Stockholms stad

Experiences from setting up public charging facilities for electric vehicles in Stockholm

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Experiences from setting up public charging facilities for electric vehicles inStockholm

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Summary

In the budget for 2014, the Traffic Committee was commissioned to contribute, together with the Environment and Health Committee and others, to the establishment of 10 new facilities for fast charging of electric vehicles and 100 facilities for normal charging. At present, eight on-street fast charging stations (installed by Vattenfall and Fortum) and more than 100 normal charging stations (in areas run by Stockholm Parkering AB) have been added within the framework for this commission.

In 2014, the Swedish Energy Agency granted SEK 1.5 million in funding to the City of Stockholm for the project "Charging infrastructure for electric vehicles – how can a city take initiatives and act?". The Environment and Health Administration is coordinating the work and runs the project together with the Traffic Administration, Stockholm Parkering AB and the Royal Institute of Technology (KTH). The aim of the project is to learn from the work with 10+100 public chargers and to develop a plan for future expansion in Stockholm.

In September 2015, a first opportunity opened to apply for state funding for investments in charging infrastructure, through the so-called Klimatklivet (Climate Step). The government's spring budget for 2015 included a total of SEK 125 million for climate investments in municipalities and regions and for the installation of charging infrastructure for electric vehicles. The grants are intended for measures that have the biggest impact on the climate. A further SEK 600 million/year has been allocated for 2016-2018.

When it comes to charging infrastructure for electric vehicles, we should think in terms of parking for normal charging and fuelling for fast charging. The vast majority of electric vehicles are charged overnight via normal battery chargers. It takes 6-8 hours to charge the batteries of today's most common electric vehicles from empty to full. A network of fast charging stations, where batteries are charged in less than 30 minutes, forms an important complement as a safety measure against electric vehicles running out of charge, and perhaps also for extending the electric range of hybrid vehicles. This network is also important for commercial vehicle fleets with many short trips in the city, for example taxis and delivery vans.

The main principle should be that just like traditional fuelling, all charging should take place primarily on private land (off-street). In

exceptional cases, well-separated parking areas on public land could be used. Good opportunities exist in the outskirts of the city for setting up normal charging sites on private land in connection with fast food outlets and petrol stations, and these businesses see a symbiotic effect of such installations.

Compilation of data from public normal charging stations shows that charging occurs significantly more on weekdays than at weekends. This can be interpreted as usage being strongly linked to work, among drivers of electric vehicles. The time of starting a charge varies in different locations. In some places evening charging is most common, whereas in other areas morning charging dominates. The use of public normal charging stations doubled for each quarter of the evaluation period (May 2014 to October 2015). The number of charging facilities doubled during the same period.

The energy transmitted during normal charging is 4-10 kW/charge and the charging time is usually 1-5 hours.

Differences linked to geographic location of public normal charging points are as follows:

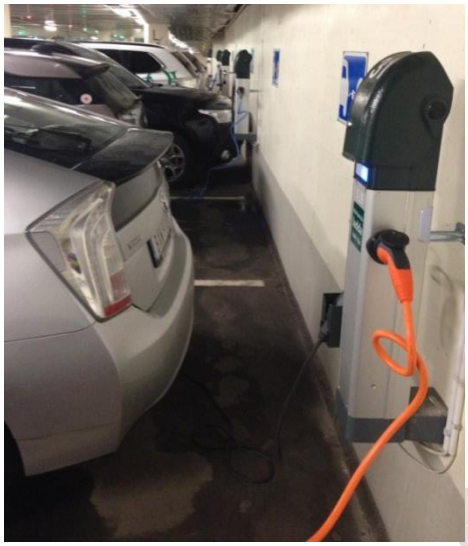
- Vällingby Centrum. Shorter charges; less than 2 hours dominate.
- City, workplaces; Gallerian and Norra Latin. Morning charging dominates (more than 50 per cent of charges start between 05 and 08 weekdays). The electric vehicles then remain at the charging place for most of the day.
- Södermalm, housing areas, Högalid and Vartofta. Afternoon/evening charging dominates.
- City “company car garage” with many, long charging sessions with high energy consumption. It is most likely that Teslas are charged here.

Compilation of data from public fast charging stations shows that the location is significant for usage. So far, the majority of users are commercial electric vehicle drivers, and attractive locations result in more users and increased usage of the fast chargers.

When payment for fast charging was introduced at the beginning of 2015, the use of fast chargers declined and changed. A slow increase has since taken place, but many previous customers seem to have stopped using fast charging.

Two types of behaviour can be distinguished in relation to fast charging: short “top-up” of 0 – 10 minutes, or longer charging sessions of10-30 minutes. The choice of location partly determines which type of charging behavior dominates among fast chargers.

Surveys show that normal charging and fast charging meet different demands for different user groups. The surveys indicate that access to public charging infrastructure is vital for some drivers. But for the biggest group, with access to charging at home, public charging infrastructure in Stockholm is only a complement to overnight charging. Access to normal charging where users park anyway, appears to be a good way of contributing to a lot of electric kilometres in Stockholm. Private individuals are unlikely to constitute the majority of users of public fast charging neither today, nor in the future. The surveys suggest that fast charging facilities are a way of enabling many electric kilometres within commercial traffic.



The parking garage at Gallerian has 10 normal charging points, which are usually used during daytime. During the first months of 2016, a further 28 charging points will be installed by Stockholm Parkering to meet demand.

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Glossary

A range of words and expressions are used relating to PEVs (Plug-in Electric Vehicles) and charging. The Swedish Academy Dictionary (SAOB) has not yet defined some of the Swedish words concerning charging and charging infrastructure, so there are no "official" definitions. However, Power Circle, an interest organisation for the Swedish power industry, has defined a number of words normally used in connection with PEVs, charging and charging infrastructure. This report endeavours to use the Power Circle definitions as seen below:

- Charging station/Charging site
  Charging stations or charging sites are where one or more ECVs can be charged at the same time. Charging stations have several chargers. There may be one or several parking places as well as other facilities adjacent to the charging station.

- Charger/Charging post
  A charger is the hardware supplying current for charging electric vehicles. There are normal chargers, semi-fast chargers and fast chargers. Charging posts refer to the same thing as chargers. Chargers/charging posts can have several charging points.

- Charging point
  A charging point is the interface between the charging equipment and the PEV. On chargers with fixed charging cables, the charging point is located at the end of the cable that connects to the inlet on the vehicle. If there is no fixed cable, the charging point will instead be the charger's outlet. A charger/charging post can have several charging points.

- Normal charger
  Normal chargers are chargers with a power output of maximum 22 kW, according to a fairly recent definition in the EU Directive on the deployment of alternative fuels infrastructure.

- Fast charger
  Fast chargers are chargers with a power output of more than 22 kW, according to a fairly recent definition in the EU Directive on the deployment of alternative fuels infrastructure. (Previously, fast charging referred to chargers with a power output of more than 40 kW – many people in Sweden believe that we should go back to that definition)

- Semi-fast charger
  Previously, chargers with a power output of 22 kW were referred to as semi-fast chargers, but with the new definition in the EU Directive on the deployment of alternative fuels infrastructure, this concept is no longer used.

- Wallbox
  Wall-mounted chargers mainly developed for normal charging of PEVs at home or in other non-public spaces. The English word wallbox is sometimes used in spoken or written Swedish.

- Electric car (EV)
  Car powered only by an electric motor. The battery of an electric car is charged from the electricity grid.

- Plug-in Hybrid Electric Vehicle
  Car 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.

- Plug-in Electric Passenger Vehicles (PEVs)
  Generic term for electric passenger cars and plug-in hybrid electric passenger cars.

- Plug-in Electric Vehicles
  Generic term for all vehicles that have batteries that can be charged externally.

Background

There are different ways of recharging PEVs. Most common is normal charging where you charge the car battery over a longer time, usually overnight, at a low current. The other type is fast charging, where an almost empty battery can be charged in less than half an hour at a high-power charging station. In addition, there is semi-fast charging.

In the 2014 budget, the Traffic Committee was commissioned to contribute to the deployment of 10 new fast charging sites for PEVs and 100 sites for normal charging. SEK 10 million was allocated for investments in charging infrastructure over the year, but only around SEK 0.5 million of the allocated funds was used. The Environment and Health Committee, Stockholm Parkering and the housing companies were assigned to work together with the Traffic Committee to expand the charging infrastructure.

In 2014, the Swedish Energy Agency granted SEK 1.5 million in funding to the City of Stockholm for the project “Charging infrastructure for electric vehicles – how can a city take initiatives and act?” The Environment and Health Administration runs the project (due to resource constraints, and because they were responsible for the project application) in collaboration with the Traffic Administration, Stockholm Parkering and the Royal Institute of Technology (KTH). The aim of the project is to learn from the experiences with 10+100 public chargers and to develop a plan for future deployment in Stockholm. Knowledge will also be shared during the course of the project.

A working group was set up in early 2014 with representatives from the Environment and Health Administration, Traffic Administration, Real Estate Administration, Stockholm Parkering and the housing companies to work with the expansion of normal charging facilities. In 2014, Stockholm Parkering installed more than 100 normal charging stations, of which around half were in their own inner city garages and half in the outskirts of the city, predominantly in outdoor parking sites. Familjebostäder installed normal charging stations at two of their public parking facilities in Stockholm.

Eight fast charging stations have been installed on public land. In addition, a couple of stations were installed at private facilities in 2014. In total, there are currently 13 fast charging stations within

the City of Stockholm and another eight stations in the rest of the county.

The expansion of public fast chargers on public land started in 2014 in collaboration with two electric utility companies; Vattenfall and Fortum. The Traffic Administration has signed access rights agreements with Vattenfall and Fortum, giving them the right to use space on public land at no cost, for parking places with fast chargers and connected installations. The utility companies themselves finance the charging equipment, power supply and necessary power lines, as well as signage and marking out of the area. At two of the eight sites, the Traffic Administration has funded the street work required for establishing suitable parking places for charging. A total of around SEK 0.5 million of the allocated SEK 10 million was used for this purpose.

The ordinance (2015:517) on support for local climate investments (Klimatklivet) came into effect in summer 2015. Businesses, municipalities, etc., can now apply for grants for charging stations for PEVs (private individuals, however are not eligible). For normal charging, grants cover up to 50 per cent of the investment cost up to a maximum of SEK 20,000/charging station. Applications are sent to the County Administrative Board in the county where the station will be located. The Swedish Environmental Protection Agency and the Swedish Energy Agency assess and approve the applications. The two application rounds in 2015 included several applications from actors in Stockholm. During 2016-2018 there will be four application rounds per year. SEK 600 million/year has been allocated for this period. There are thus good prospects for various actors to apply for grants for further investments in public charging infrastructure in Stockholm.

Stockholm Parkering is one of the actors that have received grants from Klimatklivet. A further 307 normal chargers will be put up in their parking facilities during 2016-2018. This means that by the end of 2018, Stockholm Parkering will be able to offer 1,000 charging opportunities!

Results

Normal charging

Stockholm Parkering's goals and tasks

The main task for Stockholm Parkering is to relieve the streets of circulating traffic and parked vehicles by building new parking garages and to ensure high occupancy in their garages. The garages should meet the needs in new areas, and lead to reduced on-street parking in existing areas. Stockholm Parkering builds and runs parking facilities both on the commercial market and for the sole purpose of relieving on-street parking. In order to stimulate the use of electric cars, chargers will be installed at Stockholm Parkering parking facilities.

To date, Stockholm Parkering uses normal chargers as standard. These chargers have a charging power of up to 3.7 kW, which corresponds to a voltage of 230V and a current of 16 Amps[1].

Normal chargers installed by Stockholm Parkering within the framework of the commission:

Garage/Site	No of chargers	Available charging points	Date of installation
Vällingby Centre	4	8	2014-05-30
Glasbruket	2	4	2014-08-19
Norra Latin garage	7	14	2014-08-21
Gallerian garage	2	4	2014-09-08
Rådhusgaraget	1	2	2014-09-16
Garage Norra Real	5	10	2014-09-26
Humlegården garage	2	4	2014-10-01
Viking garage	2	4	2014-10-02

[1] (Svensk Energi, 2014)

Spånga Tennis	1	2	2014-10-06
Åkeshovs Park and Ride	2	4	2014-10-10
Sjöstaden garage	2	4	2014-10-13
Slakthusplan	2	4	2014-10-13
Väll-in	3	6	2014-10-13
Kölnan garage	2	4	2014-10-14
Djurgårdsbrunn	2	2	2014-10-15
Väderkvarnen garage	2	4	2014-11-13
Åsö garage	3	6	2014-11-19
David Bagare	4	8	2014-12-01
Fleming	3	6	2014-12-01
Rågsved Park and Ride	1	1	2014-12-01
S:t Eriksplan	2	4	2014-12-04
Stora Mossen	2	4	2014-12-16
Enskedehallen	2	4	2014-12-18
Palmfelts Centre	3	6	2014-12-19
Farsta Pool and Sports Centre	3	6	2014-12-19
Mälarhöjden Sports Centre	2	4	2014-12-19
Västertorpshallen	3	6	2015-01-22
Total:	**69**	**135**	

Normal chargers installed by Familjebostäder within the framework of the commission:

Site	No of chargers	Available charging points	Date of installation
Rinkeby, Askbykroken 13	1	2	2014-10-01
Gubbängen Centre	1	2	2014-11-01
Total:	**2**	**4**	

Fast charging

Fast chargers Installed within the framework of the commission:

Site	Private actor	Date of installation
Roslagstull; Vallahallav 1	Fortum	2014-02-17
Kampementsbadet/Sandhamnsgatan	Vattenfall	2014-09-16
Tanto/Zinken, Ringvägen 35	Vattenfall	2014-09-16
Liljeholmen, Nybohovsbacken 17	Vattenfall	2015-03-06
Kista, Danmarksgatan 8	Vattenfall	2015-03-06
Malmgårdsvägen/Ringvägen 162	Vattenfall	2015-03-06
Norra Djurgårdsstaden, Kontorsvillan, Gasverksvägen 15	Vattenfall	2015-03-31
Runebergsplan	Vattenfall	Estimated early 2016
Hammarby Allé/Lugnets Alle	Vattenfall	Pending grant from Klimatklivet; spring 2016
Rålambsvägen	Vattenfall	Pending grant from Klimatklivet; spring 2016
Årstaområdet	Fortum	Spring 2016
Sköndal	Fortum	Spring 2016
Total (August 2015)	**7 installed, 5 under way**	

As early as 2012, the Traffic Administration wrote a memorandum, see Appendix 1, with possible locations for public on-street charging stations. The memorandum formed part of the basis for finding suitable fast charging sites. Other locations have been found on the initiative of the electric utility companies or via suggestions from the public. The Traffic Administration, Environment and Health Administration and Stockholm Parkering have also made a number of visits and made an inventory of possible sites.

Fortum showed great interest in installing fast chargers in the municipalities to the west and south of Stockholm. In autumn 2014, the Traffic Administration and Environment and Health Administration found suitable on-street locations in Vällingby and Farsta. In parallel discussions with private landowners, Fortum opted for two locations on private land in Vällingby and Farsta where they will install fast charging.

Fortum collaborates with Preem and McDonald's and has installed public fast chargers at a number of Preem fuel stations and McDonald's restaurants in Stockholm as well as in the rest of the country. Similarly, Vattenfall collaborates with the Max hamburger restaurant chain.

Other private actors working with public charging

The private property company Vasakronan installed two public fast chargers on their own land in in Stockholm in 2014; one in Kista and one at Garnisonen. Vasakronan has also installed a large number of public normal chargers on these sites.

Several car dealers have installed public fast chargers on their own premises:

- Nissan was first in Stockholm, and since 2012 they have public fast chargers at two of their Stockholm showrooms; in Sätra and Bromma.
- In 2014, Volkswagen installed public fast chargers at their showrooms in Akalla and Smista, Huddinge.
- In 2014, Tesla also installed public so-called “superchargers” in Upplands Väsby.

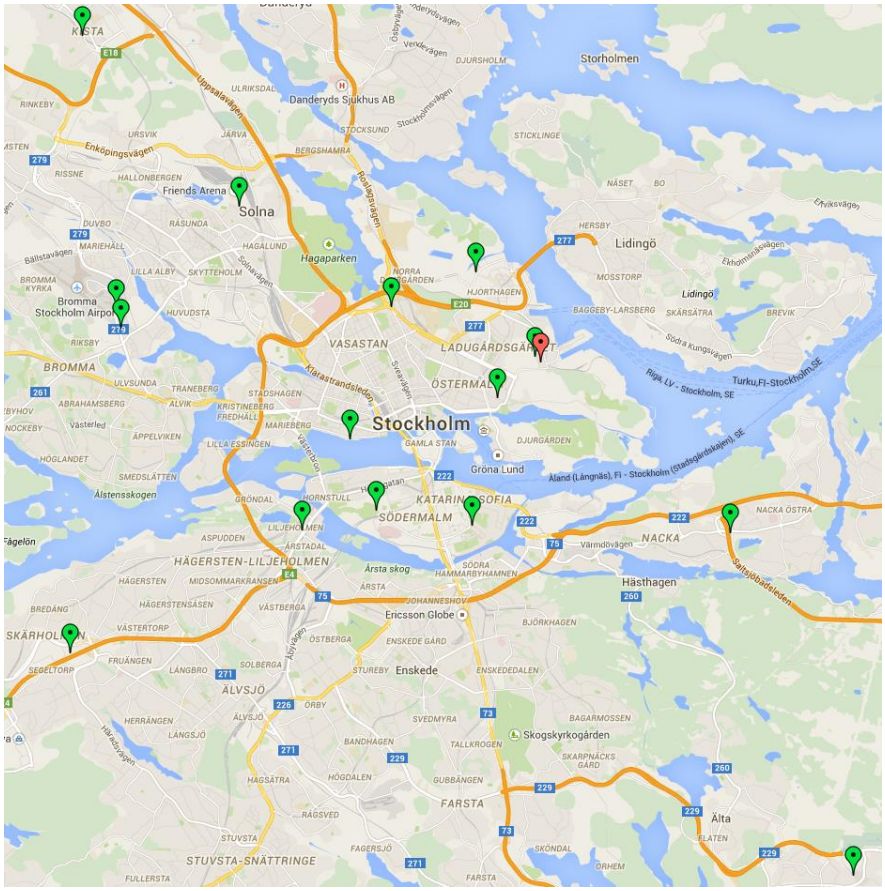
Taxi Stockholm has shown interest in setting up public charging in Stockholm. At present, Taxi Stockholm has just short of ten electric taxi cars (Nissan Leaf and Tesla Model S) but is planning to increase the electric fleet. A taxi covers around 250 kilometres on one shift, and a good time for charging would be while waiting for a fare.

Vattenfall has installed a public fast charger outside their main office in Solna.

A few other electric utility companies have shown interest in setting up public fast charging in Stockholm on public land. The Traffic Administration and Environment and Health Administration have had telephone contact and meetings with these actors, but so far discussions have not resulted in collaboration.

In total, there are currently 13 public fast chargers within the city boundaries and a further eight in the rest of Stockholm County.

Fast charging facilities in Stockholm 2015



Fast chargers in and around Stockholm 2015 from www.uppladdning.nu

Installing charging facilities outside Stockholm

Municipalities surrounding Stockholm

Municipalities in northeastern Stockholm (Stockholm NordOst) have a network for environmental strategies that has procured a consultancy study on charging infrastructure. Danderyd has singled

out a number of sites suitable for normal charging, e.g. parking areas near sports centres and neighbourhood centres.

Municipalities in Södertörn are putting together a joint development programme for coordinated goods distribution, infrastructure for clean vehicles and municipal vehicles policy. In Tyresö, the municipality has installed a fast charging station in the market square in central Tyresö, in cooperation with Vattenfall.

A network was established at the first meeting with the surrounding municipalities. In addition to email contact, the network met twice in 2015. A joint application to Klimatklivet was submitted on 13 October, 2015 regarding an information project targeted at housing cooperatives. The aim of the project is to enable more housing co-operatives to install and offer charging at their parking spaces. 25 municipalities in the county will collaborate on this project, which is a result of Stockholm's initiative to meet and share experiences.

Other major cities in Sweden

Two seminars have been held in Stockholm to explore the situation in other major cities (Gothenburg, Malmö and Uppsala) as well as in the municipalities surrounding Stockholm.

Gothenburg has five fast charging stations, four of which have been installed by the municipal Gatubolaget, and one by Preem. Vattenfall is planning for five fast chargers in the coming year. Gothenburg Energy is investigating possible investments in fast charging. Politicians have adopted a strategy on collaboration with industry, payment for charging, and off-street location of, at least, normal charging.

Malmö has three public fast charging stations, all on private land. So far, the City of Malmö has been highly reluctant to grant the use of public land for charging, and believes that it is up to private actors to arrange this on their own land.

Uppsala had far-reaching plans to install normal chargers at resident on-street parking places. The process has, however, been suspended since there is an appeal against the procurement. Both Vattenfall and Fortum have installed public fast chargers on private land in Uppsala.

Lessons learned

A general conclusion is to think parking for normal charging and fuelling for fast charging.

Normal charging

Technology

It may be difficult to select the “right” power and current when installing a normal charging station. Cars have different charging capabilities and require single-phase or three-phase power, and DC or AC, respectively. The possibility of modifying the charging station at a reasonable cost should therefore be considered. Drivers’ knowledge about charging is often limited, and they do not always know how their own electric vehicle is best charged. So-called “smart” charging stations are now available (with options for statistics, alarm, communication with the charging station, remote control, etc.) but these are an expensive option which may not always be justified.

Preliminary conclusions of experiences to date are:

- Public chargers should be of type 2, mode 3, 16A, single-phase. This corresponds to the standard for new electric vehicles and enables several cars to charge at the same parking station, while keeping investments down.
- When charging posts are put up, it makes financial sense to choose a post where two cars can charge simultaneously.
- When leasing parking places, it is important to find out from the clients which type of vehicles will be charged and the output required. Max: 16A single-phase (sufficient for overnight charging, while ensuring that the capacity in the building is enough for several electric cars).

Payment

Stockholm Parkering has tested payment via SMS and mobile apps. Evaluations show that clients found the SMS function difficult. Mainly, they were often frustrated with “IT-problems”. Having to pay separately for parking and electricity was found to be an unnecessary complication.
Because of this, Stockholm Parkering prefers to use a model where normal charging is included in the monthly parking fee.

When the property owner differs from the parking operator, Stockholm Parkering has an initial discussion regarding the distribution of costs between them and the property owner. At the same time, a record is made of existing grid connection/distribution board capacity. The cheapest option is to place the chargers close to the distribution board, two and two together, so that one post can be used for charging two cars. This offers two charging opportunities at almost the same cost as one. Signage is also important, to guide clients to the right place.

Today, it is not excessively expensive to invest in “intelligent” systems for load balancing. In this way you can avoid excess costs for grid connection as the system grows and more chargers are required in the same parking garage. Another lesson learned is to procure the posts and the installation separately. Installations are best made by an electrician familiar with the property. Experience from Stockholm Parkering also shows that in garages where there are many chargers, it is best not to reserve places for electric cars only. Instead, chargers should be placed in spaces that are normally occupied last, and they must be very clearly signposted. This is in order to avoid incorrect parking at charging sites by non-electric vehicles.

Purchase of charging equipment

The charging equipment that has been purchased predominantly consists of stations with type 2, mode 3 normal chargers (without cable) and electricity meters with communication via 3G or LAN. Both ground stations and wall stations are used. Stockholm Parkering has painted the charging stations in their own profile colour to make them stand out from the surroundings.

Recommendations for purchasing and placing of charging stations

Grid connection or distribution board – what power supply is available? Many clients want to be able to charge quickly, but the grid connection may not be able to cope with the load. When it comes to charging power, most electric cars use a normal charge. First of all, check the load capacity of the grid connection/distribution board in question. In some cases it may be worth installing a load balancing system to prevent circuit overload. Some manufacturers supply load balancers, either integrated in the equipment or for external mounting e.g. in the distribution board. Running long cable lengths results in significantly higher costs, both for materials and installation, since thicker cables are required. There could also be problems with overcrowding in the charger casing, if the cable is too thick. It

is important to check this with the charger manufacturer. Having as short cables as possible between the grid connection/distribution board, reduces costs. In some cases it is cheaper to run several thinner cables in parallel instead of a thick serial cable. A good electrician will know what is cheapest and best.

Locating a charging station between two parking places increases the opportunities for use. It can also be more economical to buy one charging station with two charging points, rather than a singlepoint. Remember that the charging cable has to reach the car inlet. Cables are normally 5 metres, but cars differ greatly with front, rear or side sockets. It is usually best to install outlets on transverse parking places where the car is parked straight, with either the front or rear against the wall or area where the charger will be installed. Diagonal parking with directional traffic should be avoided. The same applies to parallel parking alongside a wall or kerb.

When investing in normal chargers for a large public car park, it is advisable to buy type 2 (EU standard) so that the outlet is as future-proofed as possible. You can offer chargers with or without cables. If several people are using the facility, it is best not to supply a fixed cable. Then, users should bring their own cable equipped with the correct plug, or make changes if necessary. In this way, the charging station becomes more flexible and can be used by several different types of PEVs.

Connection

Owners of charging equipment, who want their charging stations to be connected to a management system, should be aware of and prevent a range of possible technical problems. “Smart” charging stations often require a separate communication card for 3G or LAN. Using 3G requires both a subscription and good coverage, (which could be a problem e.g. in underground garages). An existing network often offers more stability but could be more difficult, since network cables must be installed and switches maintained. Another on-line problem is understanding the type of communication protocol used. OCPP (Open Charge Point Protocol) versions between 1.5 and 2.0 are standard. Remember that even when a charging station and network management system use the same OCPP version, several settings may need adjusting before they can communicate properly with each other. Also bear in mind that you often have to pay for web portal services. Connecting to a customer service portal for handling reported faults could be a good idea, but also adds to costs. The customer service fees could easily exceed the cost of electricity for one or two normal charging stations. Carefully con-

sider whether the charging station needs to be connected. An advantage with a management system is that you can see whether the charger is working or out of order. There is also a whole range of useful peripheral services, e.g. energy consumption data and alarm or error messages. It is also possible to identify the vehicle being charged, and select the optimal charging profile accordingly. A connected station could therefore be a good choice when many drivers use the facility. Remote fault diagnosis enables quick corrective action. Network connection is also required for some payment and access systems.

Developments in electric cars and chargers are rapid, and software in both needs upgrading relatively often to enable all electric car models using any charging station. A connected charger can be updated without a physical visit, which saves time and money. At present, there could be several upgrades per charger/year. (Having a connected station also enables faster adaptation of payment systems, in pace with a growing market and new requirements.)

Electricity meters

There are different requirements for electricity meters, depending on their purpose. If the reading is to provide the basis for debiting/selling electricity from a normal charger, the meter must be approved for this purpose, which means that it has to be accurate and of the right standard. Using a current transformer cable could work, if you are only looking for data, but this is not an approved method when selling electricity. It is often possible to have a meter installed in the charging equipment (integrated metering), which is simple to read on-site. There are also remote reading systems based on LAN or 3G connections.

Costs

Costs incurred by Stockholm Parkering in connection with establishing charging stations include 60 per cent for the actual charging station and 40 per cent for the installation, divided per outlet. This does not include planning and operating costs. At Stockholm Parkering’s facilities, the cost of electricity is included in the normal fee for visitor parking spaces. Clients who pay for parking can also use the charging facilities for their electric cars without extra cost. The electricity cost for charging is borne by Stockholm Parkering.

To date, the average electric car client uses an average of around 10 kWh for a normal charge. It should be noted that charging require-

ments differ significantly from station to station. At some facilities, drivers charge 4 kWh and in others 30 kWh. This is most likely due to the type of car, since PHEVs, for example, can only receive a limited amount of kWh, while EVs often have a larger capacity. The charging time is also a determining factor. So far, Stockholm Parkering only offers normal charging. It would take a client around 8 hours to charge 30 kWh (30kWh/3.7kW = 8.1h).

The garage charging stations seem to attract new clients who would otherwise have parked elsewhere. This means that it is easier for Stockholm Parkering to reach their goal of high occupancy, as well as the goal of relieving the streets from circulating traffic and parked vehicles.

Examples of costs

Garage/Site	No of chargers	No of charging points	Date of installation	Cost equipment	Cost installation
Stora Mossen	2	4	2014-12-16	39000	30000
Enskedehallen	2	4	2014-12-18	40000	22000
Farsta Pool and Sports Centre	3	6	2014-12-19	59000	63000
Mälarhöjden Sports Centre	2	4	2014-12-19	39000	30000
Total:	9	18		177 000 SEK	145 000 SEK

Note that the above examples refer to relatively simple installations, which did not require upgrading of power supply. Stockholm Parkering estimates that future installations will be more costly.

Reliability

So far, there has been no extra fee for using Stockholm Parkering public charging stations. Clients who pay the stipulated parking fee can use the charger for free. Stockholm Parkering has not had to install a special debiting system for the charging stations, which also means fewer complications for the client. The result is that the basic built-in reliability is regarded as high, and in the case of Stockholm Parkering this has not been notably reduced by external technical systems. There have been few faults reported, considering that the around 700 charging stations installed by the end of October 2015, are frequently used by different clients.

Operating problems have so far been mostly due to the human factor. For example, a client accidentally switching off the residual current device (safety switch) and not knowing how to activate it again. A few cases of vandalism (forced locks and graffiti on one post) and some collision damage have been reported. Technical problems include mobile coverage (3G/2G/GPRS) particularly in some garages that are also built as air-raid shelters, with reinforced walls, floors and ceilings that effectively block signals. Extra equipment such as aerial boosters and range extenders are often needed here.

Crash barriers around charging posts are a good idea in exposed areas. The picture is from Stockholm Parkering's facility at Eriksdalsbadet.

Fast charging

Business model fast charging

During the project 10+100 public chargers, the City of Stockholm used a business model based on access rights agreements signed by the Traffic Administration and electric utility companies, in this case Vattenfall and Fortum. The first agreement included a single payment of SEK 3 011 and an annual fee of SEK 2 007, which at the time was the lowest possible rate. Subsequently, the Traffic Committee decided that access rights agreements within the project would not incur any payment.

In total, ten agreements have been signed within the framework for the commission. The agreements have been signed for three or five years. They grant the actors concerned the right to use space on public land for parking spaces with fast chargers and related installations. The actors themselves finance the charging equipment, power supply and necessary power lines, as well as signage and marking out of the area.

So far, experiences with the business model have been positive. The access rights agreements provide a clear understanding between the city and the companies establishing fast charging facilities regarding installation, operation and phasing-out.

In future access rights agreements, the Traffic Administration intends to stipulate that charging stations offer all three current fast charging standards. Requirements for reliability should also be added, and will apply equally to all actors. A reasonable requirement would be that the station is running and functioning at least 90-95 per cent of the time.

An example of a five-year access rights agreement (zero payment), is found in Appendix 2.

In addition to access rights agreements, concession of land agreements could be used to regulate the use of land for fast charging stations. Under the Public Order Act, concession of land agreements can be made when areas with detailed development plans are to be used for other purposes than intended. Authorisation from the police is required. One disadvantage of concession of land agreements is that if the city for any reason wants to revoke the lease, permission from the police must to be sought for this too. By using access rights agreements, the city retains the right of decision, which is preferable.

Signage at fast charging stations

Parking spaces for charging should be marked with an information sign E19 parking (“P”) at the top. Placed underneath, is the additional sign T24 designated for charging (“EV charging station”). There is currently no established practice for other additional signs. Some of the fast charging stations have been installed by electric utility companies on sites leased by Stockholm Parkering. Stockholm Parkering finds it sufficient with a third additional sign (“For charging only”). On public land sites (with access rights agreement), there is the additional sign “30 min”, since the city believes this is required for effective monitoring. Checking that charging is actually in progress is complicated. Further experience from monitoring and any legal cases may influence signage practice.

So far, the city does not charge for the use of fast charging stations installed to date, but instead imposes a 30 minute limit. The traffic Administration will review this system in their forthcoming commission to bring out a new parking strategy with an overall perspective on parking as a traffic management measure.

Fast charging station at Stockholm Parkering’s facility at Ringvägen/Tantolunden.

Fast charging station at the Liljeholmen turnoff. The additional sign "For charging only" is displayed even though the site is on public land. This makes it much clearer for drivers.

Lessons learned are that that sites should be scalable, i.e. there should be scope for creating further charging spaces on the same site, where there are currently only 1-2 spaces. The charging station should be placed so that vehicles park with their front or rear to the station. Parking alongside the station can be problematic since the socket location varies on different EV models, and there is a great risk that vehicles park against the direction of traffic. Charging stations should therefore not be located alongside kerbs, but on separate parking areas.

Requirement for three different fast charging standards

In future, the access rights agreements signed between the Traffic Administration and actors establishing fast chargers will include a requirement for offering all three standards of fast charging currently available:

CHAdeMO is a charging standard developed by Japanese car manufacturers, delivering up to 50 kW DC via a special connector. It takes around 30 minutes to charge an empty battery with CHAdeMO. EVs with CHAdeMO standard were introduced in Sweden in 2010 and the first fast charger was installed in Östersund in 2011. In total, there are more than 1 000 CHAdeMO chargers in operation in Europe. The name CHAdeMO is a grammatical pun, which in Japanese means roughly "While you drink a cup of tea".

CCS, Combined Charging Standard, has been developed jointly by German and North American car manufacturers. This is an AC charge with a multiple purpose connector that also supports normal charging (Mennekes type 2-kontakt), 50 kW. It takes around 30 minutes to charge an empty battery. The first EVs using the CCS fast charging standard were introduced in Sweden in 2013. The EU has decided that CCS standard is the **minimum** requirement for all new and refurbished public fast charging stations from 2018.

AC 43 is a fast charging standard developed by French car manufacturers. As the name indicates, this is AC current charge of up to 43 kW.

There is a fourth fast charging option, used by Tesla in their so called "superchargers". This enables a Tesla to be fully charged in less than one hour. Note that Tesla has a range of between 350 and 500 kilometres and can take a significantly greater charge than other EVs on the market. So far, "superchargers" have been installed in 14 locations in Sweden, of which one is in Sollentuna/Upplands Väsby along the E4 motorway. By using Tesla's own adapter, fast charging is also possible from CHAdeMO outlets.

Evaluation of stations

The Environment and Health Administration has signed a special cooperation agreement with Fortum and Vattenfall regarding data supply and evaluation of stations on public land. The Environment and Health Administration receives continuous reports on how the stations are used. This type of information from the private players is important for the city when considering new sites, expanding existing sites, etc. Data collection from the period May 2014 to October 2015 is presented below.

Through financial support from the Swedish Energy Agency, more than 100 normal chargers at Stockholm Parkering facilities now have equipment that enables simple collection and access to data on charger usage.

Three stations were in operation during 1Q15. In January and February, Fortum and Vattenfall introduced payment for fast charging. Initially, the price was SEK 3/min but was later reduced; Vattenfall charges SEK 2.40/min and Fortum SEK 2/min (April 2015).

Quantitative analysis of actual public charger usage

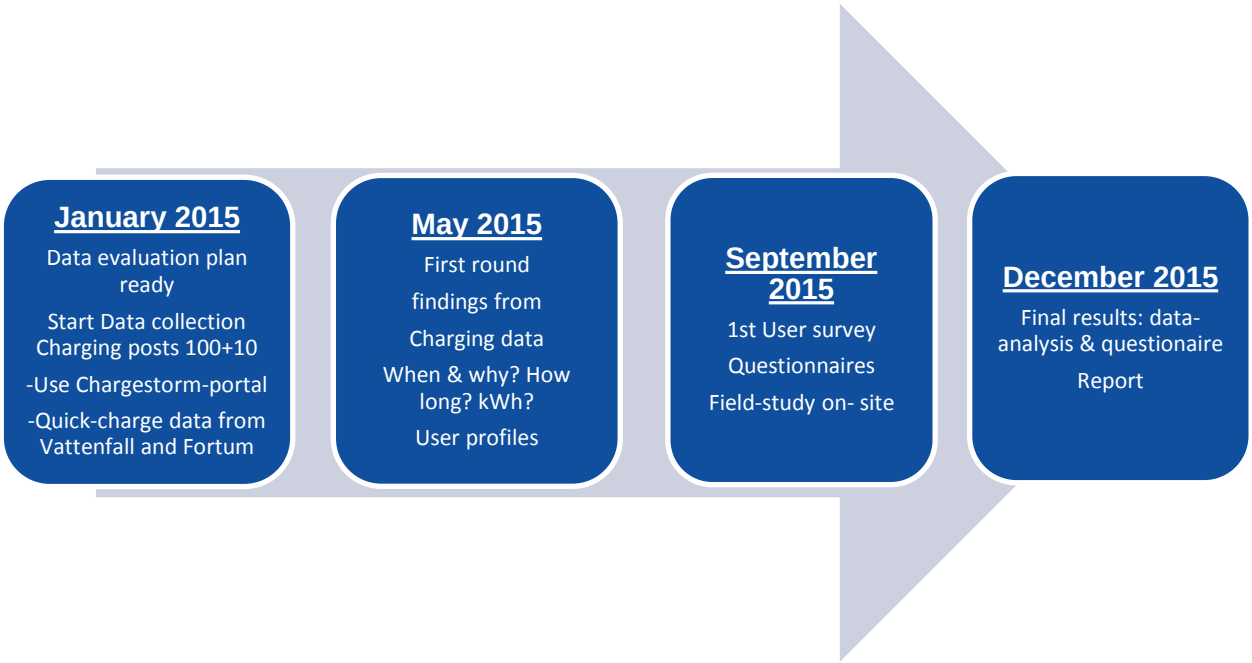
In order to study the use of public chargers, a large number of posts (but not all) were connected to the "cloud", and KTH conducted quantitative data analyses at several stages based on logged data. Data for normal chargers was logged through the Chargestorm web portal and data for fast chargers was obtained from Vattenfall and Fortum.

The main issues addressed through the analyses:

- What are the peak usage times?
- Is there a difference between daytime and evening usage?
- Does usage differ between normal and fast chargers?
- What is the occupancy rate of chargers?
- How much is charged at each post at different locations?
- Usage profiles for different locations

Key performance indicators included: kWh transferred per charge, starting time of charge, charging time, total kWh per post

Evaluation was carried out according to the plan below:



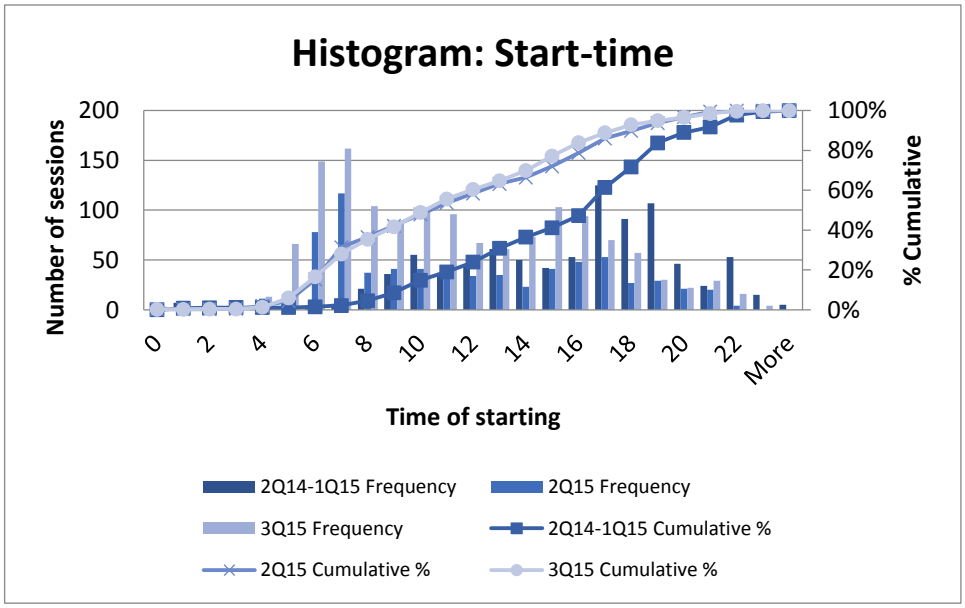
The project's evaluation plan for data collection and analysis.

Data was collected during the period 2Q 2014 to 3Q 2015. The number of connected normal chargers increased dramatically in the first six months, which explains why results differ over time. In addition, Fortum introduced a fee for fast charging in January 2015 and Vattenfall followed in February 2015. The project includes results for charging behaviour and statistics from the time before and after payment introduction.

Normal chargers

Start-time – when does charging start?

Histograms were used to find out at what time charging starts. Below are histograms for normal chargers from different periods of the project.



Histogram showing start-time for normal chargers during different periods of the project.

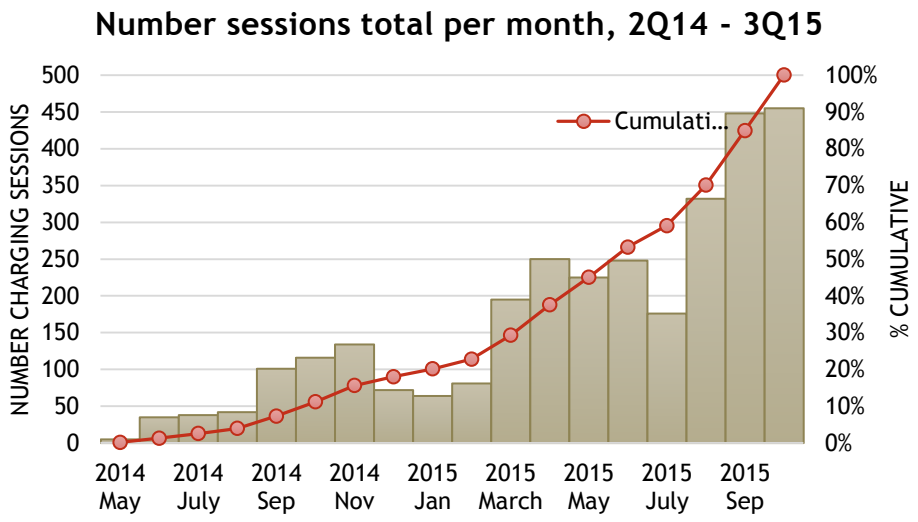
During the first three quarters of the project (2Q14 – 1Q15), the starting time for normal charging was fairly evenly distributed between 9 – 20 with some predominance (37 per cent of charging sessions) between 17 – 19. Starting times during the last two quarters (2Q15 – 3Q15) were also evenly distributed during approximately the same times of day. However, a clear shift from most charging sessions starting in the afternoon, to instead commencing early morning between 6 – 7 was shown in the latter part of the evaluation.

The most likely reason for this shift is the installation of normal chargers in the Gallerian parking garage. The Gallerian garage has a clear morning charging profile. Many EV drivers who work in the vicinity park here and charge their cars during working hours. The usage of normal chargers in Gallerian was high, and logging started in 2Q15 and dominates the data collection since then. In the pre-

vious period, Högalidsgaraget with a clear afternoon and evening charging profile had the highest number of charging sessions, and therefore dominated. It is worth mentioning that charging started a little earlier both in Gallerian and Högalidsgaraget during 2Q15 – 3Q15 compared to 2Q14 – 1Q15.

Weekdays and monthly trends

Weekday usage (Mon-Fri) of normal chargers has predominated over the entire project period. Around 80 per cent of charging sessions took place on weekdays and less than 20 per cent at weekends.



Histogram showing the total number of registered charging sessions per month for connected normal chargers, from May 2014 to October 2015.

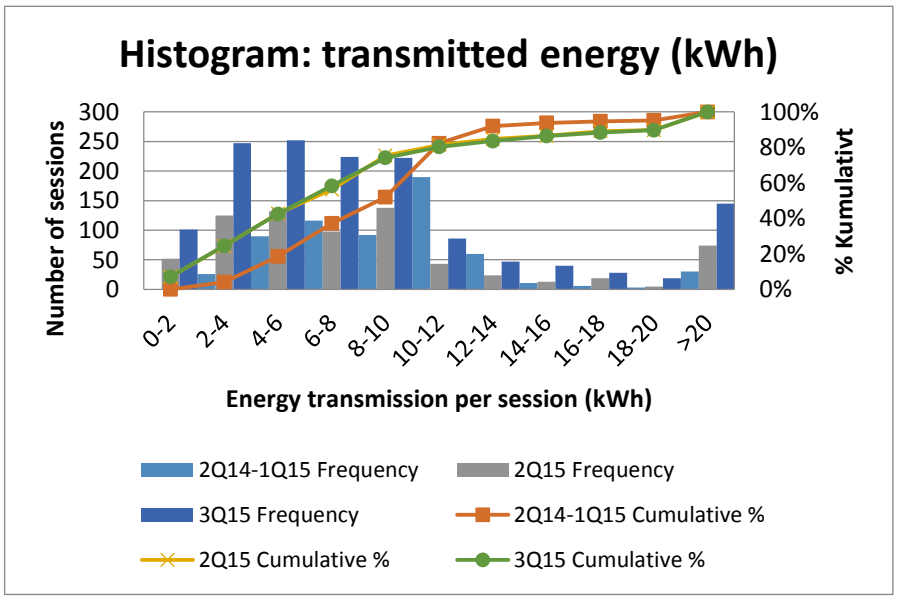
The total number of charging sessions for all connected normal chargers in the project can be seen in the above diagram. A clear increase in usage of normal chargers took place during the project period, and the number or registered charging sessions almost doubled in each quarter. This can be explained by two main factors; increased usage of established charging posts and increased number of charging posts connected to deliver data. Stockholm Parkering estimates that in February 2014, there were 36 connected posts. At the time of the last compilation of data, autumn 2015, there were around twice as many.

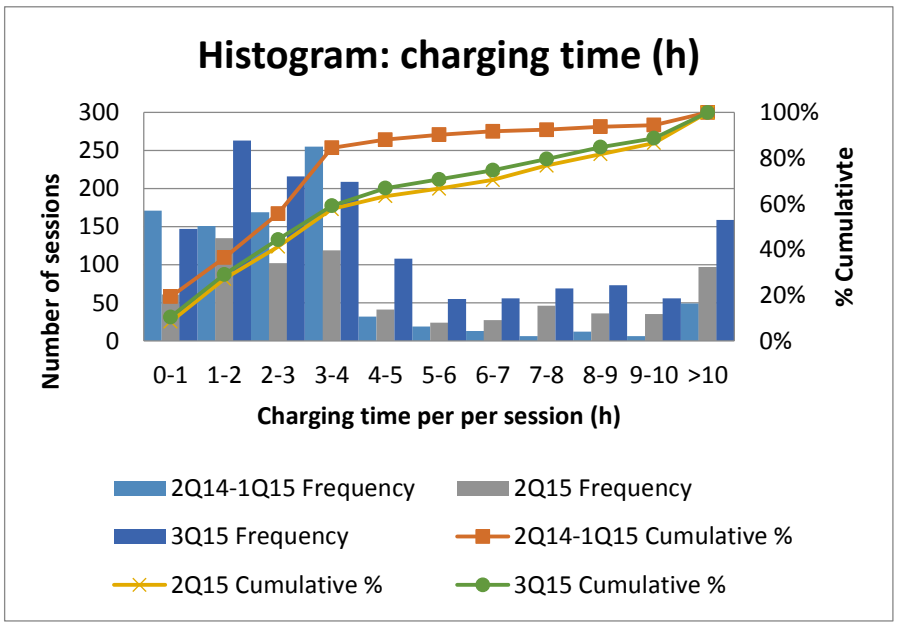
It would have been useful to be able to compare usage in relation to the number of posts delivering data, but exact month-by-month information on the number of connected charging posts was not available. Based on an estimate of the number of connected posts during different time periods, it is possible to conclude that usage of each individual post has increased significantly over the entire project

period. One estimate is that usage has doubled. However, usage decreased during the winter months (December 2014 – February 2015) and during the month of July 2015.

Energy transmission and charging time

Most normal charging sessions had a charging rate of 4 – 10 kWh and took 1 to 5 hours. This is clearly visible in the histogram below. One interesting detail is that a small number of charging sessions had a charging rate of 40 – 70 kWh and a charging time of more than 20 hours. This was most likely Teslas charging.

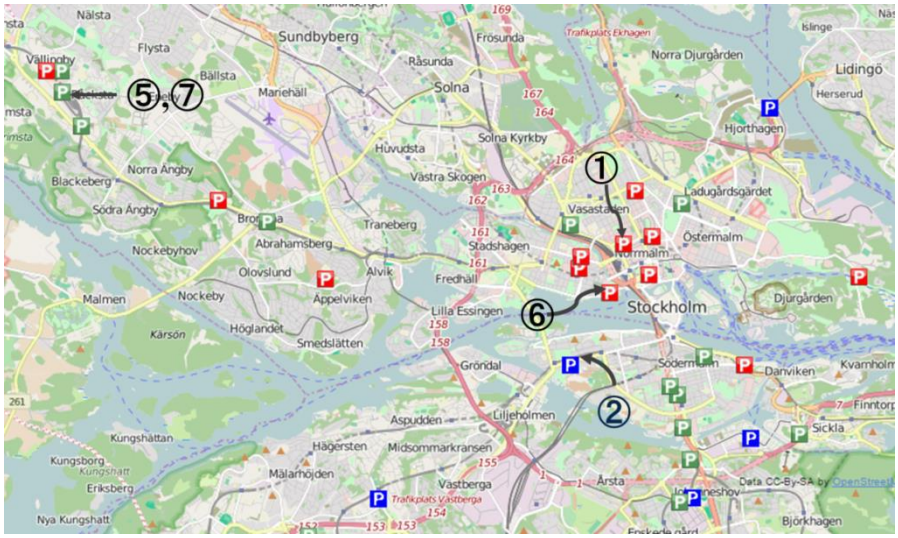




The above two histograms show transmitted energy (top) and charging time (bottom) for normal chargers during the project, divided into periods: 2Q14-1Q15, 2Q1§, 3Q15

Locational variations

Differences in usage depending on location were studied especially.



The above map and table below show differences in usage of public normal charging stations between different geographical locations.

ID	Location	Type & no. of charging points	Start date	Description	Charging behaviour	Probable users
1	Gallerian P-hus	7 Schuko 5 Type2	2012-05-01	Garage in central Stockholm at Sergelstorg, 795 visitor parking spaces	Morning charging dominates (> 50% start 05-08)	Office commuters, company car
2	Högalids-garaget	199 Schuko 5 Type2 5 Type1	2010-11-01	Garage at Hornstull on Södermalm, 209 visitor parking spaces	Evening charging dominates (> 50% start 16 – 18)	Residents
5	Åregaraget	4 Type2	2014-05-09	Visitor garage for Vällingby centre, 872 visitor parking spaces	Short charging time (> 50 % less than 2h	Visitors Vällingby C
6	Glasbruket	2 Schuko 2 Type2	2014-08-18	Off-street parking at City Hall, 40	Many long charging sessions,	Office commuters, company car

				visitor parking spaces for permit holders	charging time >10h (30%)	
7	Solurs-garaget	4 Type2	2014-05-09	Visitor garage for Vällingby centre, 600 visitor parking spaces	Short charging sessions (> 50% shorter than 2h	Visitors Vällingby C

The two charging stations located by Vällingby Centrum, Solurgaraget and Åregaraget, have short charging sessions. More than 50 per cent of charging sessions were less than 2 hours. The starting time, however, varied greatly over the day.

In central Stockholm, i.e. the Gallerian garage and Norra Latin garage have a distinct morning charging profile. Here, around 50 per cent of charging sessions start between 5 and 8 in the morning. Most likely, users are people who work in the area and want to charge their car during working hours. On the other hand, at the two charging stations connected to housing areas, charging sessions mainly started in the afternoon or evening, i.e. between 16 and18. In Glasbruket in the city, charging sessions that were more than 10 hours dominated.

The most efficient location of normal chargers was also studied. The two most used charging stations during the project, both regarding number of charging sessions and energy transmission per day, were Gallerian and Högalidsgaraget. If you compare the number of charging sessions per charging post instead, Gallerian still comes out on top (80 charging sessions/post during 3Q15). Vartofta and Norr Mälarstrand also had quite a high number of charging sessions per post (around 50 charging sessions/post during 3Q15). Five charging stations had an energy transmission of more than 1 kWh per post and day, i.e. Gallerian, Norr Mälarstrand (4.5 kWh/outlet, day), Vartofta garage (3kWh/outlet, day), Humlegården garage (1.9 kWh/outlet, day) and Högalidsgaraget (1.8kWh/outlet, day).

Conclusions normal chargers

- Significantly more charging sessions occur on weekdays compared to weekends. The assumption is that usage is strongly linked to work.
- The starting time for charging varies for different locations. Evening charging is most common at some facilities, whereas morning charging dominates at others. The usage of

public normal charging doubled for each quarter of the project period. The number of charging opportunities doubled during the same period, but also usage per post is estimated to have doubled.

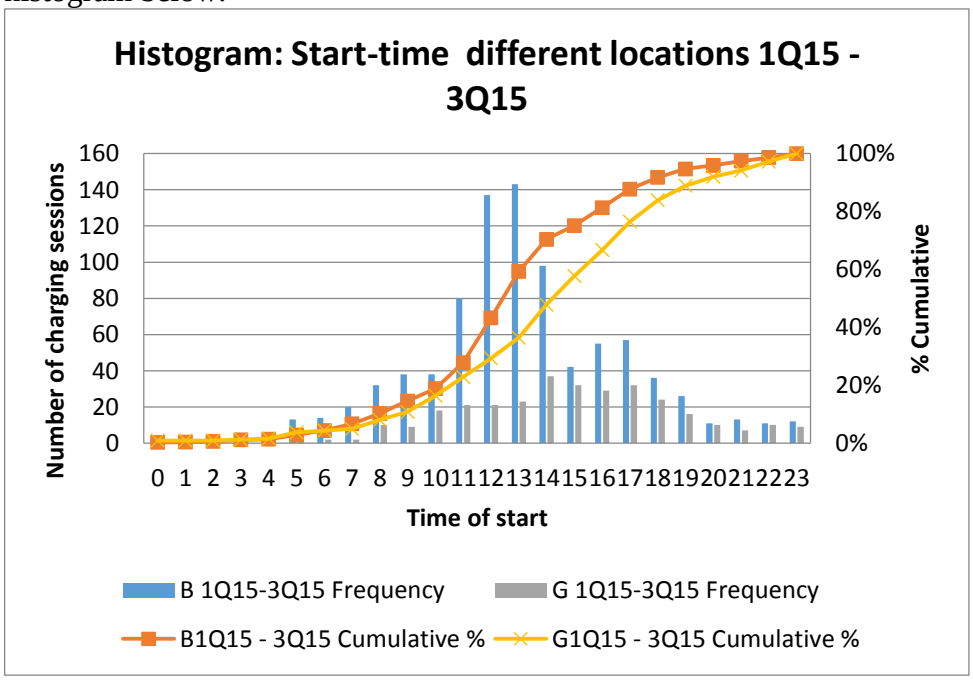
- Transmitted energy during normal charging is 4 – 10 kWh/session
- Charging time is normally 1 - 5 hours.
- Differences related to geographical location:
    - Vällingby Centre. Shorter charging sessions of less than 2 hours dominate.
    - City, work places: Gallerian and Norra Latin. Charging sessions started in the morning dominate (more than 50 per cent of charging sessions start weekdays between 5-8).
    - Södermalm, housing areas, Högalid and Vartofta. Charging sessions that start during afternoon/evening dominate.
    - City “company car” garage with many long charging sessions using a lot of energy. With all likelihood Teslas are being charged here.

Fast charging

Start-time and weekdays

Weekdays dominate also when it comes to fast charging; around 80 per cent of charging sessions took place on weekdays. This means that a great proportion of fast charging is mainly related to work and work journeys.

The start-time of fast charging sessions was spread over the day, between 5 and 23. There was no fast charging at night, as shown in the histogram below.

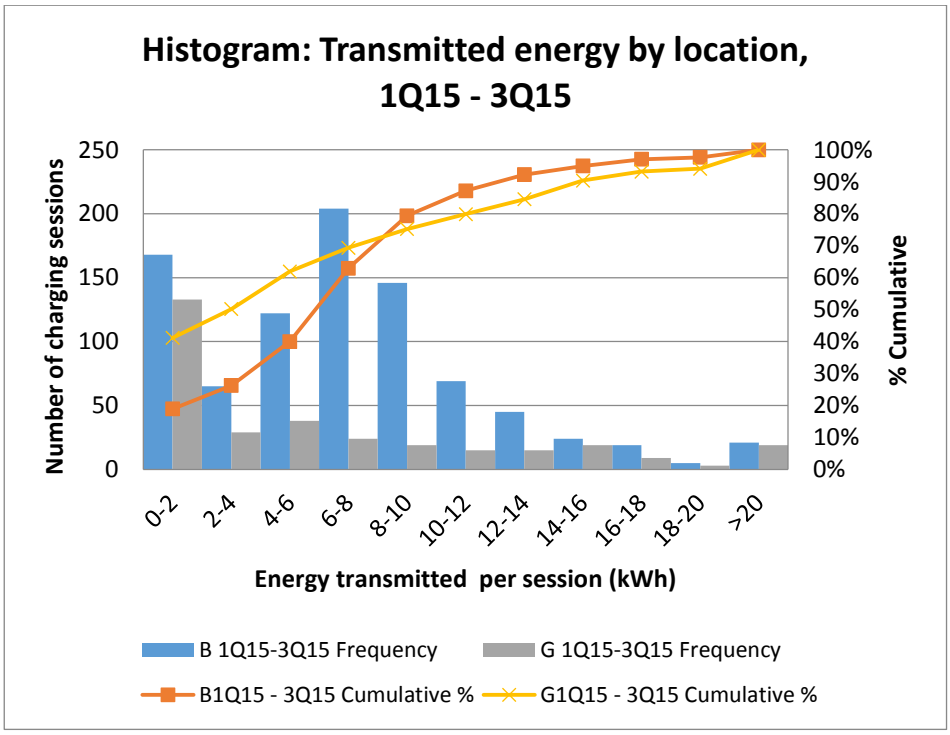


Histogram showing when charging started at two different locations in Stockholm.

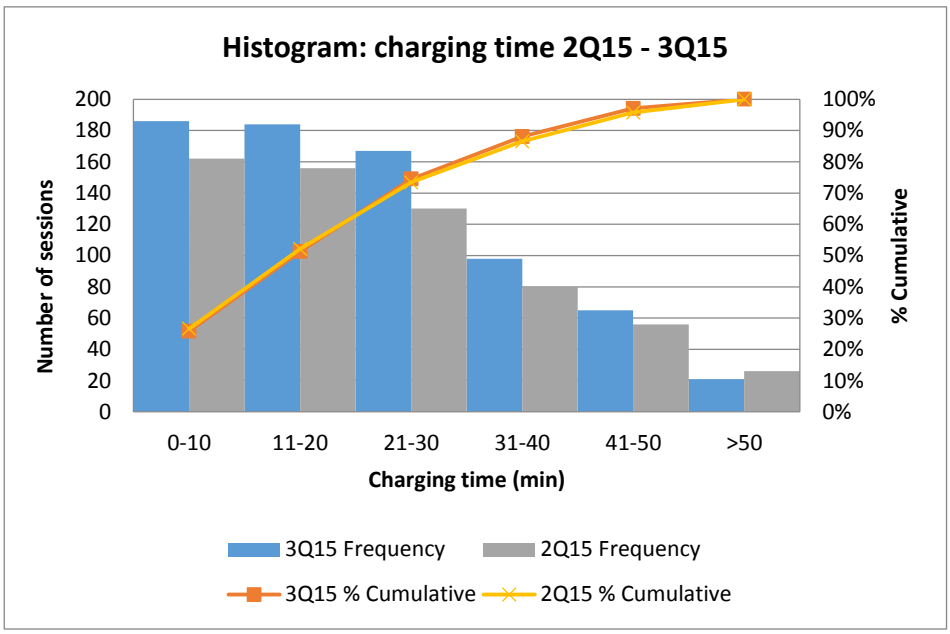
One of the fast chargers shows a peak around lunchtime (11 to 14). The same peak is not found at the other fast chargers. This was at first assumed to be company cars parked for charging at lunchtime. An investigative site visit revealed that the high lunchtime usage was due to a nearby delivery company with a high proportion of electric vehicles in their fleet charging their cars mid-day to manage the afternoon shift. Drivers from the delivery company fast-charged several electric cars, one after another, at lunchtime.

Energy transmission and charging time

The histogram below shows the spread of energy transmission for different locations.



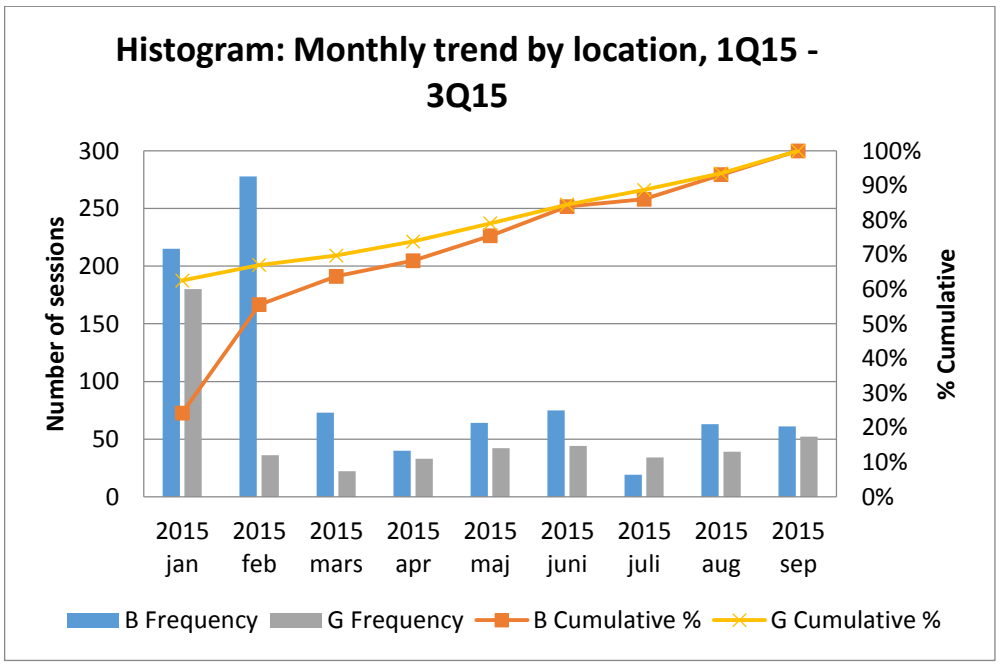
The above histogram shows energy transmitted per session for fast charging stations at two different addresses in Stockholm. The histogram below shows charging time per session.



Fast charging sessions of less than 1 kWh are considered failed sessions. Something has gone wrong and the client has had to start again. Discounting such failed sessions, an energy transmission of 4 – 8 kWh clearly dominates. The average transmission for all fast charging sessions during the project period was 8.9 kWh per session and the average charging time was 23 minutes. It is interesting that registered charging times spread over the whole interval 0–30 minutes (including failed sessions). A number of charging sessions had

an energy transmission of more than 20 kWh, and in some cases even exceeding 50 kWh (not shown separately in the histogram). It is assumed that this must be Teslas fast charging, since this is the only make of electric car with such high battery capacity. Teslas can fast charge CHAdeMO providing that the car owners bring their own adapters.

Mothly trend



The above histogram shows the number of charging sessions per month from January to September 2015, for two of the fast chargers in the project.

The use of fast chargers, as shown in the above graph, was significantly higher in January and February 2015, compared with the rest of the period. A payment system was introduced in January and February 2015 for the two fast chargers in the study. Even though usage increased continuously after March, the fast chargers were only used half as much in September as in January 2015.

One conclusion is that users changed their behaviour and usage of fast chargers when payment was introduced, most likely in favour of home-charging or public normal charging stations. Prior to the introduction of payment, a large number of plug-in hybrids used the fast chargers, and usage among this group has now sharply declined. Exactly who used fast chargers before and how they charge now is not within the scope of this report.

Conclusions fast chargers

- Choice of location is important to attract high usage by EV drivers
- Commercial EV drivers are the most frequent users of fast chargers to date
- When payment for fast charging was introduced, use of the fast charging stations declined and changed. A slow increase has since taken place. Many customers today, however, have chosen to charge elsewhere.

Qualitative user study of public charging

A survey was carried out in September and October 2015 to find out who uses the public charging stations in Stockholm today, as well as when and why. Questionnaires are a popular method of collecting and collating data from a large number of respondents in a structured way. Results can be shown as statistical or qualitative. In this survey, results have been analysed in a qualitative way. Quotes or comments reflect the reasoning of a large part of the respondents, unless otherwise stated. The questionnaires also enabled answers describing the need for an increased number of public charging stations and, if so, where.

Basic data

A large number of PEVs are leased from leasing companies. Official registers only show the name of the leasing company; i.e. the owner of the vehicle. This makes it difficult to contact the actual PEV drivers. To reach the users, a printed questionnaire was distributed and collected on site at three public normal charging stations.

Stand with questionnaires in Vartofta parking garage

To enable the study of users of public normal charging, the three parking garages with the highest usage were selected, based on technical data from 2Q15: Gallerian parking garage, Högalid and Vartofta. A stand with questionnaires, pens and a locked letterbox was placed close to the garages' charging stations, see picture above, for one week. The survey took place over a total of three weeks between 14 September and 5 October 2015 and resulted in 7 completed questionnaires. The response rate was much lower than expected! This documentation was therefore later supplemented by replies from another group of users (background explained

below) who completed a further 13 questionnaires in a web survey. In total, the survey of public normal charging includes 20 respondents.

Experiences from the survey in parking garages demonstrated the difficulties in reaching the users at charging stations. When planning a user study for fast charging, Vattenfall and Fortum were asked about the possibility of accessing their customer databases. Fortum did not reply, but Vattenfall agreed and supplied the project with mail addresses to around 380 people in Stockholm. They were invited to participate in the survey via email with a link to a web questionnaire. The web survey remained open for 3 weeks (28 October – 18 November) and attracted 269 responses. During the fast charging web survey, several respondents contacted the City of Stockholm praising the initiative to investigate the issue of public infrastructure. Thirteen of these respondents were asked if they would also take part in a web survey on normal charging facilities (with 100% response rate) and their replies were added to the questionnaires collected at parking garages (see above).

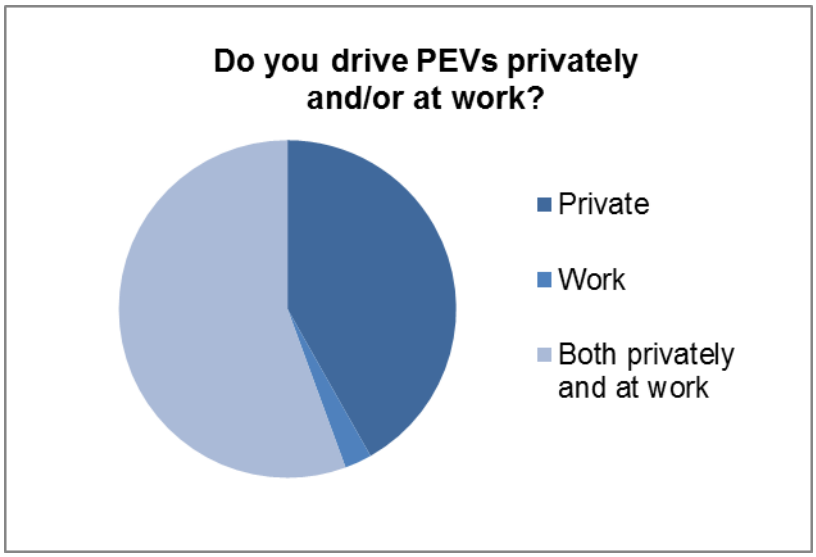
Type of public charging station	Type of questionnaire	Number of respondents	Group
Normal charging	Printed questionnaire	7	R1
Normal charging	Online questionnaire	13	R2
Fast charging	Online questionnaire	269	R3

Compilation of survey documentation

Results

Results from the qualitative survey are presented in two parts. The first part deals with results from the printed and online questionnaires on normal charging facilities, R1 and R2. The two questionnaires supplement each other, as they represent two different user groups with different usage and demands for normal charging facilities. Respondents of the printed questionnaire, R1, mainly use the public charging stations during working hours and drive PEVs that are principally company/fringe benefit cars (86%) or used only for work (14%). The respondents of the online questionnaire, R2, to a greater extent drive PEVs privately (38%) although many also use these vehicles for work (62%).

The second part treats the use of fast charging facilities. The respondents, R3, represent a more mixed user group (see figure below) and where responses mainly illustrate private usage. The email invitation to participate was also sent to a number of companies, but it is assumed that they reached fleet managers or similar who did not always circulate to users.



Background of fast charge users (N=269).

Normal charging

As mentioned before, group R1 represents drivers who mainly use public normal charging stations during working hours, while group R2 includes drivers who use these facilities in a private capacity. This becomes evident when looking at which day of the week the public facilities are used – R1 mainly use public charging stations during weekdays, and because it is close to their work place or because they have a company parking agreement with a certain garage. They park during the day, usually 7–12 hours. R2 mainly use public normal charging stations during weekends when they are in the area doing errands, and the charging time is determined by how long the errands take. Both groups are largely able to charge their cars at home.

In some of the questions on attitude, respondents were asked to weight their answers according to a Likert scale, where 4 was the highest (corresponding to agree completely) and 1 was the lowest (completely disagree). The answers revealed that access to public normal charging stations was perceived as more important for R1 than for R2; 3.29 and 2.08 respectively, and that active interest in finding a normal charging station was higher in R1 compared with R2; 3.14 and 1.85 respectively. This was not due to a higher usage of plug-in hybrids among R2, which could have been an explanation as hybrids can also run on other fuels. Quite the reverse, elec-

tric vehicles are in clear majority among R2 (85%). Electric cars were also the most common vehicle technology among R1 (57%).

All in all, public charging seems to be more important for R1 than for R2. From free-text responses it appears that employers subsidise charging, e.g. by offering company parking in centrally located garages in Stockholm. These users do not therefore bear the total cost of the parking space. R2, who mainly drive PEVs privately, use public charging stations when they are parking anyway.

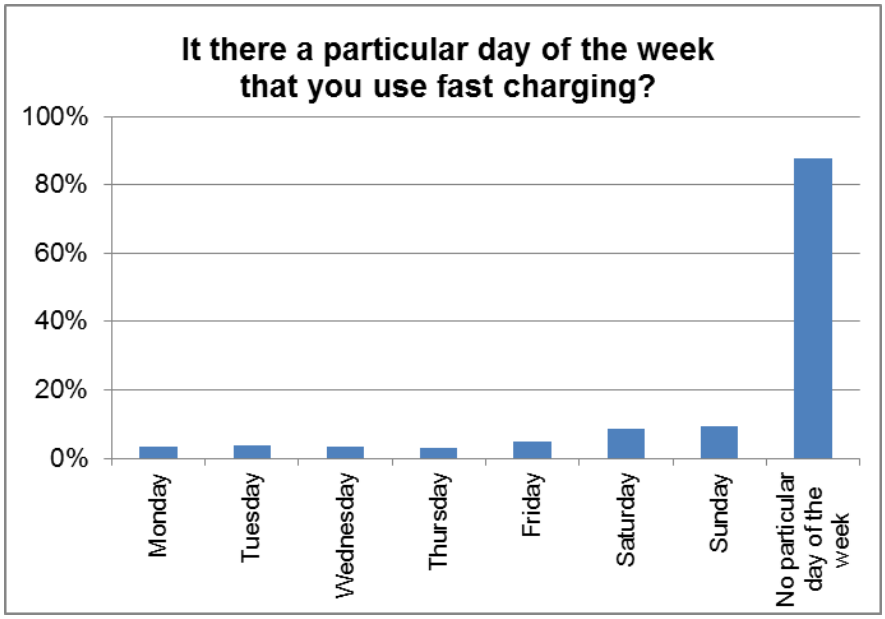
R1 respondents weight the need for public charging quite highly. It is interesting to note that R1 seem to be less informed about the different sources for finding public charging stations than R2. The survey shows that R1 often return to the charging stations they are familiar with. In several cases, drivers had located possible charging stations when they acquired their PEV and have used very few alternatives since. R2 are more knowledgeable about available charging stations and mention several different alternatives in the questionnaire. A likely explanation is that drivers who have decided to invest in a PEV privately take a greater interest.

The preferred charging stations in the survey were those in central parking garages, both by R1and R2. It is evident that normal charging stations are used while having to park anyway. Other locations where respondents would like to see more normal charging opportunities include shopping centres, and more specifically there was a demand for an increased number of public normal charging stations in the suburbs south of Stockholm. Many respondents would like to see normal charging stations at on-street parking spaces – perhaps because such parking is used when meeting family and friends, while parking garages are mainly used for more specific purposes or errands.

Respondents frequently refer to some factors that favour a specific charging station. Many users feel that access to real-time information is important. To have confirmation of an accessible and functioning charging station helps when deciding where to go. The responses also indicate a demand for chargers with a transmission rate of 22 kW AC. Largely, this is not from a personal experience since most PEVs today are limited by the onboard charger, which normally has a charging rate of around 11 kW AC (with the exception of Renault and Tesla), but rather a more theoretical wish. Both R1 and R2 also state that charging stations in parking garages normally have good maintenance and high technical availability (that the charger functions).

Fast charging

Respondents of this questionnaire, R3, drive mainly (70%) electric cars. Although all of the respondents have a customer relationship with Vattenfall and its fast chargers, a third of them never use public fast charging facilities. Respondents demonstrate a slightly higher likelihood of using fast charging at weekends, but the differences in perceived need during weekdays are small, see figure below.

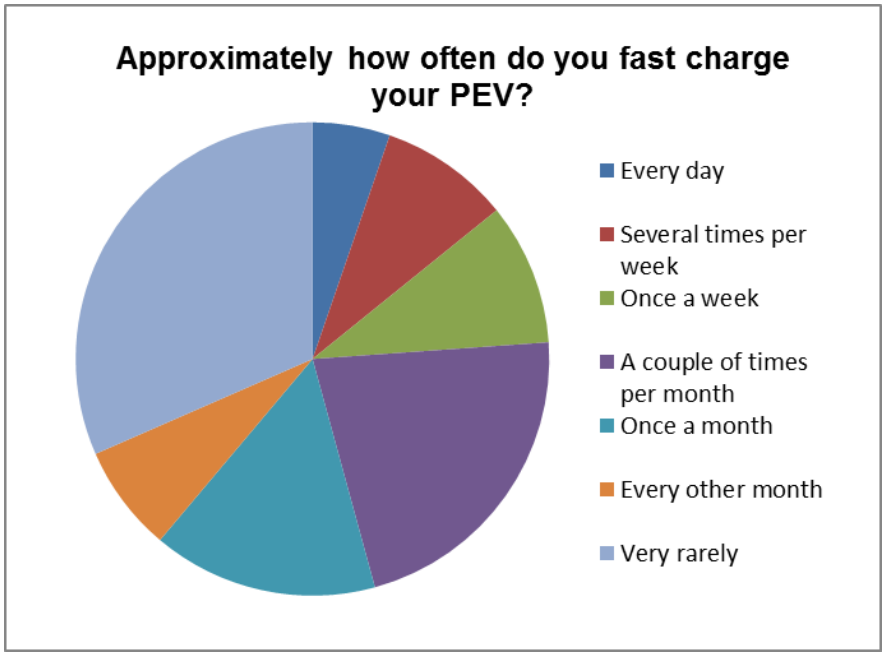


Use of fast charging divided by days

As a consolidated group R3 weights fast charging as 2.76 on a Likert scale of 1-4. Looking in detail, user behaviour is polarised; fast charging is either used often, or not at all. Less than 25 per cent state that they use fast charging at least every week, see figure below. An actual need for charging could be an explanation for these users, who often combine fast charging with a break for lunch or coffee.

The best strategic location of public fast charging stations for these drivers is virtually user specific, but at present they adjust their driving behaviour according to the locations of fast charging. A general recommendation from users to the City of Stockholm is to locate fast charging facilities near the thoroughfares leading in and out of the city. A more prominent user group, among those who frequently use fast charging, are drivers who charge at facilities that have not yet introduced payment. In general, the active interest in finding a public fast charging station is relatively low; 2.36. This can be explained by low demand from a large part of R3 and a limited demand beyond the possibility of free charging. The majority of users, who

state that they rarely use fast charging, use facilities outside the Stockholm area when they are on long journeys.



Use of fast charging divided by frequency

Among R3 respondent, 36 per cent state that they never use public normal charging stations for reasons such as “normal charging in town is not worth the trouble of taking out the charge cable”. With such reasoning, it is unlikely that fast charging would be an absolute prerequisite for PEV users either.

85 per cent of respondents state that they use fast chargers for between 5 and 45 minutes. The majority of these, 49%, estimate the charging time to 15–30 minutes. The survey shows three distinct reasons that determine the amount of time used for fast charging: the car is fully charged; 80 per cent of the battery capacity is charged (at 80 per cent, charging slows down to protect the battery); or drivers have finished the errand that took them to the charging station.

Summary – surveys

The surveys show that normal charging and fast charging meet different demands for different user groups. The questionnaires reveal that for some drivers, access to public charging infrastructure is vital. But for the majority, who have access to charging at home, public charging infrastructure in Stockholm is seen as a supplement to overnight charging. Opportunities for normal charging at parking

places where users would park anyway, appears to be a good way of contributing to many electric kilometres in Stockholm. Private individuals are probably not the main users of public fast charging, today or in the future. The survey shows that fast charging stations are rather a way of enabling electric kilometres for commercial traffic.

Sharing information

Information from the public charging infrastructure project has mainly been shared through talks at external conferences, seminars, etc. The project has also received visits and held interviews and in-depth telephone discussions with stakeholders such as municipalities, energy utility companies, etc. A half-day seminar on charging infrastructure was held in October 2015, together with Elbil2020.

Experiences from public normal charging stations within the project were published in a newsletter, see Appendix 3, and circulated to 2 000 housing cooperatives in Stockholm with the aim to inspire them to install charging in their parking areas. In 2015 especially, the project was contacted by a number of housing cooperatives asking for more specific advice on how to install charging facilities. At the same time, many private individuals have been in touch asking for information in cases where their housing cooperatives have shown little interest due to lack of time and knowledge, etc. Since the most important place for charging your car is where you park overnight, and many people in Stockholm live in housing cooperatives, spreading information to this group has been a priority.

A PowerPoint presentation summarising the project is found in Appendix 4.

Plan for continued work

Discussions with the leading market actors Vattenfall and Fortum show that they see access to public fast charging as an essential complement to normal charging stations, but that the greatest part of electricity sold for charging will be for normal charging where cars park overnight. The discussions with the two energy utility companies indicate that establishment of fast charging stations in the outskirts of Stockholm will be mainly on private land, such as comercial parking areas, shopping centres, filling stations, fast food chains, etc.

The principle for continued efforts should be that charging, just like traditional fuelling, should take place on private land. In exceptional cases, well-separated parking areas on public land could be used. This would be a temporary measure to enable the establishment of a basic network of fast charging stations across Stockholm, in order to speed up the transition to fossil-free driving. Expanding the well-separated parking sites already in use for fast charging would then be a suitable option.

On-street parking spaces alongside pedestrian pavements should never be used for charging. The spaces are often not wide enough and charging equipment may interfere with pedestrian access. Since the socket location varies on different EV makes and models, there is a risk that vehicles park against the direction of traffic.

During 2016, the transition to more electric vehicles will be supported through continued collaboration with academia and industry on the deployment of charging infrastructure. A common long-term goal for Stockholm will also be drawn up. The Traffic Administration will coordinate the work, including the Environment and Health Administration, Stockholm Parkering and other stakeholders concerned. The Traffic Administration will also investigate the prerequisites for creating “charging streets”, i.e. streets dedicated to parking and normal charging of EVs. The Environment and Health Administration will support the Traffic Administration with this through information measures. It is important to inform e.g. property owners and businesses about available grants for installing charging infrastructure.

Stockholm Parkering will continue with the deployment of public normal charging stations at around the same rate as over the past two years. In 2016 – 2018, a further 307 charging stations will be

installed at Stockholm Parkering facilities, which means that by the end of 2018 they will be offering 1 000 charging opportunities. These planned investments will be partially funded through Klimatklivet (state funding programme where different stakeholders can apply for grants for installing charging infrastructure).

The opportunity to apply for grants through Klimatklivet has resulted in more actors being interested in installing public charging in Stockholm. Public normal charging along designated streets, as mentioned above, may become a reality. A couple of actors are currently discussing this with the Traffic Administration and Environment and Health Administration. The 2012 memorandum from the Traffic Administration will continue to form a primary basis for suitable locations. The administrations are also discussing further locations for public fast charging stations with a few additional actors. It is hoped that some new public fast charging stations will be installed in 2016 and the following years.

Another essential task is to carry on with evaluations of existing and planned charging infrastructure, as well as continued monitoring of market developments, contacts with energy utility companies, parking operators, property companies, etc. It is also important to investigate if and where semi-fast charging stations can be installed, and whether the City of Stockholm should play a role in this work.

Nordic cooperation and sharing experiences and lessons learned with other Swedish municipalities is highly important. This work will be on-going. For the City of Stockholm, it is especially urgent to share experiences and collaborate with the rest of the county. The Environment and Health administration coordinates the network of municipalities in Stockholm County that was established in 2014. A joint information initiative, targeted at housing cooperatives, will be carried out in 2016 (information meetings with “mini fairs”, templates, checklists, and possibly a short instruction video).

References

Svensk Energi. (26 September 2014). *svenskenergi.se.* Downloaded from Svensk Energi: http://www.svenskenergi.se/Global/Dokument/V%C3%A4gledningar/Sv%20Energi_laddinfrastruktur%20uppdaterad%2026%20sept%202014.pdf den 21 10 2015

Appendixes

The Swedish version of this report has the following appendixes. Theses have not been translated and are therefore not included here. Available in Swedish only:

1) Proposal for possible locations of charging posts for electric vehicles, 2012-09-19
2) Example of five-year access rights agreement (zero rate) for fast charging stations
3) Clean Vehicles in Stockholm, newsletter to housing cooperatives (BRF-extra) 2015
4) Experiences from establishing public charging in Stockholm, summarising PowerPoint presentation, Eva Sunnerstedt