Mobility and sustainability practices in Viva, a sustainable residential building complex in Gothenburg, Sweden

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Abstract

In a relative central area in Gothenburg Sweden there is a tenant-owner complex with 132 apartments. The complex was built in 2018–2019 with the ambition of being Sweden's most innovative and sustainable apartment building complex. Sustainability, in all its dimensions, guided the construction process and design from installing solar panels, energy storage facilities, facilitating recycling and providing sharing opportunities both for space and goods. From a mobility perspective no residential parking places were constructed and instead tenants are offered access to mobility services such as electric car-sharing, electric bikes and cargo bikes, larger bicycle garages and facilities for bike repair and care. We have followed the residents of Viva through interviews and surveys, before and after moving in the apartment, to assess the impact of moving to Viva has had on their sustainability practices with a special focus on mobility. We find that not having any residential parking does not imply that it is a car free housing. Both the before and after surveys show that there is a fair share of households that have retained a car, some of which reducing from previously having two. From the survey results we don't find that gender or environmental interest has any correlation with deciding to keep the car. However, car owners are slightly older than those without cars. From the interviews we find that other issues such as the ease of making everyday life work are more influential. One household with kids, e.g., was prepared to pay for parking in an adjacent parking lot for a year prior to the move, to be sure that they could retain the car. While another household, also with kids, found a large freedom in not owning a car and the financial opportunity to purchase an apartment in a relative central part of town. In general, the tenants perceive that Viva has facilitated a more sustainable living.

Introduction

The transport sector is responsible for about 24 % of CO2 emissions from fuel combustion globally (IEA 2020) and in a country like Sweden, with low emitting heating and electricity sector, this share is even higher (31 %) (EPA 2022). A major share of this is from personal vehicles. Besides technical changes also changes in behavior and practices are needed to reach climate targets (Larsson et al. 2021). Specifically, for transport the Swedish goal is a reduction of 70 % compared to 2010. At local level, such as for the city of Gothenburg, the goal is even more ambitious with a reduction of the climate impact of transport with 90 % in 2030 compared to 2010 and with a specific goal on transport work, i.e., passenger- and ton-kilometer travelled, of a reduction with 25 % in 2030 compared to 2020 (Klimat2030 2022).

Regulating parking availability can be a tool to reduce vehicle ownership and usage and thus facilitate the achievement of the climate targets while also reaching other goals in the urban context such as reduction of local emissions and congestion. Previous studies have shown that access to low-cost parking increases vehicle ownership and usage even in areas with good public transport (Guo 2013; McCahill et al. 2016) .

Parking has historically in Sweden and internationally been regulated through parking minimums set to guarantee that

mobility needs are met and based either on vehicles ownership or some kind of proxy (often close to one parking space per apartment) (Shoup 2014; Trafikverket 2013a). However, recently more flexible norms have been implemented where different factors such as building characteristics, neighborhood characteristics and access to other mobility services imply a reduction of the minimum parking requirement (Trafikverket 2013a, 2013b). This has led to new residential building with less parking and access to mobility services such as car sharing and bike sharing (Sprei et al. 2020). Even in Europe and the US lower parking requirements are being implemented (Mingardo et al. 2015; Network 2022; VTPI 2018)

While in most cases this reform results in moderate reduction of parking places, there are some cases in which no residential parking is offered. One of these is Viva an apartment building complex built in Gothenburg with 132 apartments. The building complex has had very ambitious sustainability targets encompassing all three dimensions of sustainable development (see Background section for a more description of Viva). Instead of parking they have provided different mobility services such as electric car-sharing, electric bike sharing and electric cargo-bikes.

The aim of this the paper is to provide an overview of how living in Viva has affected the residents' sustainability practices with a special focus on mobility. We do this through surveys and interviews both before and after moving into Viva. This is the first comprehensive study of Viva and of a zero-parking residence in Sweden. While other studies have been made they have either focused on evaluating specific features such as the mobility services provided (Smith et al. 2019), the app connected to these services (Lund et al. 2020) or the architecture and living space (Braide and Nylander 2021).

The paper is structured in the following way: in the background we give description of Viva and of other related studies. We also summaries the literature regarding car-free and low-car developments. We then proceed to describe the data and methods used in this study. Our results are presented in two different sections one for the surveys and one for the interviews. We conclude with a discussion and some conclusions.

Background

The ambition with Viva has been to be the most sustainable and innovative housing project in Sweden. It is built by Riksbyggen, a company owned by building unions, housing associations and by national co-operative associations. They mainly build and manage tenant-owned housing associations[1]. Viva consists of 132 apartments ranging in size from one to five rooms. It's located in Gothenburg in an area that is 10–15 minutes away from the city center by public transport and in walking distance from both Chalmers technical university and one of the major university hospitals.

Close attention has been made to ensure that the housing complex adhered to high standards within all areas of sustainability. Among the innovations introduced are concrete with 30 % lower CO2 emissions, solar cells and reusage of batteries from electric buses for storage, ecosystem service analysis and design of spaces for social interaction such as a common greenhouse area. There are also special facilities to encourage sharing of tools such as drills. Regarding mobility there is no parking provided for personal cars, instead different mobility services are supplied to support car-free living. Special attention has been made to the bike parking garage where also shared e-bikes and electric cargo-bikes are stored. Three electric car sharing cars are provided, with free membership. There are special delivery cabinets to facilitate online shopping. The mobility services are coordinated through an app called EC2B which at times also has given reduced price for public transport. When moving into Viva the new residents were invited to "mobility evenings" where they got information about the services and the opportunity to test them (Lund et al. 2020). The e-bikes and cargo-bikes are free to use, while the carsharing and the car sharing has standard pricing, but the tenants do not have to pay any membership. The establishment of the mobility services and EC2B app where partly covered by different research and innovation projects and by Riksbyggen. The running costs after that are included in the monthly fee for apartments.

Six of the apartments in Viva are "youth flats". They are reserved for young people between 18 and 30 years and are capped way below market price. The price cap is also set for the resale of these flats. The idea is to give young people with lower economic resources the chance to have their own apartment even in a central location.

There are a few other studies of Viva. Trivector, the transport consulting company that also provides the app EC2B, conducted surveys and follow-ups before and after the residents had moved in (Lund et al. 2020). The response rate for the follow-up survey was 23 % and 15 % for the digital travel diary. They find that a significant share of residents has kept the car, but that they still used the app especially for booking the bikes. Through the travel survey they found that walking was the most common used travel mode, followed by public transport and then bike. They compared the results with the travel survey from Gothenburg and found that the residents used the car less frequently than the average person living in Gothenburg. While the different mobility services were used and appreciated by many, they didn't serve all purposes. E.g., using car sharing for going longer periods to the summer cottage became expensive (Lund et al. 2020).

Smith et al. (2019) conducted interviews with 26 households in Viva with the purpose to understand how the users perceived and used the EC2B app and the connected mobility services, that together can say to form a MaaS (Mobility as a Service). This service was partly funded through different research projects. The long-term aim is to make it an economically self-sustained service. They found that the most active users were younger and have lived in Viva the longest (note that the interviews were carried out within a year after moving into Viva) and did not own a private car. Shopping and errands were the most frequently reported use of the car sharing and bikes, especially cargo-bikes. The second most common use was for leisure trips. Many of the active users chose to use apps directly related to the services rather than the collected EC2B app, but the information provided at "mobility evenings" and support was appreciated. The lack of residential parking had a dampening effect on car use, even for households that still owned a car since they had to park further away (e.g., 700m),

1. https://www.riksbyggen.se/om-riksbyggen/about-us/

making car use less convenient. For some households though access to car sharing implied an increased car usage and driving interest.

Andersson and Nilsson (2021) followed-up 13 tenant-owned associations in Gothenburg, Mölndal and Partille, of which one of them was Viva. They found that the car sharing services were more frequently used in Viva compared to other tenant-owned associations that also had parking. They found that the average utilization rate of the electric bikes varied between 8 % in the winter to up to 32 % in the summer. The cargo-bikes were used to a lower extent and reached a utilization rate of 15 % in the summer. It should be noted that these numbers were collected during 2021, thus might be affected by the restrictions during the Covid-pandemic. They also found that the occupancy rate of the bike parking was 35 %.

Braide and Nylander (2021) carried out a survey and interviews with residents of Viva. The main aim of their analysis was the living environment and how the residents perceived the apartments and the shared spaces. However, they also reported on some mobility aspects. They found, similar to Smith et al. (2019) and Lund et al. (2020), that a fair share of households still owned a car (about 50 % of the respondents). According to Lund et al this implies that vehicle ownership is about 0.18 cars per person. They compare the numbers to entire Gothenburg that has a vehicle ownership of 0.28 cars (however this is probably higher than vehicle ownership in the neighborhood around Viva). About half of the respondents said they used the shared bikes and car sharing services. The respondents perceived that access to public transport was the most important to be able to live without a car, followed by car sharing.

Outside of Sweden, there are a few studies that have looked into car-free landow-car developments.

Kushner (2005) based his analysis on sites visits of housing projects in Europe that provided restrictions on parking or vehicle ownership. Example sites were GWL-Terrein in Amsterdam, Beginenhof in Bremen, Gartensiedlung Weisenburg in Munster and Florsidorf in Vienna. Similar to Viva these housings didn't only focus on mobility but aimed to create a more sustainable living, e.g., through construction materials, water and energy management, creating an appealing outdoor environment and more social cohesion. Many of these also included reduced or more distant parking and access to car sharing vehicles.

Ornetzeder et al. (2008) studied a car free housing in Vienna and how sustainable their lifestyle was compared to a control group living in a similar housing complex nearby. They based the consumption patterns on interviews combined with data from the Austrian consumer expenditure survey and national accounts. They found that households from the car free settlement had lower emissions related to ground transportation and energy use, but somehow higher when it came to air transport, nutrition and "other" consumption, implying that the overall decrease in emissions was not that large. But given their higher income they still had a lower impact per Euro.

The district of Vauban in Germany is not directly car-free but restricts parking to designated parking houses in the outskirts of the area and with very high fees. Nobis (2003) found that even if the area attracted car owning car households, nearly half of the households decided to get rid of the car. The result from their survey also showed that the residents were very happy with their mobility options.

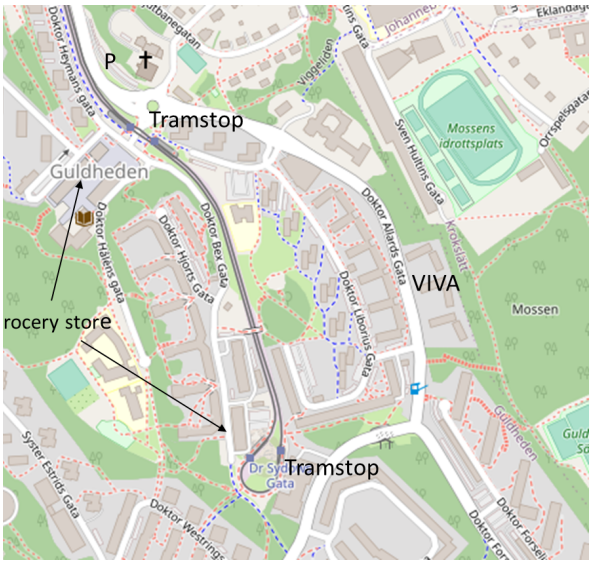


Figure 1. Map of area around Viva with marked tram stops, grocery store and the parking where several residents park their cars (P) (Source: Open Street Maps + authors).

Melia (2009; 2014) distinguished between two different types of car-free developments: areas where cars are excluded and places where people are living without cars. He also compared these with 'low car' developments where parking is limited, and the area is designed with the aim to reduce car use. He found that there was limited literature on European car-free developments, but that there was evidence that they did reduce car use and increase walking and cycling. However, there are problems and dissatisfaction as well among the residents, especially regarding parking arrangements and having to park separated from the housing.

Baehler and Rérat (2020) looked at nine developments in Germany and Switzerland that included in the tenancy or mortgage agreement a commitment not to park within the development or in the surroundings. They found four different strategies to handle living car free. Once concerning alternative transport modes, primarily bikes, including cargo bikes and e-bikes and public transport. The second was related to having access to the car when needed through car sharing. The third strategy implied choosing activities that were close by or that were accessible by walking, biking and public transport. And the fourth related to having a supporting community around. Legal and social norms as well as infrastructure and built environment were necessary to enable people to live without a private car.

Data and methods

The analysis is based on a mixed method approach relying both on surveys and interviews (Creswell and Clark 2007). The combination of methods allows us to look at larger trends but also to dig deeper into behavioral changes and perceptions. We do not have any control group to be able to compare the behaviors with similar residents in the area. To be able to see any changes we base our analysis on surveys and interviews both before

and after moving into Viva. However, the pre- and post-survey were designed by different researchers so a direct comparison cannot be made. Interviews before and after were carried out and analyzed by the same researchers. For a timeline of the data collection please see Table 1.

The pre-survey was carried out in the fall of 2016 with prospective residents of Viva, i.e., persons who had signed up for an apartment and paid a deposit. This survey was designed and analyzed by the authors of this paper. The survey was sent out to 139 e-mail addresses and 65 responses were received (47 % response rate). The survey covered not only transport modes but also general questions about among other things sustainability, sharing practice, attitudes and reasons for choosing and being interested in Viva.

The post-survey was carried out by Centrum for boendets arkitektur (CBA) (Center of housing architecture) during the spring of 2021 and presented in Braide and Nylander (2021). The survey was sent out to the 132 households living in Viva, 69 of these responded (52 % response rate). The survey was mainly focused on the perception of the apartments and the living area. However, there were a few questions about mobility and sustainability for which the authors of this paper had access to the raw data and thus carried out further analysis compared to the report by Braide and Nylander (2021).

In the analysis we have also used results from the surveys carried out by Trivector (Lund et al. 2020), where on the authors was involved in the design of the survey. Utilization rates for the different services were collected through Andersson and Nilsson (2021).

Nine household interviews were carried out during 2016 and 2017 with prospective resident households. Four more interviews were carried out in 2018 with prospective residents of the youth flats. In total this covered 26 people that were planning to live in Viva. These interviews were carried out in the resident's home or at a working place. The interviews were semi-structured, and the respondents were first asked to talk about themselves and their daily life. All interviews were recorded and transcribed.

Nine more household interviews were carried out during 2021 as a follow up. The aim was to see how the expectations and thoughts prior to moving in had been fulfilled after living in Viva for a few years. Of the 9 households that were first interviewed four had actually moved into Viva. Of the four moving into the youth flats one was interviewed again, the rest did not answer our attempts to reach out to them, but we think they moved into Viva. The remaining were contacted through e-mail to understand the reasons why they had decided not to move in. Of these two responded. The five interviews were complemented with other households that were either suggested from the households interviewed or found through acquaintances of the authors. Since these interviews were carried out during the Covid-pandemic all but one, were carried out through a video call. The interviews were recorded and later transcribed. The interviewees are given fictive names in the paper to preserve their anonymity.

Table 1. Timeline of data collection events and move to Viva.

Event	Time
Pre-interviews	Winter 2016-2017 4 interviews 2018
Pre-survey	Fall 2016
Moving into Viva	12/2018 – 5/2019
Post – survey	Early spring 2021
Post-interviews	Late spring 2021

Survey results

GENERAL DESCRIPTIVE CHARACTERISTICS OF RESPONDENTS

Table 2 shows some general statistics about the respondents in the two surveys.

From Table 2 we can see that the residents that have responded to the two surveys have fairly similar profiles, even if the respondents in the pre-survey are slightly older and more men. The higher share of men in the pre-survey can be that the e-mail list that was used for recruiting respondents was dominated by men since more of these signed up for the apartment. The household size is fairly similar. The education level for people residing in Viva is above the average in Gothenburg (49 % in 2018) and in the pre-survey we also found that the income was above average which would be expected considering that the purchasing price for the apartments in this area of town is relatively high.

VEHICLE OWNERSHIP

In the pre-survey 31 of the respondents replied that they owned one car and 13 that they owned two cars. When asked how many cars they expected to own once they had moved into Viva the number of two car household shrank to one, but 37 respondents still expected to own a personal car.

This is also reflected in the post-survey where 31 respondents answered that they still owned a car. This is slightly lower, but since these could be different samples, we can't draw any conclusions on the difference in these numbers. What is clear is that despite the fact that there is no residential parking many residents of Viva still choose to own a private car. Similar results were also found by Lund et al. (2020) shortly after moving into Viva. Lund et al. (2020) also asked where the residents with a car parked it and found that many parked on the streets in the surrounding area, rented parking spots walking distance from Viva or at relatives' places.

When analysing the post-survey, the only socio-demographic variable that had any influence on vehicle ownership was age, where car owners were older than non-owners. Factors such as attitude towards sustainable lifestyle, perception of public transport or closeness to services was not significantly different between vehicle owners and non-owners. Even the usage of car sharing and bike sharing was not different between the two vehicle owner categories.

In the post-survey 4 % answered that they had sold the car when moving to Viva, none that they had any concrete plans to sell the car and 12 % that they might sell the car in the future. Public transport was overwhelmingly the most important service that enabled car free living. Followed by car sharing. The cargo bikes were the least important. Lund et al. (2020) found very similar results in their survey. They even asked those that had sold the car or were considering selling it what would be

Table 2. Overview of characteristic of the sample in the pre- and post-survey.

Characteristic	Pre-survey (2016)	Post-survey (2021)
Age (average years)	49 (SD: 17)	44 (SD: 17)
Gender (% women)	40	48
Household size	32 % one adult 40 % two adults 23 % two adults with kids	39 % one adult 41 % two adults 20 % three or more persons
Education (% with university study)	75 %	74 %
Sample size	65	69

the main reason and the most frequent answer then was that it was too complicated to own a car without having a parking spot. Access to mobility service and the central location of Viva were two other major reasons.

When it comes to bike ownership in the pre survey the total number of bikes in the responding households was 138 but when asked how many bikes they expected to own once moving into Viva the total number shrank to 120. In the post-survey the total number of bikes sums up to 52 normal bikes and 8 e-bikes. According to Andersson and Nilsson (2021) the bike storage facility was only occupied to about 35 %.

THE MOBILITY SERVICES PROVIDED

In the post-survey 44 % of the respondents answered that they used the car sharing service. This is a quite high share of users especially compared to the national average that is only 2 % (Roos 2020). More relevant would be to compare with the Gothenburg average, however we did not find any numbers on this. Among the comments the reason for not using the services were that they either owned a car or had access to a car through family, didn't have a driving license or that it was too expensive. Some stated that they hadn't yet put were expecting to do so in the future. Shopping, visiting friends and relatives or as an alternative when their own car was unavailable were stated reasons for using the car sharing service. Several respondents that used the service thought that it worked very well.

When it comes to perception of public transport and access to services in the area, we couldn't find any difference between those that used the car sharing and those that didn't. The same goes for the importance of having a sustainable lifestyle. This last part could partly be explained by the fact that the majority of the respondents (90 %) replied that they believed that it was important to lead a sustainable life.

Looking at the relation with car ownership we can find a slightly higher car ownership among those that don't use the car sharing. But the difference is minor, 39 % instead of 33 %.

From Andersson and Nilsson (2021) we find that the number of unique users from May 2020 to March 2021 varied between 30 and 40 which corresponds pretty well with the number from the total number from the survey. If we presume these are the same users and from different households it means that about 1/3 of the households in Viva use the car sharing service regularly. The number of bookings per month during the same period varies between 85 and 165, which means that in average each user books the service 3–4 times per month.

The bike sharing service is used by slightly more residents, i.e., 51 % of the respondents. The reason for using the bike sharing (both regular e-bikes and cargo-bikes) is mainly for shopping and leisure activities. For shopping picking up packages and larger grocery shopping are explicitly mentioned. Leisure activities mentioned are longer outings, visiting friends, restaurants, and other errands in the city center. A few respondents mentioned that the cargo bikes were also used for taking kids to activities (from the survey we find that there are no privately owned cargo-bikes)

While the response rate for bike sharing was higher in the survey the number of unique users was not much higher. For the normal e-bikes the maximum number of unique users per month was 47 during June 2020, dropping to 18 in February 2021. The electric cargo bike showed a similar seasonal pattern with a maximum of 18 unique users per month. Dropping to 2 in December. The number of bookings on both services also fluctuated with the season with a maximum of 186 bookings in June 2020 for normal e-bikes and 56 in August 2020 for the cargo bikes. This results in a utilization rate of about 30 % for the normal e-bikes during the summer and 10–15 % for the cargo bikes during the same period (Andersson and Nilsson 2021).

There is a small difference in the average perception of the access to services and public transport between those that use the bike sharing and those that don't. On a scale between 1–5 where 5 is "works very well", those that use the bike sharing have an average of 4.1 for services in the area, while those that don't use the bike sharing answer 3.7. For public transport, bike sharing users answer on average 4.5, i.e., they think it works well or very well. Non -user of bike sharing have a slightly lower average for public transport of 4.1.

Interview results

MOBILITY

The mobility patterns of the interviewees had changed quite a lot, but mainly because of the Covid pandemic rather than moving into Viva. Working or studying from home was much more prevalent and thus all respondents were less mobile than usual. The families with children were a bit more mobile since many kids' activities were still ongoing but they tried to avoid public transport and instead used a combination of other modes (car, biking, waking and even e-scooters). The retired people were the ones avoiding public transport the most and have instead used the car for errands and walked. Among some of the car owning households covid has led to increased car usage. In general, many different modes were used to make everyday work, especially in combination with trying to avoid public transit. These included

both services provided by Viva but also other service such as e-scooters or the public bike-sharing service (Styr& Ställ).

Six of the interviewed households still owned a car. One household (Ruth and Roger) went from having two cars to one. The cars were used for commuting, leisure activities, grocery shopping, visiting family and summer house. While parking was a major issue in the pre-interviews, it was less of an issue in the post-interviews. Those with a car managed to find parking close to Viva. Many had their car at a parking lot about 700 m from Viva where you can rent spots from Gothenburg City (See Figure 1). For shorter stops, such as dropping of groceries or between trips they also used and paid for parking at the guest parking spots at Viva. One family decided to sell their car when moving to Viva (see one of the illustrative examples below).

Most of the interviewees had tested the car sharing service and were satisfied with both the cars and the app. The car sharing was used even by families with car when for e.g., they lent their car to others or both adults in the household needed a car at the same time.

When it comes to biking the fact that Viva is located at the top of a hill was seen as an impediment. One of the interviewees (Louise) however states that this was less of an issue at the time of the interview than in the beginning since her stamina improved. The overall location and closeness to university and workplace had the largest effect on mobility choices. There are also schools at walking distance for the families with children. The bike sharing bikes were not used regularly but all interviewees have tried at least the e-bikes, mainly out of curiosity. The cargo-bikes were perceived as a good resource but a big clumsy.

CHANGED LIFESTYLE

The interviewees didn't experience that the move to Viva had any major influence on their lifestyle, even if it implied going from two cars to one for one family and from one car to none for another. However, they did experience that there were features that made it easier to live sustainably and that were seen as positive. Two households brought up that it was easier to recycle the trash (Ruth and Bengt; and Charlotte). Having well-functioning car sharing and bike sharing and the ease of use of these services was seen as positive. They also thought that the availability of the services would facilitate more usage even in the future. The fact that the car sharing service consists of electric cars seems to have improved the image of electric cars: at least two of the interviewees (Helene and Robin) talked about purchasing an EV in the future.

EXPECTATIONS VS REALITY

Those that we interviewed before moving in and that had high expectations on Viva, especially from the social engagement side, were somehow disappointed with the involvement of the other residents when it came to common issues and the board of the tenant organization. Partly this was due to more residents than expected were PhD-students, students or researchers that choose Viva for the closeness to the university and hospital rather than its sustainability profile. Still Viva gave those that want to be engaged and social the opportunity to engage, through e.g., a cultivation group in the common greenhouse. The interviewees also perceived that the design and architecture promoted social interaction and cohesion.

Some technical issues have been problematic, especially for those interviewees involved in the board. However, the mobility services were appreciated and worked, with exception of the EC2B app that was perceived as unnecessary and an extra step.

Overall, the interviewees were very satisfied with living in Viva. What was perceived as most positive differed between interviewees. Louise appreciated the possibility to live car free and sustainably; Ruth and Bengt, the green surroundings, the social life, and an apartment that can accommodate grandchildren; Helene, the closeness to the university and a pretty apartment; Charlotte, the possibility to purchase an apartment and the location (close to the university); Urban, the social environment, the architectural choices, and common places where they can socialize with children and grandchildren.

We received two responses from those that had not moved into Viva. One was disappointed that some of the outdoor features that were first suggested were not followed through. But the most important issue was that they thought the choice for interior design such as kitchen cabinets were ugly and not as sustainable as expected. This person moved out to the countryside instead. Even the second respondent didn't like the choice for interior design such as the tiles. They also mention the lack of parking as one of the reasons (even if not decisive). They did not want to sell their car since they needed it for work and had a summer house, and thus having to park a bit away was one of the negative aspects that made them decide not to fulfill the purchase of the apartment.

ILLUSTRATIVE EXAMPLES

The analysis of the survey didn't give any clear indication of which households decided to keep a car or not. However, the interviews that went deeper into the households' life situation and attitudes were more revealing and gave insights into different motivations for having or not having a car. Here are some illustrative examples that show different reasonings around car ownership and mobility.

"The high cost of parking"

This household consists of two adults (Josefine and Rickard) and a 12-year-old child. Prior to Viva they lived in an apartment in another central part of Gothenburg, also fairly central. Both adults work and normally commute to work by car or public transport. During the pandemic they worked from home and went to the office sporadically. In those cases, they used the car. The car is used to visit relatives and driving to sport activities both for the child and adults. For them retaining the car was very important and thus in order to be sure that they would have a place to park the car they paid for a parking spot about 700 m from Viva for a year prior to moving in, while at the same time paying for parking by the apartment they were still living in.

In the pre-interview they were very concerned about the parking situation not just for their own car but even for guest coming to visit. Josefine often had relatives from out of town that came by car to visit. They felt embarrassed that they would have to pay for parking. In the post-interview they however said that they have stopped being embarrassed and have realized that if you live in the central parts of a town like Gothenburg you have to pay for parking. By visiting other friends and talking to colleagues they have found that there is no free parking. "So, I have stopped thinking it is embarrassing. They [the

relatives] have the app now, and they have understood that if you are in Gothenburg then you have to pay for parking".

The household also uses and pays (SEK10 ~1 Euro per hour) for the guest parking spaces when they temporarily stop by home and don't want to go down to the parking lot. "… and we ourselves park often up here if one is somewhere and one has to park an hour or two, one does not really have the energy to drive down the slope and walk home".

They have tested the different mobility services. Mostly because they find it fun. The e-bikes are not used that often, because Josefine appreciates her own bike a lot and does not like e-bikes that much. She finds biking around Viva very easy with good bike paths. Biking home up the hill was strenuous in the beginning but now she finds that her stamina has improved. Both Josefine and Rickard have also tried the car sharing service and used it when their own car has not been available, e.g., when it needed service or one of the adults was away skiing. They don't think the EC2B app works very well and prefer using the apps directly related to the specific services. One of the issues they bring up is concerning the security in the bike parking where a lot of burglaries have occurred. This happened especially in the beginning and now security has improved.

In summary even if this household decided to retain their car when moving into Viva, they still have a multi-modal mobility. They don't perceive that they have changed that much to a more sustainable lifestyle: "I don't know really how I would be able to do more than what I did before". However, they do mention the usage of electric cars and the bike sharing as some small improvements and that they now have the possibility to compost as well. Moving to Viva has also changed their attitude toward parking both when it comes to location: parking does not have to be right be the house; and when it comes to costs: there is no longer an expectation that parking should be free, especially for visiting people.

"Car free(dom)"

The household consists of two adults (Louise and Daniel) and three children aged 8, 16 and 19. They previously lived in a detached house outside of Gothenburg. Before living in Viva, they had two cars that they sold when moving to Viva. They have always had an interest to live more sustainably but found it hard to implement in their previous housing, especially concerning mobility. To be able to live more sustainably was one of the driving forces to move into town, to not be so dependent on the car. They first were attracted to the area where Viva is but found the apartments quite expensive. When they realized that Viva was designed for not having a car and that they wouldn't have any car related expenses they realized they could afford the apartment. Thus, the car free arrangement made it possible for them to move into a new, larger apartment in a central part of town.

At first, they thought that living without a car would be a trial and that if it was too complicated to live without one that they would purchase a car again. But they never felt that way, rather the opposite that it has been very pleasant not having to own a car.

The main fact that makes it possible to live car-free is that they are close to work and services which enables them to either bike or take public transport. Even if during the pandemic they have not used public transport as much. For their transport needs in general they combine different solutions and modes. Grocery shopping is mainly done online, or they take a car sharing car or cargo bike to the supermarket. Besides the mobility services at Viva, they are also members of another external car sharing service to be sure to always have a car, especially on weekends. During the pandemic, to avoid public transport, they also started using e-scooters. Even this household comments on the bad security in the beginning in the bike garage.

Not having to own a car is pointed out as one of the positive aspects of living in Viva. "I think it is an incredible big difference, we talk about it often, every time… Now we don't have to change tires. Yes, so nice that it is not like this: it smells a bit burnt now that we brake."

They really appreciate not having to own as many things and find using the services easier than expected. From believing that car sharing would never work they have now experience that it actually does.

For this family moving to Viva has enabled a much more sustainable lifestyle. Both the location and the access to different mobility services has enabled a car free life. They use a combination of different modes and services to make their mobility work. The family finds this lifestyle has increased their well being and allows them more freedom compared to when they were dependent of a car.

"I would love a parking lot at Viva – but it is not going to happen"

Samuel is 26 years old and lives with his girlfriend Stephanie in one of the "youth flats". Before moving to Viva, he had a sublease contract for a flat in another part of central Gothenburg. He works in an office at a larger company in one of the suburbs of Gothenburg City, while Stephanie is a student. Samuel kept his car when moving into Viva. He drives it a lot, for commuting to work every day[2], grocery shopping, and visiting his mother. "I'm that kind of person who is dependent upon a car, so, for me it is a bit difficult when you don't have a parking lot close at hand." Stephanie on the other hand uses public transport to the university.

Samuel describes the public transport option for commuting to work as troublesome, requiring one or two transfers. He has never tried it but "checked it up". He claims that public transport would take him 1 hour to 1:20 compared to approximately 15 min by car. These figures are a bit exaggerated[3]. When shopping for groceries, Samuel and Stephanie take the car to a supermarket 3 km away. The stores nearby, accessible by foot or by bike, are only visited for urgent top-ups.

Samuel and Stephanie see the sustainable profile of Viva as a bonus. It wasn't decisive for their interest in the youth flat. Anyway, they appreciate the different initiatives and services at Viva, even if they don't use so many of them, at least not yet. They have tested the electric cargo-bikes in the car sharing, but only for fun. The bikes were better than expected, but still, they can't really see the point in using them, at least not for grocery shopping. The frozen food wouldn't stay fresh on the way home on a summer day. They both have bikes, but seldom use them – it is nice to start a biking trip but going up-hill on the way home

2. When the pandemic doesn't require working from home.

3. When double checking with google maps, going by car takes 22 min, and public transport 43–58 min on a Monday morning.

is tough. When asked for something that would improve life at Viva, Samuel suggests parking, but also knows it is impossible. He parks his car at the square nearby, where many Viva-tenants have their cars. "I was pretty worried about the parking situation, until I got a parking contract two or three days after we moved in, so I managed quite perfectly."

Discussion & Conclusion

The aim of this study was to follow residents of the parking free housing complex Viva from before moving in until after living in Viva for a while. A few factors have not made it possible to complete the project as planned. The development of Viva contained many innovative factors not only connected to mobility and thus involved many actors and organizations. This made it hard to design a study that focused only on mobility and sustainability, especially without bothering the residents too much. This implied that the post survey was not designed by the same researchers as the pre survey, thus not having the same questions and not being able to follow specific individuals.

The pre and post interviews were carried out by the same researcher. However, given the smaller sample and that not all pre-interviewees decided to move into Viva the sample size of interviewees that was followed up was even smaller (5). Still the interview material gave illustrative examples of living in Viva. The challenges of this study show how hard it can be to thoroughly evaluate real life projects, especially those that are more innovative and gather many projects and actors.

Another challenge was the pandemic. The last building in Viva was finished late 2019, thus leaving little time before the pandemic restrictions were introduced. This had a larger effect on the residents' mobility patterns than moving to Viva. The interesting question is what the long-term implications are and how the combination of the pandemic with living in Viva will play out in the long run.

Our, and previous studies, show that parking free does not automatically imply car free. The residents that find it important to still own a car find ways to park. For many in Viva this has been a parking lot about 700 m away. This shows that there has most probably been a surplus of parking in the area around Viva. Thus, one take away is that when determining the number of parking places for a new building the parking availability in the surrounding area should be taken into consideration. Another is that parking doesn't always have to be suited right by the apartment building but could rather be positioned further away to make alternative modes more attractive.

From the survey we can't deduce any general traits or perceptions that determine whether a household decides to keep their car or not. From the interviews we find that it is household specific conditions such the perception of how much the car is needed for different activities and not just commuting to work. The availability of different mobility services has facilitated and prompted the households that have chosen to sell their cars. Even households that have kept their car have a multi-modal mobility pattern. From the interviews and surveys, we find that the location of Viva combined with public transport are the most important enablers for living car free, even if public transport has been used less during the pandemic. Even if the mobility patterns may not always change, there can be a shift of attitude towards parking as happened in one of the interviewed households. Thus, one of the outcomes of a parking free housing is that low cost (or free) parking is not taken for granted and that the real costs of parking are carried by those that choose to still own a car.

References

Andersson, Jenny and Nilsson, Elin (2021), 'Promoting Sustainable Mobility in Urban Areas – the Role of Residential Parking. A Multiple Case Study of 13 Homeonwer Associations in Gothenburg, Mölndal and Partille', (Chalmers).

Baehler, Daniel and Rérat, Patrick (2020), 'Beyond the car. Car-free housing as a laboratory to overcome the "system of automobility"', *Applied Mobilities*, 1–18.

Braide, Anna and Nylander, Ola (2021), 'Uppföljning av Brf Viva 201 -Bostadsundersökning – hållar gestaltning, hållbar livstil', (Gothenburg CBA, Chalmers).

Creswell, John W and Clark, Vicki L Plano (2007), 'Designing and conducting mixed methods research'.

EPA, Swedish (2022), 'Sveriges Territoriella utsläpp 202', 16-01-2022.

Guo, Z. (2013), 'Home parking convenience, household car usage, and implications to residential parking policies', *Transport Policy,* 29, 97–106.

IEA (2020), 'Tracking Transport 2020, IEA, Paris: https://www.iea.org/reports/tracking-transport-2020', 2022-01-14

Klimat2030 'Göteborgs Stad Klimatlöften', 16-01-2022.

Kushner, James A (2005), 'Car-Free housing developments: Towards sustainable smart growth and urban regeneration through car-free zoning, car-free redevelopment, pedestrian improvement districts, and new urbanism', *UCLA J. Envtl. L. & Pol'y,* 23, 1.

Larsson, Jörgen, et al. (2021), 'Konsumtionsbaserade scenarier för Sverige – underlag för diskussioner om nya klimatmål.', *Mistra Sustainable Consumption* (Rapport 1:11.; Göteborg).

Lund, Emma, Larsson, Freddy, and Adell, Emeli (2020), 'Mobilitetstjänsten EC2B i det bilfria boendet Brf Viva: Erfarenheter från det första året', (Lund).

McCahill, Chris, et al. (2016), 'Effects of Parking Provision on Automobile Use in Cities: Inferring Causality', *Transportation Research Board* (Washington DC).

Melia, Steve (2009), 'Potential for Carfree Development in the UK', (University of the West of England).

Melia, Steven (2014), 'Carfree and low-car development', *Parking: Issues and Policies,* 5, 213-33.

Mingardo, Giuliano, van Wee, Bert, and Rye, Tom (2015), 'Urban parking policy in Europe: A conceptualization of past and possible future trends', *Transportation Research Part A: Policy and Practice,* 74, 268–81.

Network, Parking Reform 'Parking Mandates Map', 16-01-2022.

Nobis, Claudia (2003), 'The impact of car-free housing districts on mobility behaviour-case study', *WIT Transactions on Ecology and the Environment,* 67.

Ornetzeder, Michael, et al. (2008), 'The environmental effect of car-free housing: A case in Vienna', *Ecological Economics,* 65 (3), 516–30.

Roos, John Magnus (2020), 'Konsumtionsrapporten 202:Acceleration. ', (Gothenburg).

Shoup, Donald (2014), 'The High Cost of Minimum Parking Requirements', Parking Issues and Policies (Transport

and Sustainability, Volume 5) Emerald Group Publishing Limited, 5, 87–113.

Smith, Göran, Sochor, Jana L, and Karlsson, MariAnne (2019), 'Adopting Mobility-as-a-Service: An empirical analysis of end-users'experiences.', *ICoMaaS*.

Sprei, Frances, et al. (2020), 'Review of the Effects of Developments with Low Parking Requirements', *Sustainability,* 12 (5), 1744.

Trafikverket (2013a), 'Parkering i storstad – Rapporter från ett forskningsprojekt on parkeringslösningar i täta attraktiva städer', (Trafikverket).

--- (2013b), 'Parkering i täta attraktiva städer – Dags att förändra synsätt', (Trafikverket).

VTPI 'Parking Management: Strategies for More Efficient Use of Parking Resources', 16-01-2022.

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