicles in the City increased by approximately 30 percent from 2022 to 2024.

The City of Stockholm has over 33 000 non-public parking places off street. A majority of these are owned by the City's three housing companies. The goal is to offer charging possibilities on all of these parking spaces in the inner city and 80 percent of them in the suburbs by 2030. The work is well under way and approximately 25 percent of parking spaces have charging points. Insights from data compilations such as the one described in this report gives insights to further development.

1.1 Gathering data from home chargers in Stockholm

During the period 2023 to August 2024, data on non-public charging was collected from approximately 966,000 non-public charging sessions. The data is from five different operators. To protect the operators' business operations, the operators have asked to be kept anonymous. After cleaning the data from error records, duplicates and insufficient location information, just over 390,000 charging sessions remained and are used for the quantitative analysis. Among these sessions, 233,000 are from 2023 and 157,000 from 2024. In total, data has been retrieved for 4,189 charging points, which have been categorized into five main groups: private apartment housing associations, garages, offices, private multi-owner housing associations, and a category for "uncategorized" where information about location is missing. See figure 1. All charging points have a charging power of less than 22kW and are AC models.

Categories for location of charging points	**Number of charging points**
Apartment housing associations (BRF: Bostadsrätts-föreningar)	761
Garages	981
Offices	106
Multi-owner housing associations (Samfälligheter)	57
Uncategorized	2 284
Total	4 189

Figure 1) The number of charging points that have provided data for this report divided into five different categories. During the analyzed time period of 2023 up to and including August 2024, charging points have been added, the table shows the total number of unique charging points during the period.

Figure 2 presents the location of the studied charging stations in Stockholm. Each charging station includes several charging points. Ring-shaped zones have been used to study differences in charging behaviour depending on the charging stations' distance from the center. The outer zone has a radius of 25 km, the charging stations outside this circle have not been considered in this study.

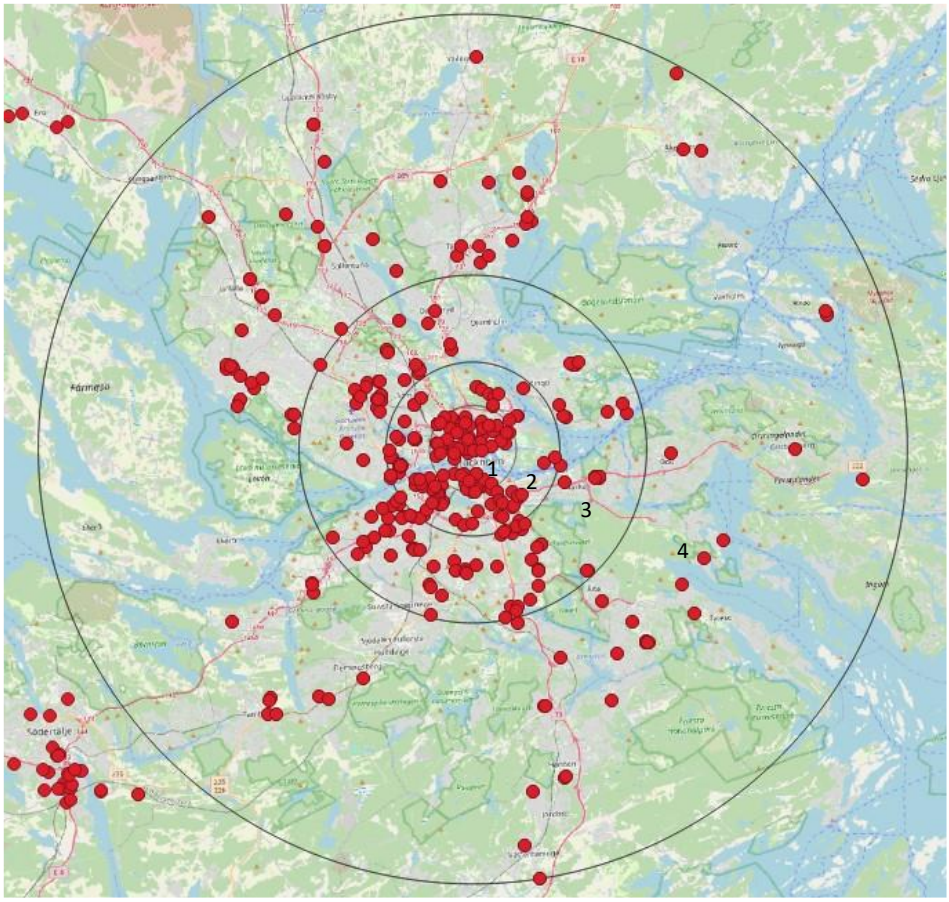

Figure 2) Charging stations and zoning for the studied non-public charging in the City of Stockholm and surrounding area.

Included in the analysis is also non-public charging provided by Stockholm Parkering AB (a parking company owned by the City of Stockholm). They provided non-public charging in 56 different garages throughout the city. 67 percent of the analyzed charging sessions took place within the municipality of Stockholm, and 33 percent outside. The distribution between the zones 1 to 4 is relatively even, but there is a certain predominance in Zone 1 (32%). The smallest proportion is in Zone 4 (18%).

1.2 Business models and price flexibility

The private charging operators that have provided data to this report do not have direct contact with end customers for electric vehicle charging, but rather collaborate primarily with property owners, private apartment housing associations and multi-owner housing associations. However, Stockholm Parkering AB has direct contact with most of the end customers. Common revenue models include commissions based on either charging time or transferred energy, as well as monthly fees for associated services and applications. A unique model is applied by one operator where the association is not financially burdened and the entire kWh price goes back to the association without commission. Prices for end users vary between 2–4 SEK/kWh depending on the operator and context. Generally, the price is higher for charging at offices compared to homes. Some players charge fixed monthly fees, such as 600 SEK/month for charging (Stockholm Parkering AB), in addition to other subscription costs. Some operators also offer complete solutions with sales of chargers, installation services and operator services, including customer service and payment flows.

Price flexibility is a key aspect, several operators offer support for dynamic electricity prices linked to the spot market, provided that the property owners' systems allow this. This allows property owners and end customers to charge electric cars at lower prices during off-peak hours, such as at night when demand is lower. At the same time, there are operators that apply fixed price levels, regardless of the time of day, which limits the possibilities for price optimization. Load management is another key function offered by most operators and is adapted to the technical conditions and needs of the facility.

2 Results from home charging in Stockholm in 2023 and 2024

2.1 The typical non-public charging session in Stockholm

Figure 3 below provides an overview of the average key figures for non-public charging in Stockholm, based on the collected data, which includes all location categories and the entire time period.

	Result
Average number of charging sessions per day	0.2 – 0.5
Average charging time per charging session	10.5 h/day
Average charger occupancy	11 %
Average amount of energy transferred per charging session	13.3 kWh

Figure 3) The typical non-public charging session in Stockholm in this study

2.2 The number of charging sessions increase by time in 2023

The highest number of charging sessions was in December 2023, when a total of 14,300 charging sessions were measured. At the same time, the number of charging points also increased during this period, which can therefore explain the increased number of charging sessions. The number of charging sessions was lowest in July 2023, probably due to the summer holiday. At the same time, the number of charging points decreased slightly during July, which may be due to some chargers not being used and therefore no data was reported for them at all during that time.

2.3 Highest number of charging sessions per charging point in housing estates and garages

Figure 4 shows the number of charging sessions per charging point and month, divided by location category for the year 2023. For all location categories, in addition to offices, a similar trend is noted, with a higher number of charging sessions per charging point at the beginning and end of the year, and a dip during the summer months (June, July, August, September).

Garages had the most charging sessions per charging point, which varied between approximately 10 - 14. The number of charging sessions per charging point fluctuated during the year, with a slightly lower number in July and the highest in November. Private apartment housing associations followed a similar trend but with a slightly lower number of charging sessions per charging point, between 8 - 10. For multi-owner housing associations, the number of charging sessions per charging point increased in October, November and December. (Due to incomplete data, some operators have been excluded from the analysis in figure 4. Additionally, office data has only been included for November and December. Note that the uncategorized charging sessions have not been included in the charging session analyses).

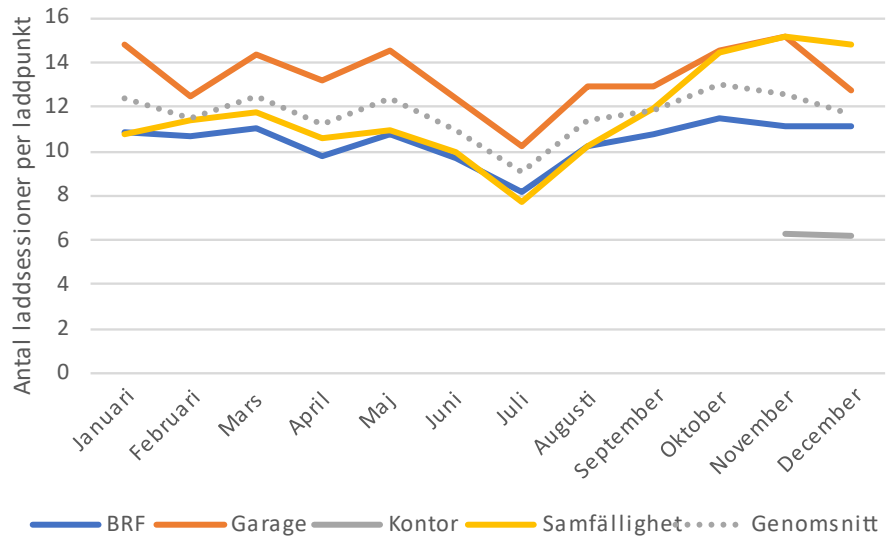

Figure 4) The number of charging sessions per charging point and location category in 2023 distributed per month (January – December). (Blue BRF= apartment housing association, Grey Kontor = Office, Yellow Samfällighet = multi-owner housing associations and grey dotted line Genomsnitt is average of all categories).

2.4 Most charging sessions occur on weekdays

Most of the charging sessions occur during weekdays, as can be seen in Figure 5. The largest change occurs for offices that have a peak on Wednesday and a clear dip on the weekend. Private apartment housing associations and multi-owner housing associations are similar to each other and have a relatively even distribution over weekends and weekdays, however, private apartment housing associations see a small increase in charging sessions over the weekend while multi-owner housing associations have a slightly higher proportion of charging sessions during weekdays.

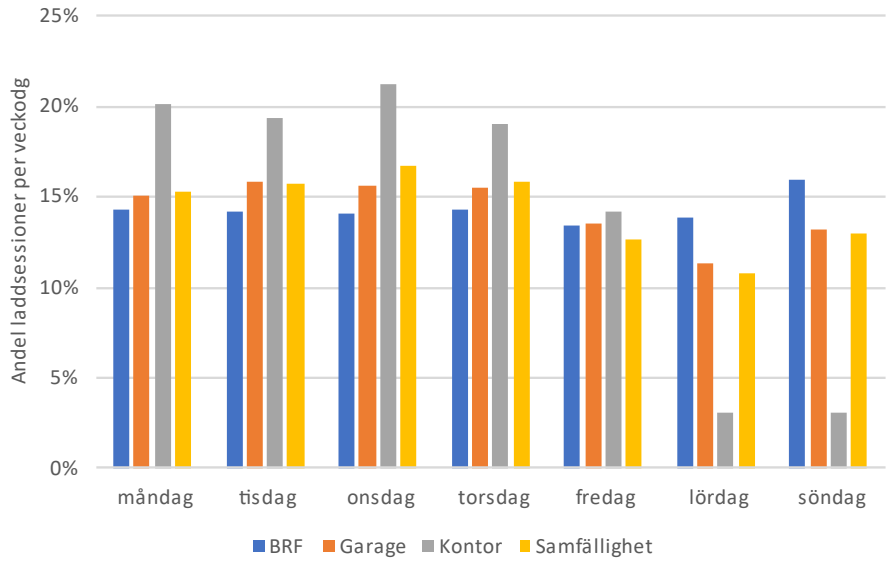

Figure 5: Proportion of charging sessions per weekday for each location category in 2023 Monday through Sunday. (Blue BRF= apartment housing association, Grey Kontor = Office, Yellow Samfällighet = multi-owner housing associations)

2.5 Charging distribution during an average day

Charging at offices usually starts between 08:00 and 10:00 in the morning, with a peak around 09:00. The proportion of charging sessions started then decreases until 22:00, when they increase slightly during the night. This behaviour shows that offices are used for workplace charging to a large extent. Garages, private apartment housing associations and multi-owner housing associations all show a similar pattern with a peak in charging sessions starting in the evening between 17:00 and 19:00 on weekdays. On weekends the charging is

much lower in offices but still occur. The other categories peak in the late afternoon and evening on weekends. All location categories have a low proportion of charging sessions started during the night.

2.6 Charging time is on average 10,5 hours per charging session

The average charging time for all categories is 10,5 hours per charging session.
There is a clear variation depending on the location category. Both private apartment housing associations, as well as multi-owner housing associations and garages, have a large proportion of charging sessions that are between 1–3 hours and 12–16 hours, which suggests that both shorter and longer charging sessions occur depending on the needs of the users. Offices have the highest proportion of charging sessions of between 6 – 9 hours, which is consistent with the length of a workday. For offices, it is interesting to note that charging also occurs on weekends, which may indicate that users also work on weekends or that the locations are used by work vehicles parked at the workplace during the weekends. Charging sessions that start in the morning tend to be shorter, which can be interpreted as users charging the vehicles in preparation for the day. Charging sessions that start later in the day, especially around 17:00, show a longer charging time, which suggests that vehicles are more often left to charge overnight. This pattern may in turn reflect an increased use of charging points during the evening when vehicles are less in use.

2.7 Charging units used between 20 and 50 percent of the time on average

The average number of charging sessions vary between 0.2 – 0.5 per charging point per day. This means that each charging point is used every two to five days. It is difficult to draw conclusions from the analysis regarding occupancy as the information on actual usage is limited. A large part of the analyzed facilities have fixed parking spaces where the person who rents or owns the space is the only one who uses the parking place and charging point. As expected, a charger is then used one or a few times a week. The charging infrastructure is under construction, where in all categories there is a rationality to invest and build to meet future needs. The highest average occupancy was recorded at night, which is consistent with home charging connected to private apartment housing associations, multi-owner housing associations and garages. Data from public charging on street in Stockholm show a similar occupancy rate for normal charging.

2.8 The majority of charging sessions have an energy transfer of less than 10 kWh

The non-public charging sessions with an energy transfer of less than 10 kWh per session dominate, as can be seen in Figure 6 below. On average, about 56% of charging sessions within all location categories have an energy transfer of up to 10 kWh per session. Private apartment housing associations and garages are slightly above this share, with 62% and 58%, respectively. The share of charging sessions within each range then decreases exponentially with increasing energy transfer.

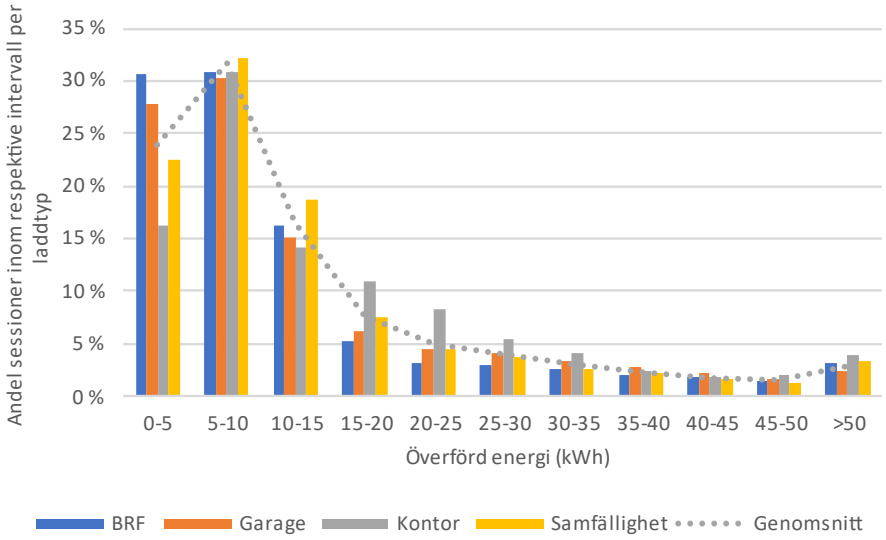

Figure 6: Proportion of charging sessions for each location category divided by amount of energy transferred.

(Blue BRF= private apartment housing association, Grey Kontor = Office, Yellow Samfällighet = multi-owner housing association, and grey dotted line Genomsnitt is average of all categories).

2.9 Average energy transfer of 13 kWh per charging session

The average energy transfer per charging session fluctuates depending on when charging is started. On both weekends and weekdays, the average energy transfer per charging session is higher if charging is started during the night, which amounted to approximately 20 – 28 kWh. Charging sessions started from 05:00 onwards have an average energy transfer more in line with the overall average over the entire period, of approximately 13 kWh. Since the number of charging sessions at night is significantly fewer in number, this figure should not be taken as evidence that more energy is transferred overall during the night hours.

2.10 Differences in energy transfer depending on distance to the city center

Figure 7 below shows the average energy transfer per charging session in different zones with respect to distance from central Stockholm (se figure 2 above). In zones 1 and 2, which represent the areas closest to the city center, the energy transfer is relatively even for all categories. In the outer zone 4, the average energy transfer increases for multi-owner housing associations, garages and, above all, offices. Private apartment housing associations have a lower energy transfer per charging session in the outer zones. The further away from the city centre, to where the chargers are located, the higher amount of energy is transferred. This might be due to longer commuting distances, which results in a higher energy demand.

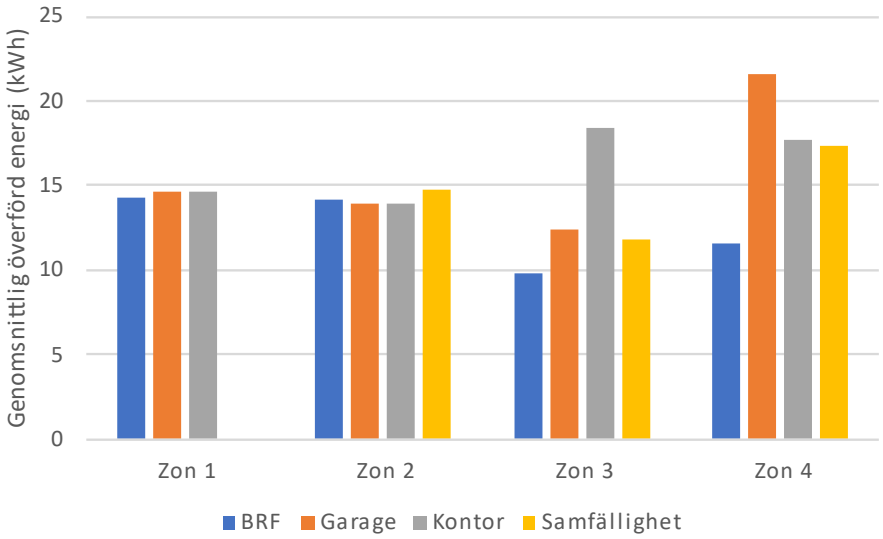

Figure 7) Average transferred energy per charging session for the different location categories within each zone. The different zones are presented in figure 2. (Blue BRF= private apartment housing association, Grey Kontor = Office, Yellow Samfällighet = multi-owner housing association)

3 Discussion

The results and findings in this data compilation is very close to what was expected; office charging being used during office hours and home charging being used in evenings and throughout the nights. Normal charging (under 22 kW) gives long charging time and the energy transferred matches the average distance travelled with a car in Sweden. Most of the non-public chargers in this study are used by one electric car since the data is mostly compiled from places by where the same cars park every day. The rate of occupancy (when the charger is connected to a car) of 20 percent is just what can be expected. Statistics from Stockholm Parkering AB in 2024 show that many garages have a higher occupancy rate, even as high as 50 percent. In a time where investments in charging equipment are made to prepare for the future and make it attractive to invest in electric vehicles these are impressive figures. The analysis made according to different zones and distance to the city centre also provide interesting information that to most extent was expected.

The non-public charging infrastructure in Stockholm contributes to reducing emissions and plays an important role in meeting the increasing demand for charging electric cars. The insights gained about usage patterns,

occupancy and energy transfer provide a basis for the city's continued work to develop an efficient and accessible charging infrastructure.

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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. Eva has presented at many international conferences including several EVS events.

Martin Görling is part of the Energy Advisory team at Sweco Sverige AB, focusing on strategic issues and future trends in energy use within the transportation sector. His assignments have encompassed a wide range of topics, including renewable fuel production, Power-to-X (PtX), electrification, charging infrastructure and onshore power supply for ships. Martin holds a PhD in Chemical Engineering from The Royal Institute of Technology in Stockholm, with a specialization in biofuel production and PtX.