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Public Policies for Charging of Electric Vehicles in Multifamily Dwellings - A Case Study in Gothenburg

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Summary

The most important location for charging of electric vehicles is nearby the household. Access to a charging point is in general possible for people who own their car park, but could be more complicated for residents in multifamily dwellings. A case study was conducted with the aim to develop a common strategy for charging of electric vehicles in the proximity of multifamily dwellings in the city of Gothenburg. The suggested policies align with the city's local aims and do not hinder future densification or high utilization of parking areas.

Keywords: EV, charging, case-study, infrastructure, policy

1 Introduction

The single most important location for charging of electric vehicles (EVs) is where the car is parked most of the time, usually nearby the household for private EV users [1-4]. Access to a charging point is today in general possible for people who own their own car park, but could be more complicated for those who live in multifamily dwellings such as apartments and condominiums [5]. More simplified, close-to-home access to EV charging is therefore needed for residents of multifamily dwellings.

Sweden has a national goal to be climate neutral in 2050 and to have a fossil fuel independent vehicle fleet by 2030 [6]. In an energy scenario for Sweden 2050, which aims at providing close to 100% of the energy from renewable energy sources, short distance car journeys will be powered by electricity and longer distances journeys will be powered by a combination of electricity and biofuel [7]. One important step towards the future scenario and national goals is to facilitate the introduction of EVs. Simplifying charging of EVs near the home could promote a more rapid transition toward an EV fleet and thereby a renewable energy transport sector.

An identified barrier to make people buy an EV is, for example, range anxiety. Enabling access to charging stations could address the range anxiety even better than an extended range of the vehicle [8]. The importance of EV charging infrastructure for EV uptake is also supported by studies in Norway [9]. Most research that has addressed EV charging in multifamily dwellings almost only considers the technical solutions and optimization techniques for the EV charging infrastructure, usually with the goal of lowering the load on the electricity grid [10-12] or optimizing the cost based on electricity use [13].

Several cities have started the journey toward an electrified city with charging possibilities for residents in multifamily dwellings. In London, there is a policy for residential, retail and employment uses to provide

EV charging points [14-15]. Of the parking spaces, 20 percent should be provided with or prepared for EV charging. In California, property owners of multifamily dwellings may not forbid residents to install an EV charger at his or her current assigned parking space [16]. However, there have been some upcoming issues, for example, who is responsible for the installation costs including upgrading the electrical capacity and what payment system should be used for the electricity [17]. There is also a demand on the resident to have $1 million of umbrella liability insurance. Amsterdam has come a long way in offering publicly available EV charging. Success factors have been that Amsterdam has continuously had discussions with the stakeholders involved in the process of setting up EV chargers and has also interacted closely with researchers that have followed the development. In Amsterdam EV drivers do have priority on the city's parking permit waiting lists, but it is still a challenge to enable sufficient charging facilities in semi-public parking garages and new apartment buildings owned and maintained by owners' associations [18].

Different cities have different goals that need to be addressed when planning how to work with EV charging. Also, the size of the city and its future needs need to be covered. Placing EV chargers without first examining the need for them may result in unused chargers [19].

In Gothenburg, it is considered urgent to meet the residents' demand for charging possibilities. From a city perspective, the expansion of charging infrastructure should preferably have a common strategy and public policy. The risk is otherwise that property owners create their own solutions that could cause confusion among citizens and deadlocks regarding parking areas. Good utilization of parking space is also desired, both from the city's perspective of reducing the space required for parking, but also from a property owner's perspective to yield a higher income. Parking space reserved for EVs is therefore not seen as an optimal solution. A low proportion of EVs in comparison to the number of reserved parking spaces could result in unused parking spaces and annoyed citizens. Reserved parking for EVs could also be seen as a benefit only for those that can afford the more expensive electric cars.

Gothenburg is the second largest city in Sweden with a population of approximately 580 000 inhabitants in the urban area and about one million in the metropolitan area. In the urban area, there is a population growth of 8000 people a year, which means that the city will need to grow denser and the land and parking areas need to be used more efficiently. Today, two-thirds of the inhabitants live in multifamily dwellings. The required number of parking spaces when planning a building has been 0.54 per apartment in the inner city and around 0.7 to 0.8 in the outer parts. From the end of 2016 the city is planning to allow flexible parking numbers where different mobility solutions can lower the number of required parking spaces [20].

In general, the prerequisites for EV charging in Sweden are relatively good if you look from an energy network perspective. Today, Sweden's power grid is stable and well-developed. At the same time, there are a large number of block heaters that are normally used for preheating engine during the winter, which means that many parking spaces already are equipped with power and ten ampere fuses.

Parking spaces used by residents in multifamily dwellings in Gothenburg differ depending on who owns the building and how they have solved the issue of parking' for their residents. In some cases, the housing company owns the parking lots, which can be situated in garages, parking decks or on the housing company's own land at ground level. In these cases, tenants often have fixed parking spaces that they are allowed to rent when renting an apartment. In other cases, the city's municipal parking company provides parking for the residents. Then the resident may pay a reduced monthly fee to park in a certain area. However, these parking spaces are open to anyone to use, which therefore does not provide a guaranteed parking space, but rather means that at certain times or some days the tenant must look for a space a bit further afield. The municipal parking company's parking lots can also be situated in garages, parking decks or at ground level. Street parking is also still used, even though the city is actively working to reduce the number of street parking spaces in favour of more space for green areas, bicycles, and pedestrians.

In the city, there has been a lack of solutions and knowledge in which technology to use, who to pay and where chargers should be installed. There has also been a lack of experience in working systematically with charging infrastructure issues. Most of the existing chargers that have already been installed in Gothenburg are public chargers usually situated close to stores and have therefore mostly been used as an extra secondary charging possibility for people already having their primary charging at home. These chargers are therefore normally not functional as a primary charging alternative for residents in multifamily dwellings.

1.1 Aim

A case study was conducted during February to November 2016 with the aim to develop a common strategy for future proof charging of electric vehicles in the proximity of multifamily dwellings in the city of Gothenburg, Sweden.

2 Method

In order to gain a deeper understanding in how to enable home charging for residents in multifamily dwellings a case study was set up in Gothenburg, Sweden. Enabling EV charging in the proximity of multifamily dwellings spans several traditional responsibility areas. Installation and ownership of new equipment on existing parking spaces, measure and charge for consumed electricity, maintenance and related services could be mentioned as a few of them. Cooperation between several actors was therefore considered important to establish a unified solution. The suggested strategy should also align with the city's local aims and not hinder future densification or high utilization of parking areas and therefore it was important to include an actor who could represent the city. The municipal energy, housing, and parking companies as well as the Urban Transport Administration Agency for the City of Gothenburg were therefore identified as relevant stakeholders.

In the planning of the project the following key topics were identified as crucial for implementation; technical specifications, areas for implementation, business models, formation of policies and dissemination to the target group. All stakeholders were considered important in the project in order to identify and take into account their respective preconditions and requirements regarding the topics, not least any legal issues. The stakeholders were also chosen because they had a large market share in their respective business area in Gothenburg, and proposed solutions had therefore a greater chance of being implemented. The Urban Transport Administration Agency for the City of Gothenburg had the special role of providing input that was linked to the city's goals.

The work was mainly carried out in the form of five multi-stakeholder workshops [21] with the aim to systematically debate problems and solutions for each of the identified topics [22]. Participatory methods such as brainstorming and participant presentations were used during the workshop to enhance discussion, participation and communication among the stakeholders. For each topic, a relevant stakeholder was assigned to be responsible for and to lead the workshop. A pre-meeting was held with the responsible stakeholder to prepare the agenda and the most important questions to cover during the workshop. These questions were sent to the other stakeholders so that they could prepare and compile the best knowledge according to their own organisation's preconditions and experiences. Occasionally, assignments crucial to the topic were also sent to stakeholders prior to the workshop.

Alternative solutions and ideas from other cities was presented at each workshop to complement the knowledge in the group. The information originated mainly from meetings with delegates from other cities, but also from suppliers of hardware equipment. Study visits to other cities were arranged as inspiration for the project group.

During the workshops, conflicting needs and demands were identified and a common understanding was iterated through discussions. Representatives from the research group acted as mentors in difficult questions and ensured that the meetings followed the agenda. Data was collected in the form of meeting notes. Any unresolved questions were assigned the relevant stakeholder and noted on the agenda for the forthcoming workshop.

The gathering of relevant stakeholders was considered an important part of the method as cooperation was perceived to be a key ingredient to a successful outcome in the study and for simplifying and promoting further discussions on the subject after completion of the study. Cooperation during the workshops also allowed the freedom to raise new problems, exchange ideas and be able to quickly get suggestions for solutions.

The participants in the workshops had the task to gain approval for the results within their own organization. The Urban Transport Administration Agency for the City of Gothenburg acted as an important information channel for dissemination to the target group, i.e. residents of the city. Thus, the results were not only a final report.

3 Results

This chapter contains the results and outcomes from the workshops. The results are clustered into the identified key topics although some questions may have been resolved during a workshop with a different topic. The aim was to consolidate the results into a single strategy for the city at the end of the project that all actors should follow. However, due to the actors' heterogeneous needs and preconditions the result ended up in various action plans for the different actors, but with a basis in joint standpoints that forms the common strategy and with the goal of keeping the action plans compatible with each other.

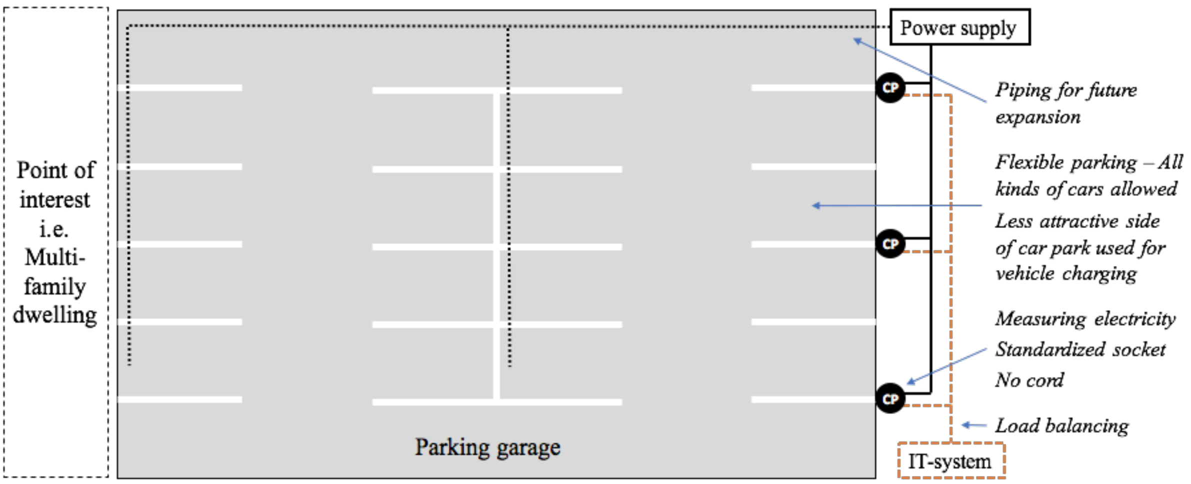

Figure1: Example of parking garage with flexible parking combined with EV charging possibility.

The actors in the study identified a need to quickly agree on a solution that was good for the city's long-term development. Individual actors not included in the study, such as tenant-owner associations, would irrespectively implement EV charging sooner or later and would then have to make their own solutions if there were no proposed policy to follow. These solutions would not necessarily be consistent with the city's goals. This common insight gave the motivation to try to reach common solutions within the project group. Some of the common viewpoints that the actors in the city of Gothenburg should strive to achieve according to the project group are exemplified in Fig. 1. The following chapters will describe the solutions and why they have been chosen.

3.1 Technical specifications

The aim was to find a feasible charging solution that could be used by as many as possible, that is safe to use and that is not too expensive. Any charging equipment installed should therefore comply with the current standards as well as with the rules for procurement and electrical safety. For charging sockets in Gothenburg this means the European standard Mode 3 Type 2 [23]. The existing block heaters are not guaranteed to meet sufficient electrical safety since they were not initially built for EV charging and therefore the project has chosen to comply with the existing standard.

It was also agreed that public charging equipment should be provided with sockets instead of fixed cords. Experiences from existing EV-chargers in Gothenburg and in other cities showed that cables sometimes get stolen, stuck frozen to the ground, destroyed by snow plows or vandalized. Sockets instead of cords could reduce repairs and maintenance and at the same time allow charging with adapters for older cars that do not follow the European standard.

When installing new chargers or constructing a new parking area, pipes should be buried close to the nearby parking spaces to allow cables to be put in later when more chargers are to be installed. In order to reduce costs related to guaranteed access to sufficiently high power, the charging poles should be prepared for load balancing. Load balancing refers to the ability to control and regulate the available power through the use of ICT. This could reduce the total cost by decreasing the maximum power needed and by sharing the installed power with nearby major energy consumers such as a real estate, a dehumidifier or an air condition aggregate. The charging poles could also preferably be placed between the vehicles and fitted with dual sockets so that two vehicles can charge from the same pole at the same time.

The chargers should also preferably be prepared for electricity measurement. Today, Swedish regulations require that electricity consumption in the home can be calculated per hour. Despite this, there are no rules for EV charging, but it is possible that it will be necessary to specify the electricity used per individual customer in the near future.

3.2 Areas for implementation

Cars parked in the street environment are considered to be a growing problem that the city wants to avoid in the future. Street parking contributes to congestion by making it more difficult for those who travel by foot, bike, car or by public transport to use the area. It also prevents the area to be used for other valuable purposes like green space. Adding a great number of EV chargers at street parking spaces, that might come with an increased number of EVs in the cities, is also considered to hinder snow plowing and street cleaning machines and could obstruct accessibility of disabled persons, for example cables to trip over [24]. At the same time, parking in the street environment is considered more easily accessible and not as unpleasant to drive into as a parking garage, according to the municipal housing and parking companies.

In certain areas of Gothenburg, parking garages are not used to full capacity despite the advantages that the car can be guarded from thieves and vandalism or protected from weather. Due to the fact that parking garages often imply a significant construction cost compared to parking spaces in the street environment it is of great interest to have high occupancy rates in the parking garages, see chapter 3.3 Business model. The construction cost of a single parking space in a parking garage above ground in Gothenburg is estimated to at least around 10 000 €. An underground parking space in a garage can amount to more than 50 000 € [25-26].

With this background, the project identified an opportunity to use the change in technology from internal combustion engines to electric drive to introduce new habits that decrease the rate of street parking and the difficulties that come with it. The aim is to reverse the trend of parking in the street environment by making parking in garages and parking decks more attractive if enhanced with charging facilities. The problems with chargers that reduce accessibility and hinder street cleaning are then also solved.

3.3 Business models

During an initial meeting with the stakeholders, flexible parking was pointed out as a core issue that needs to pervade any business model related to the introduction of charging infrastructure in the city. Flexible parking means that there should be no fixed parking spaces for a certain user or car, and that all types of cars should be allowed to park at all parking spaces instead of having dedicated parking spaces for a certain type of vehicle, such as an EV. If charging facilities are not available at all the flexible parking locations, charging spaces should be placed primarily at the less attractive parking spaces in the parking garage. There are primarily four reasons for these suggestions: 1) Separate parking spaces for EVs is not space efficient and requires on average a higher number of parking spaces per car. It also increases search traffic with a negative impact on congestion and the environment. 2) A great number of unused parking spaces reserved for EVs could cause dissatisfaction among the majority who do not have an EV. 3) Reserved parking for EVs at the most attractive locations has been considered not to be fair from a social perspective as it mainly benefits those who can afford to buy an expensive car. 4) It is less likely that less attractive parking spaces are occupied first and access to a charger will then be possible when needed. In addition, the least attractive area of a parking deck or garage is often used for central electricity. Placing chargers on the less attractive parking spaces can therefore potentially reduce costs.

It is not uncommon for people in Gothenburg to rent a fixed parking space. This is something that the city would like to avoid, unless it is private land, since it is not space efficient to have a parking space dedicated to one vehicle. The workshop participants also feared possible deadlocks if individuals were allowed to install and own a charger at their rented parking space. Discussions mainly concerned difficulties related to moving a tenant to another parking space if necessary, and how to handle the equipment and the costs related to electricity supply if the tenant would move away from the area. It was therefore agreed that charging infrastructure should be provided, when possible, by the parking operator.

It is relatively easy to implement the solution with flexible parking combined with EV charging possibility when constructing a new car park, but assuming that everyone who had their own parking space would suddenly accept a flexible parking option is not reasonable. It was therefore suggested that how the transition could occur in stages. Charging points are initially installed on requested locations and the tenant is informed that it will be available for a cost during a transitional period. When the demand for chargers increases in the area, the charger can be made available to others during times when it is usually not used, such as during the day. At the same time, the price for the initial tenant is reduced. If semi flexible parking spaces works as intended or when the tenant ends the agreement, the parking space can be made flexible.

The initial cost of establishing public charging points in Gothenburg is paid by the property owner or the local parking company. To enable a high number of charging points and a fast-growing charging infrastructure in the city, the business model needs to bear its own costs, e.g. the users of the infrastructure should pay the cost of implementation. Though, the initial cost for the user should not be too high, because that could be seen as a barrier to obtaining an EV. The cost should therefore be spread over a longer period of time. Depending on the owner, the total cost could either be paid directly by the individual EV-user or split among all users on the parking lot. In the second case, the hourly cost, paid by each car, is increased to cover the cost for infrastructure, administration and electricity. This could typically be at a parking lot, owned by the city, also used by visitors of a nearby shopping area. These costs could be added to the prevailing hourly cost.

If the user is to be charged the actual cost of the energy used, the installed technology has to be capable of identifying the user, measuring the energy used and charging the actual cost including cost for infrastructure and any additional administrative cost. The option to let everyone, car drivers or even residents, share the cost of electricity is not quite fair but could mean a lower total cost. Still there are no regulations in Sweden that require electricity measurement per individual and therefore the project only suggests preparing for future measurement if that option suits the parking operator better.

3.4 Formation of policies

The final goal of the project was to suggest a policy regarding EV charging in multifamily dwellings in the city of Gothenburg. Without this common policy, there was a risk that property owners create their own solutions that would not agree with the city's long-term goals and that could cause confusion among citizens and deadlocks regarding parking areas, for example street parking charging with the problems described above. The common viewpoints, that have been described in the result chapters, were taken at the last workshop put together to form the common policy that the project partners could agree to strive to follow when handling issues regarding EV charging in multifamily dwellings in the city of Gothenburg. Each actor got the task to adapt the common viewpoints to their own organisation and describe in more detail their actual action plan. The common policy with adaptations for each actor were anchored by the project participants in their respective organizations. These were then approved in the organizations at internal steering committee meetings.

The project partners also agreed that for the city for being successful in supporting a mass introduction of EVs the residents in multifamily dwellings should not be denied access to an EV charging station close to home. The project partners have therefore decided to work actively to help arrange a charging solution in order to help the residents feel comfortable enough to get an EV. This does not mean that you always have to install a charging station on that specific parking space the residents use today, it might instead require some residents to change to another car park.

It must also be easy for citizens to get information on how to proceed when you want to get an EV and have the opportunity to charge it if you live in an apartment. Information on how to proceed and referrals to whom you as a resident turn to for information on prices and procedure for acquiring access to a charger, should be available on the city's publicly available website.

4 Discussion

Enabling EV charging in the proximity of multifamily dwellings spans several traditional responsibility areas. Cooperation between several actors was therefore considered important to establish a unified solution. The collaborative method used to find future proof solutions for a future need of EV charging for residents in multifamily dwellings was perceived to be successful and resulted in a number of policies for establishing charging infrastructure in the future.

Now about a half year after the end of the project the municipal housing company in Gothenburg has started to build a new multifamily building with a new parking area where the solution with flexible parking combined with EV charging should be implemented. At start, 20 percent of the parking area will be equipped with chargers. The municipal parking company in Gothenburg now has an offer for EV charging if you are living in Gothenburg, typically in a multifamily dwelling. They are starting the implementation process where the demand for charging is the greatest. Both of these activities are based on the results from this study. These actors all have a significant part of the city's multifamily buildings. With the planned strategy, the city's actors will be able to satisfy a gradually increasing demand for charging in line with the growing need.

One of the key issues during the project was to not get locked into situations where utilization will be locked for only one purpose, either by a certain technique or that the ground could not be exploited otherwise. Flexible parking allows surfaces to be easily converted to other purposes than car parking if the mobility pattern changes, for example to be used for cargo bikes or electric bike charging.

As far as technology is concerned, the idea was to find solutions that are cost-effective and fit as many vehicles as possible while meeting safety and standards requirements. A solution discussed in the project was to use the existing block heaters, normally used for preheating the engine during winter. Block heaters are relatively inexpensive and the existing installations work relatively well to charge EVs, but experience says they are not built for higher effects and are not guaranteed to meet sufficient electrical safety for continuous EV charging at daily use. Therefore, they were not recommended to use.

Another technology discussed was to include equipment in the charger that controls the phases. Each charger is then connected to all three phases with three separate cables for maximum flexibility to control the power. A central unit moves the load between the phases to avoid overload if several cars connect to the same phase. The need for controlling the phases depends on the number of chargers and if the power supply is poor. The recommendation is therefore to investigate in each case whether this technology is required.

Cities of similar size and with a similar situation as Gothenburg should have good opportunities to take advantage of the experience gained and the plans developed within this study. On the other hand, the stakeholder constellation will probably be different in other cities, which could affect roles and responsibilities. The result will also differ in cities where congestion is a smaller problem and where it is possible to park along the streets. It probably also becomes more complicated in cities that lack parking garages, or where a fixed parking space is included in the apartment itself and therefore difficult to convert to a flexible parking space.

When adapting to a specific city, the results from Gothenburg indicate that the interaction between the stakeholders is a key to success. Although this study has been clearly limited both in time and economically, the participating actors have been very pleased as the collaboration has significantly increased their knowledge of the subject. The fact that all actors have a basic knowledge and have understood the problem, has led to that better solutions being identified. Early proposals were obviously not feasible as they solved only a part of the problem or created additional problems for other actors and the city. Due to the limitation in time the purpose of this study was to focus on general solutions to steer in the right direction and not in-depth solutions.

4.1 Conclusion

This paper has presented a common strategy for implementing charging infrastructure in multifamily dwellings in cities. It has also been shown that using cooperation between key actors as a working method has been a successful strategy to help the partners agree upon a united policy.

By focusing on the city's goal of removing parking from streets and getting a higher occupancy on existing parking spaces, solutions were provided with flexible parking facilities combined with charging, and the opportunity to use the introduction of EVs to move cars into parking garages through the new need for EV charging.

4.2 Future work

In this article, the importance of collaborating to solve charging infrastructure for residents in multifamily dwellings has been raised several times. Determining common viewpoints and planned activities in Gothenburg are the first steps in solving the challenge. The next steps should include adjustment of the policies when tested in practice and continued cooperation on new issues that emerge along the way. Also, the actual users need to be included, with the purpose of following up how they perceive the solutions. In addition, there are issues that have not yet been resolved, and actors in the form of, for example, private housing companies and tenant-owner associations that need to be included in the strategy work to avoid solutions that do not support the city's long-term goals.

At the end of this study, the Urban Transport Administration Agency for the City of Gothenburg promised to continue the work and take the role of cohesion in the city around these questions. Issues addressed for future work are for example; making sure that new business models match the city's goals; communicate with and inform other municipalities and private actors, such as tenant-owner associations; finding appropriate garages and parking decks where chargers for residents could be located close to multifamily dwellings regardless of who owns the parking lot and finding charging solutions for residents in multifamily dwellings with no nearby parking decks or garages and where it is difficult to enable EV charging other than at street parking.

This case study was executed in a large city in Sweden. Addressing the same question in smaller cities will most probably give other solutions and must therefore be further investigated. The same applies to larger cities outside Sweden and cities with different goals, regulations and key actors, but most likely collaboration will be the key for success for all of them.

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