

Review of the effects of developments with low parking requirements

Frances Sprei
Chalmers University of Technology
SE-431 39 Gothenburg
Sweden
fsprei@chalmers.se

Cecilia Hult
IVL, Swedish Environmental Research Institute
Aschebergsgatan 44
SE-411 33 Gothenburg
Sweden
cecilia.hult@ivl.se

Åsa Hult
IVL, Swedish Environmental Research Institute
Aschebergsgatan 44
SE-411 33 Gothenburg
Sweden
asa.hult@ivl.se

Anders Roth
IVL, Swedish Environmental Research Institute
Aschebergsgatan 44
SE-411 33 Gothenburg
Sweden
anders.roth@ivl.se

Keywords

car transportation, mobility, individual mobility, parking, car sharing

Abstract

Parking management and planning can be used to address several issues related to sustainable urban development. E.g., parking availability affects both car ownership and usage, and parking planning can affect both land use and building costs. A tool used in several countries is minimum parking requirements (MPR) and lowering these could be a pathway to more sustainable mobility. However, the actual effects of lower MPR have not systematically been studied. In this paper we present the results of a review of twelve developments with low MPR in Sweden, Austria, Germany and Switzerland. Existing research and reports have been analysed to compare these and draw conclusions on the effect of MPR on mobility patterns and mobility services. In addition, interviews were conducted with representatives from municipalities and developers. Some of the key findings are:

- All of the studied projects have good prerequisites for sustainable mobility such as access to public transport, central location, mobility services, and bike paths.
- Results indicate that the mobility patterns of individuals in the studied projects are more sustainable than in nearby projects. However, the causality of MPR and mobility is hard to establish.
- Many projects combine MPR with mobility services such as carsharing. For this to be successful, requirements for MPR and mobility services should be included in the planning permission.

- Legally binding contracts are needed to clarify responsibilities between developer, municipalities and mobility service suppliers.
- Studied developments in and outside Sweden differ in posed requirements. Swedish projects only put requirements on parking and mobility services, whereas those studied in Germany, Switzerland and Austria put requirements on traffic or car ownership.
- It is important to look at a wider geographical area and not only the specific project. Parking availability and pricing in the surroundings might affect the outcome of a low MPR project.

Introduction

Faced with increasing challenges with global (e.g., climate change) as well as local implications (air quality and land use) cities are looking at new ways to address issues such as transportation planning and urban land use (Banister 2008). One core issue is to move away from the status quo of the car being the dominant mode of transport (Kent 2013). In a study of travel behaviour with regard to mode of transport and trip purpose (work, shopping and leisure), car ownership was the most important variable – if people own a car, they use it (Dieleman et al. 2002). There is also a link between vehicle ownership, use of vehicles and parking availability (Guo 2013; McCahill et al. 2016). Thus, reducing parking availability can have beneficial environmental consequences but might imply less mobility and accessibility for people. Combining restrictions on parking with access to mobility services such as car-

sharing may be an attractive solution to this dilemma (Vaca and Kuzmyak 2005).

Another strategy to shift mobility patterns is to incentivize the use of alternative modes of transport. Studies in the US, however, have shown that the effect of these incentives is strongly reduced by free workplace parking (Hamre et al 2014). Christiansen et al (2015) found, in Norway, that the availability of both residential parking and workplace parking affect vehicle use. There is also a growing evidence of the connection between the availability of parking and increased car ownership and car use even in areas with good access to public transport (Guo 2013, McCahill et al. 2016, Weinberger 2012, Henriksson 2008). A review report from the Swedish Transport Administration found that several studies point to parking prices as an efficient tool to reduce congestion and vehicle use in cities (Trafikverket 2013).

Urban planners have been setting minimum parking requirements (MPR) for different types of land use. Shoup (1999) lists different types of land use that have, at least in the US, been subjected to minimum parking requirements and these include bingo parlours, veterinarians and convents. Most commonly minimum parking requirements have been associated with residential buildings, offices and other commercial developments. In Sweden they have been used for housing from the 50s (Johansson & Henriksson 2018). Minimum parking requirements related to residential buildings are normally formulated in relation to the number of apartments, such as one parking space per apartment. In Sweden they were set based on US conditions despite car dependency being much larger in the US. The actual origin or motivational grounds for minimum parking requirements is not very clear (Shoup 1999). It thus seems that parking has for a long time been regulated on little empirical evidence of its effects and weak scientific base for its implementation.

Increasing evidence that liberal parking requirements lead to more expensive housing prices and to increased car use (Guo 2013; McCahill et al. 2016; Shoup 2014; Weinberger 2012) has led to a redesigning of the requirements. New parking management strategies have been recently used by several cities in Europe to manage mobility, congestion and to create more attractive environment (Kodransky and Hermann 2010). For residential buildings flexible parking requirements often allow for reductions in the number of parking places provided other solutions, such as carsharing are available (Trafikverket 2013b). In Sweden over 30 cities have introduced lower parking requirements if mobility services are provided. Lower parking requirements exists in the major Swedish cities Stockholm, Gothenburg and Malmö, as well as smaller cities. Internationally the cities of Washington, Portland, London, Berlin and San Francisco have adopted flexible parking requirements.

The shift to new forms of parking requirements has also sparked a need for knowledge especially in combination with the provision of mobility services. Urban planners and developers need to better understand how these parking norms should be designed and what the consequences are. What is an appropriate level of parking requirement? What factors determine an appropriate level of parking requirement? Do they actually reduce vehicles ownership or do they transfer vehicles to on-street parking instead? Does low-parking housing mainly attract people that already have a car-free lifestyle? What is the demand for these type of developments? As a step in trying to

address these questions we have studied evaluations of twelve existing low-parking developments. The aim of this study has been to look at the effect on mobility patterns, try to identify what lessons can be learned by projects so far but also look at the quality of the evaluations and what recommendations can be made for future studies.

For this reason we have identified the following research questions:

1. What lessons can be learned about low parking requirements based on existing evaluations? What type of measures are offered to reduce car dependence? And, are there any documented effects on mobility patterns?
2. How are developments with low parking requirements evaluated? What is the quality of these evaluations and what parameters are being evaluated?

The paper is structured in the following manner. First we describe the data that has been collected, the selection criteria for the developments and the methods used to analyse the data in the Data and Methods section. In the Results section we present first the results related to the first research question, i.e., summary and lessons learned from the evaluations, and thereafter the results regarding the quality of the evaluations. In the section after Results we discuss our results and look at developments that have recently been constructed or that are planned. We end with conclusions and recommendations.

Data and Methods

We base our analysis on twelve developments with low minimum parking requirements: eight in Sweden, one in Austria, two in Germany and one in Switzerland. Most of the developments are residential buildings, however one in Sweden is an office building and the one in Switzerland is a shopping mall and workplace. The reviewed developments can be found in Table 1.

The study is mainly based on secondary data: literature review of research papers, evaluations and reports from the developments, building permits and detail plans of the developments. In addition, interviews were made with representatives from municipalities and developers. We selected the developments based on the following criteria:

- They had lower minimum parking requirements than the rest of the municipality, or similar areas in other municipalities.
- They were fully constructed and inhabited.

In addition to this we also identified the following criteria as desirable but not necessary:

- The development had been evaluated in some way¹ regarding effects on car ownership and car usage/mobility behaviour. Evaluations carried out by researchers were prioritized.
- The development included some kind of mobility service such as carsharing.

1. We were not that strict on exactly what type of evaluation had been done, but rather that some kind of assessment of the effects had been made.

Table 1. Reviewed developments.

Name of development	Type of building	Country
Almedal	Residential	Sweden
Embla	Commercial – offices	Sweden
Florisdorf	Residential	Austria
Fullriggaren	Residential	Sweden
Hammarby Sjöstad	Residential	Sweden
Ohboy	Residential (and hotel)	Sweden
Kvillebäcken	Residential	Sweden
Porslinsfabriken	Residential	Sweden
Sihlcity	Commercial (shopping mall and offices)	Switzerland
Stellwerk 60	Residential	Germany
Stockholm Royal Seaport	Residential	Sweden
Vauban	Residential	Germany

In the first screening 28 developments were identified. 12 of these met the above criteria and were thus included in the study. Municipalities, organizations with knowledge of parking and a reference group helped us to identify existing developments in the first step.

The main focus has been developments in Sweden. The eight selected developments in Sweden are representative for inhabited and evaluated developments. The four included developments from other European countries were chosen due to the fact that they had been fully or partly inhabited for at least 10 years, and had been evaluated. They can thus show long term effects. The European developments have lower parking requirements than the majority of Swedish projects and can possibly been seen as extreme cases even in a European context. For a more in-depth description of the developments see Roth et al (2018).

Evaluations and other material have been analyzed based on a number of factors. First more descriptive parameters such as type of development, size and parking norm (parking space/apartment) have been identified. Thereafter we have looked at the requirements set on the developers when building and what types of measures have been taken to reduce car dependence. When available, effects on car ownership, car usage and mobility patterns have been analyzed. Last we have studied motivation for lower MPR and what have been the success factors and challenges for these developments.

Results

The results are divided into two different sections related to the two main research aims. In the first part we summarize and analyse the evaluations of the developments. We look at the different type of developments based on size and parking norm, the different type of measures that have been implemented to reduce car dependency, the effects on mobility patterns and other insights from the evaluations. In the second part we analyse the quality of the evaluations.

SUMMARY AND ANALYSIS OF EVALUATIONS

Figure 1 shows the residential buildings that have been evaluated and plot these based both on the size of the developments measured with the number of apartments and the parking norm, i.e. the number of car parking spaces/apartment.

Three case studies, Ohboy, Florisdorf and Stellwerk 60, have a parking norm below 0.3 and were all marketed as “car-free”. They can be seen as a type of “concept housing”, where the absence of cars is prominent. These are smaller projects with less than 1,000 apartments. While both Florisdorf and Stellwerk 60 have parking spaces, cars are not allowed in the residential area (Moser and Stocker 2008; Mantau 2011). Parking spaces are limited to the outskirts of the area.

Four case studies, Stockholm Royal Seaport, Hammarby Sjöstad, Vauban and Kvillebäcken, are larger residential areas and not individual buildings. The total number of apartments range from 2,000 to 12,000 units. The parking norms are on the higher end of the studied developments (0.5–0.65) (Stockholm 2014; Foletta and Field 2011), but still lower than a traditional 1 parking space/apartment. They are or were developed during a longer period of time (5 to 26 years) and the whole residential area has environmental or sustainability programs or goals for other aspects than mobility and transport, such as energy efficiency or land use. These programs and goals are set up in collaboration between the municipality and the housing companies involved (Svane 2008; Holmstedt 2017).

There are a variety of measures that have been implemented to reduce the dependency on privately owned vehicles and thus parking in the studied developments. These can roughly be divided into five different categories:

1. **Car related:** basically all developments have some form of carsharing that is provided by the housing company, often through some other commercial actor, for the tenants and users. Another measure is charging places for electric vehicles (Stockholm Royal Seaport). In the European car-free projects such as Florisdorf, Stellwerk 60 and Vauban the tenants sign a contract binding themselves not to own a car. Vauban, Stellwerk 60 and Sihlcity also have high parking fees to cover a higher share of the actual parking costs (up to full recovery of costs).
2. **Bike related:** Hammarby Sjöstad, Ohboy and Stockholm Royal Seaport have bikes that the tenants can borrow. Ohboy also offers other types of bikes such as cargo-bikes, as do Fullriggaren and Kvillebäcken. These three developments, plus Embla and Stockholm Royal Seaport also offer high quality bike-storage. In Embla, Ohboy and Kvillebäcken

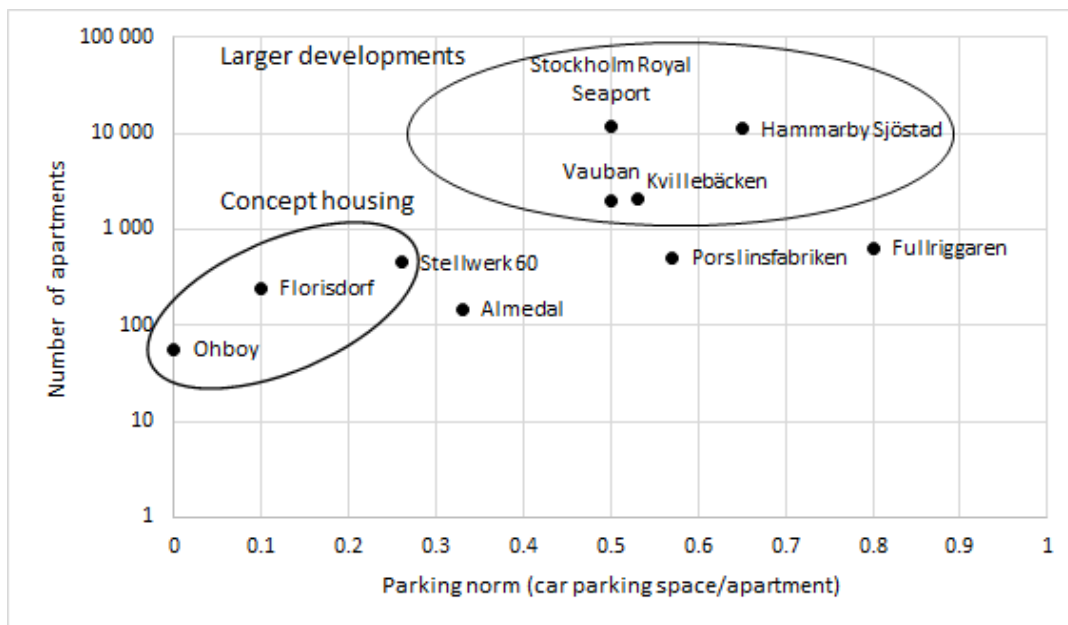


Figure 1. The studied developments plotted based on number of apartments and parking norm (car parking space/apartment). Two groups are identified: concept housing with parking norm below 0.3 car parking space/apartment and larger developments with at least 1,000 apartments and parking norm above 0.5 car parking space/apartment.

there is also a service station for bikes. Another bike related service is to provide showers and changing rooms for office workers (Embla).

3. **Public transport related:** These measures have mainly been implemented in Ohboy that has both a subsidized public transport card and real-time billboard for public transport in the entrance.
4. **Goods delivery related:** When living car-free the acquirement of different goods can be more troublesome. To address this Ohboy offers delivery boxes for packages. On the other side of the delivery, Sihlcity, a shopping mall, offers home delivery of goods by bike.
5. **General measures:** E.g., a mobility management fund, i.e., part of the revenues from parking fees are set aside for investments that enhance sustainable mobility such as better bike parking (Embla), and information efforts about sustainable mobility (Fullriggaren, Embla).

The Swedish and European developments differ in posed requirements for developers and tenants. For Swedish projects to achieve reduced parking requirements from the municipality there are only obligations to provide some mobility services. The demands, from the municipality, are only set on the developers and not on the residents and there is no compulsory follow up. In the European developments there are stronger demands on the residents that often have to sign contracts binding them not to own a vehicle. For commercial developments such as Sihlcity there are regulations on the amount of car trips to and from the area with high fines if these are surpassed.

Most of the developments have been evaluated concerning the mobility patterns of the residents. In general these patterns are more sustainable than in comparable areas (even if not all studies have a real control group to compare with – see section on quality of evaluations). Workday trips are those that most

often are done without car even in the developments with a parking requirement of 0.5 parking space/apartment or higher. The car is mainly used for leisure trips and shopping trips.

In ten of the studied developments vehicle ownership has been studied and in all of these it is lower than in comparable areas (again the quality of this comparison is sometimes questionable). The developments that are marketed as car-free in Figure 1 stand out since they have the lowest vehicle ownership and most sustainable mobility patterns. Car trips are often substituted by biking or walking. When vehicles are used they are from carsharing or car rental.

While the evaluations find that there is a positive effect regarding mobility patterns some aspects should be kept in mind. First of all the quality of the evaluation can, in many cases be questioned. This implies also that the causality, especially the specific effect of lower parking requirements, is hard to establish. It is very plausible that these type of developments attract people that already have more sustainable mobility patterns. The issue of residential self selection in relationship to mobility patterns is either not at all mentioned or poorly discussed in the evaluations. Second, all of the studied developments have good prerequisites for sustainable mobility such as access to public transport, bike paths, central location, and access to services. This implies again that the reason for the more sustainable mobility patterns is hard to establish. Regarding public transport the infrastructure has not always been in place before the construction – but has been expanded when the first residents have moved into the newly built houses or shortly thereafter. At the same time for some of the developments access to more parking has been available in the surrounding area either in the form of a parking garage nearby or on-street parking. It is thus important to look at the wider geographical area, the on-street parking availability, and not only the specific project since parking availability and pricing in the surroundings might affect the outcome.

One important factor for a positive outcome of the developments both when it comes to reducing car use and the satisfaction of all the involved parties is a clear definition of roles between the actors. Legally binding contracts are needed to clarify responsibilities between developer, municipalities and mobility service suppliers. For example the contracts could cover which actor has the responsibility for providing and promoting the mobility services, and the business model used. The consequences of not fulfilling signed commitments (e.g., not providing an agreed number of shared cars) could also be brought up in the contract, as well as forms for terminating a mobility service before the contracted time ends in the case of a lack of interest from residents or potential users. In the projects in Germany, Austria and Switzerland there have also been contracts regulating car ownership of the residents.

Regarding specifically the mobility services provided these should be included already in the planning process and permission and not be added ad hoc.

QUALITY OF EVALUATION

We now look at the quality of the evaluation taking into consideration who has performed the evaluation and what type of report that was produced, what type of methods are used, if there is a control group, if there was any before and after study and what parameters have been studied.

Few evaluations are carried out by independent researchers and most are reported in the grey literature. Only three of the case studies have been evaluated by researchers with a focus on parking and mobility: Porslinsfabriken, Florisdorf and Vauban (Antonson 2017; Ornetzeder 2008; Nobis 2003). Almedal Terrace, Fullriggaren, Hammarby Sjöstad and Stellwerk 60 have been evaluated in master or bachelor theses or by researchers with other focus than mobility. The remaining evaluations were carried out by the building companies, property owners or the city.

Different methods have been used. The most common method for the evaluation is a survey to the tenants of the developments (7 out of 12 had done this) and in four cases interviews were also performed to investigate attitudes or self-reported changes. In four of the reports it was unclear what method was actually used.

Most evaluations look at mobility patterns in one way or another, i.e., to what extent different travel modes are used and for what purpose. In some cases self-reported changes in mobility patterns are asked as well. Car ownership is another common parameter that is reported in 10 out of 12 reports. In some cases vehicle registry data has been used to determine car ownership levels. Two evaluations also look at bike ownership and six in membership in carsharing. Attitudes towards carsharing and mobility are also reported. None of the studies however have any pre and post surveys of the inhabitants.

When it comes to having any form of control group, five out of twelve evaluations compare parameters with a reference object. However, only in the case of Florisdorf and Vauban the control group is selected to make sure that location and demographics are similar. Income, employment, age and household composition are all important factors for car ownership and mobility pattern that need to be considered when selecting a control group. Evaluations of Stellwerk 60, Fullriggaren and Hammarby Sjöstad compares evaluated parameters with reference areas such as a nearby city districts or the city average. Stellwerk 60 and Fullriggaren parameters are compared with average of the same the city district, without discussing differences in average apartment size, income levels or demographics. Hammarby Sjöstad is compared both to nearby city districts and Stockholm municipality average values without commenting on the differences in demographics. Fullriggaren is also compared to a "reference district", but the characteristics of this district are not clear and neither are the criteria for selection, it could be based only on geographical similarity.

The quality of evaluations regarding documentation vary. Non-academic evaluations generally lack documentation of method used, population or sample size or complete information on questionnaires. There is also a lack of consistency when evaluating mobility patterns, where different measures are used to describe travels. Stellwerk 60 modal share is based on total travel length by mode, whereas share of number of travels is a more common measure. Using different methods for assessing car ownership can result in different outcomes in the same city district, e.g., if registry data of privately owned cars are used or if company cars are included. In Stockholm, car ownership rises between 2–20 % depending on district if company cars

Table 2. Overview of projects and if the evaluation has a control group and if it is carried out by an independent researcher.

Name of development	Type of building	Country	Control group	Independent researcher
Almedal	Residential	Sweden	No	Kind of
Embla	Commercial – offices	Sweden	No	No
Florisdorf	Residential	Austria	Yes	Yes
Fullriggaren	Residential	Sweden	"Yes"	Kind of
Hammarby Sjöstad	Residential	Sweden	"Yes"	Kind of
Ohboy	Residential (and hotel)	Sweden	No	No
Kvillebäcken	Residential	Sweden	No	No
Porslinsfabriken	Residential	Sweden	No	Yes
Sihlcity	Commercial (shopping mall and offices)	Switzerland	No	No
Stellwerk 60	Residential	Germany	"Yes"	Kind of
Stockholm Royal Seaport	Residential	Sweden	No	No
Vauban	Residential	Germany	Yes	Yes

"Yes" means that there is some comparison but not discussion or evaluation if this is appropriate.

are included (Stockholms Stad 2015) in the measure. This has to be taken into consideration when comparing results, and when drawing conclusions. Another source of uncertainty or bias on reported results arises when, instead of comparing with a control group, data is collected from other sources such as an annual city travel survey. The survey could have been carried out during a different time period, which in particular affects the share of bike trips.

There are not that many studies that best practices when it comes to studying real life transportation related interventions. The literature is rather related to evaluations of social interventions (see e.g. Lipsey and Cordrary, 2000). Graham-Rowe et al (2011) and Möser and Bamberg (2008) review transport policy measures and find that a large share of these have not been evaluated following strict qualitative criteria. The golden standard that they put forward are randomized control trials. Still these are very hard to carry out in real-life experiments and may not always capture the underlying processes (Anable 2012).

Quasi-experimental designs can be implemented in which there is a matched control group or some kind of cohort-analytic method where other groups are observed as well (Graham-Rowe et al, 2011). However, there will always be a selection bias. Even identifying and comparing with a control group can be challenging to implement. A control group could be selected from a larger sample such as a general travel survey by statistical methods that reduce the selection bias (Lipsey and Cordrary, 2000). One question is what parameters should be guiding the identification of a control group. It could be selected from a comparable location based on geodemographic profiling as well as proximity. Income and number of children are important, but also other factors such as leisure activities and location of workplace may influence mobility patterns. More research on best practices of evaluation and selection of control group are needed.

There are challenges in creating good evaluations in a naturalistic setting, and our results show that there is large room for improvement in current evaluations and that these improvements are needed to increase the robustness of results, facilitate comparability of studies and in the end increase the knowledge of the effects of reduced parking requirements.

Discussion and future outlook

As mentioned in the Introduction, several Swedish municipalities have changed their parking policy in recent years. In a review of the parking policy of ten medium and large Swedish cities the residential parking requirements now vary from 0 to 1.2 car parking space per regular new apartment that is built (Larsson et al 2018). This is significantly lower compared to the situation ten to twenty years ago. For Gothenburg and Malmö (second and third cities in size) the parking requirements for apartment buildings now vary from 0.2 to 0.5 and from 0 to 0.4 car parking space per apartment in central areas. This means that the minimum parking requirement in most cases is lower than the level of car ownership in the cities. Further, most of the cities offer an interval for new housing at a specific location depending on the availability of mobility services. Generally, a reduction of the parking requirements of 10–25 percent is given depending on what mobility services are provided by the real estate owners (Larsson et al 2018).

This means that the Swedish projects studied in this paper are part of a bigger context and a more general development toward lower minimum parking requirements in Sweden². From a situation where low parking requirements have been introduced in smaller projects as the zero parking projects Ohboy in Malmö and BRF Viva in Gothenburg there are now two other visible trends (Johanneberg Science Park, 2019). One is mentioned above that municipalities adopt lower and flexible parking requirements as a new standard for all new developments in a city. The other trend is that ambitions could be even higher for large areas and projects where municipalities and real estate owners work together. This implies that low parking developments are moving from niche projects to mainstream. In the coming years these changes will be more visible since they will affect larger areas and a larger number of residents compared to the situation today. In Stockholm, for example, 140,000 new apartments are planned during the next 15 years.

An example of a large project is Ulleråker in Uppsala, with 7,000 new apartments with an average of 0.4 car parking spaces per apartment. Parking will be localized in parking houses at the edge of the area and the planning has a focus on biking, walking, accessibility to public transport and a range of other mobility services such as carsharing (Hansson et al 2016).

Frihamnen in the central area of Gothenburg is one more big development area in Sweden with plans for 9,000 apartments and 15,000 jobs in 2040. Regarding residential parking the ambition is to have a significantly lower parking norm compared to the requirements of today (0.2–0.5). Just as in Ulleråker parking houses are planned at the outskirts of the area in combination with public transport and a wide range of other mobility services (Gothenburg city 2014).

The scale of coming projects in combination with rising awareness of the question among different stakeholders will probably lead to that new groups of residents will meet the new parking requirement, i.e., not only residents that already have a “green” lifestyle with for example low car ownership. This implies that future evaluation will give more knowledge about the effects of lower parking requirements on the larger population. For these cases acceptability of the measures will also be an important factor (Marsden 2006).

There are also good prospects that future evaluations will be of better quality. There are now a number of projects where researchers are involved from the planning stage. In Uppsala and Ulleråker, evaluations are planned to be made with the Mistra financed project Mistra Carbon Exit. In Gothenburg, evaluations of carsharing services in combination with low-parking requirements will be evaluated by Chalmers University of Technology and IVL (Swedish Environmental Research Institute) in a research program financed by the Swedish Energy Agency and The Swedish Research Council Formas. Further, the zero carpark project BRF Viva with 132 apartments will be evaluated in a big EU-project.³ In Stockholm, KTH is evaluating two residential buildings in collaboration with the developers (Johansson & Henriksson 2018). For both BRF Viva and the

2. Even in other European cities parking management is being revised, see e.g. Kodransky & Hermann (2010).

3. IRIS – smart cities, <http://irissmartcities.eu/irissmartcities/>.

two buildings evaluated by KTH future residents have filled in surveys prior to moving into the apartments and controls are being planned as well.

Conclusions

We have reviewed 12 developments with minimum parking requirements ranging from 0 to 0.8 parking spaces per apartment. We find that the mobility patterns of individuals in the studied projects are more sustainable than in nearby projects. However, the causality of MPR and mobility is hard to establish. One of the reasons is due to the low quality of the majority of the evaluations. Also all the studied projects had good prerequisites for sustainable mobility such as access to public transport, a central location, mobility services, bike paths and good access to services. Availability and price of parking in the surrounding area also affects the outcome of the project. It is thus important to take into consideration a larger area when evaluating the developments.

To reduce car dependence, many projects combine low MPR with mobility services such as carsharing. For this to be successful, requirements for MPR and mobility services should be included in the planning permission. Similarly, legally binding contracts are needed to clarify responsibilities between developer, municipalities and mobility service suppliers.

Regarding the quality of the evaluation we find that there is a large room for improvement. Ideally evaluations should be based on comparison with a control group selected based on relevant criteria and not just location. We acknowledge that this might not always be easy to implement but should still be the ambition. If this is not available and instead more general data is used, statistical methods should be used to artificially construct a control group and not just compare with the general population. Another factor that should be taken into consideration are seasonal difference that can affect, e.g., biking frequencies.

Looking forward we see that there are several even larger developments planned with lower parking requirements in Sweden. Many of these are being evaluated by researchers hopefully ensuring a better quality and therefore more robust knowledge of the connection between parking requirements, provision of mobility services and mobility patterns.

References

Anable, J. Evaluation travel interventions: where the best evidence is the enemy of the good. Becc, Sacramento, 2012.

Antonson, H., Hrelja, R., Henriksson, P., People and parking requirements: Residential attitudes and day-to-day consequences of a land use policy shift towards sustainable mobility, *Land use policy* 62, 213–222, 2017.

Banister, D., The sustainable mobility paradigm. *Transport policy*, 15 (2), pp. 73–80, 2008.

Christiansen, P., O. Engebretsen, and J.U. Hanssen, Parkeringstilbud ved bolig och arbetsplats, in *TOI rapport*, TOI, Oslo 2015.

Dieleman, F et al, Urban form and travel behaviour: micro-level household attributed and residential context, *Urban Stud*, 39 (3), 507–527, 2002.

Fastighetsägarna, Från parkering till mobilitet, www.fastighetsagarna.se, 2018.

Foletta, N., Field, S, Europe's Vibrant New Low Car(bon) Communities. Institute for Transport & Development Policy, 2011.

Graham-Rowe, E., Skippon, S., Gardner, B., Abraham, C., 'Can we reduce car use and, if so, how? A review of available evidence', *Transportation Research Part A: Policy and Practice*, 45 (5), 401–18, 2011.

Gothenburg city, Program för Frihamnen och del av Ringön, Inom stadsdelen Lundbyvassen i Göteborg programsamråd 4 juni–9 september 2014. Diarienummer: 0652/12. 2014

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

Hamre, A., Buehler R., Commuter mode choice and free car parking, public transportation benefits, showers/lockers, and bike parking at work: evidence from the Washington, DC Region, *Journal of Public Transportation*, 17 (2), 2014.

Hansson S., et al, Ulleråker, Trafikutredning, Uppsala Kommun, 2016.

Henriksson, G., Stockholmnas resvanor – mellan trängselskatt och klimatdebatt, Lund University, 2008.

Holmstedt, L. Can Stockholm Royal Seaport be part of the puzzle towards global sustainability? – From local to global sustainability using the same set of criteria, *Journal of Cleaner Production* 140 (1), 72–80, 2017.

Johanneberg Science Park, Hållbarhet: Nu startar inflyttningen Riksbyggens Brf Viva i Göteborg, www.johannebergsciencepark.com/nyheter/hallbarhet-nu-startar-inflyttningen-riksbyggens-brf-viva-i-goteborg, [Accessed 2019-01-07]

Johansson F., Henriksson G., En modern entré till mer bilfria vardagsliv i Älvsjö och Haninge? Lägenhetsköparens resvanor, dagliga aktiviteter och förväntningar före flytt till BRF On Track och BRF Blicken, med mobilitetstjänster och låga parkeringstal. TRITA-ABE-RPT-1846, KTH, Stockholm, 2018.

Kodrasky, M. and Hermann, G., Europe's parking u-turn: from accommodation to regulation, Institute for Transportation and Development Policy, 2010.

Kent, J., Secured by Automobility: Why Does the Private Car Continue to Dominate Transport Practices? Doctoral Thesis, University of New South Wales, 2013.

Larsson, M.-O. et al, Mobilitetstrender, städers politiska mål och fastighetsaktörers möjligheter att hantera mobilitet vid bostadsbebyggelse, IVL report B 2322, ISBN 978-91-88787-94-1, 2018.

Lipsey, M. W., & Cordray, D. S. Evaluation methods for social intervention. *Annual review of psychology*, 51 (1), 345–375, 2000.

Marsden, G., The evidence base for parking policies – a review, *Transport Policy*, 13 (6), 447–57, 2006.

Mantau, F., Autofreie Stadtviertel – Planung, Finanzierung und Realisierung aus der Perspektive der Bewohner, Investoren und Stadtplaner. [Car-free neighborhoods-planning, financing and realization from the perspective of the residents, investors and city planners] Master thesis. Geographisches Institut RWTH Aachen, 2011.

McCahill, C., Garrick, N., Atkinson-Palombo, C., Polinski, A., Effects of Parking Provision on Automobile Use in Cities: Inferring Causality, TRB, Washington DC, 2016.

- Moser, P., Stocker, E, Autofreies Wohnen; Evaluierung der Mustersiedlung in Wien Florisdorf. Stadt + Regionalforschung GmbH, commissioned by City of Vienna, 2008
- Möser, G., and Bamberg, S. 'The effectiveness of soft transport policy measures: A critical assessment and meta-analysis of empirical evidence', *Journal of Environmental Psychology*, 28 (1), 10–26, 2008.
- Ornetzeder, M., et al, The environmental effect of car-free housing: A case in Vienna. *Ecological Economics*, 65, 516–530, 2008.
- Roth, A., Hult, C., Hult, Å., Vikengren T., Koucky M., Sänkt p-tal som drivkraft för attraktiv stadsbyggnad och hållbar mobilitet. IVL, NR C 276, Stockholm, 2018.
- Shoup, D., The trouble with minimum parking requirements. *Transportation Research Part A: Policy and Practice*, 33 (7–8), pp. 549–574, 1999.
- Shoup, D., The High Cost of Minimum Parking Requirements, *Parking Issues and Policies, Transport and Sustainability*, 5, 87–113, 2014.
- Stockholms Stad, Parkering i Norra Djurgårdsstaden [Parking in Stockholm Royal Seaport], 2014.
- Stockholms Stad, Riktlinjer för projektspecifika och Gröna parkeringstal i Stockholm för bilparkering, 2015.
- Svane, Ö., Situations of Opportunity – Hammarby Sjöstad and Stockholm City's Process of Environmental Management, *Corporate Social Responsibility and Environmental Management*, 15, 76–88, 2008.
- Trafikverket, Parkering i storstad – Rapporter från ett forskningsprojekt om parkeringslösningar i täta attraktiva städer. Trafikverket, Stockholm, 2013a.
- Trafikverket, Parkering i täta attraktiva städer – Dags att förändra synsätt. Trafikverket, Stockholm, 2013b.
- Vaca, E., Kuzmyak, J. R., Parking Pricing and Fees-Traveler Response to Transportation System Changes, *TCRP Report 95*, 2005.
- Weinberger, R., Death by a thousand curb-cuts: Evidence on the effect of minimum parking requirements on the choice to drive, *Transport Policy*, 20, 93–102, 2012.

Acknowledgments

We gratefully acknowledge the following funding sources: Trafikverket (Swedish Transport Administration), Swedish Energy Agency and Swedish Research Council Formas. We also want to thank Torunn Vikengren from Koucky & Partners for help with gathering of evaluations and analysis of these.