Beyond the car. Car-free housing as a laboratory to overcome the 'system of automobility'

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Abstract

The car is being called more and more into question in cities due to its impact on, for example, congestion, air pollution and greenhouse gas emissions. However, since the 'system of automobility' appears to be very resilient, it is important to understand how it can be overcome. Car-free housing projects, where residents commit to living without a private car in the long term, represent laboratories for a post-car system. A mixed-method study of nine developments in Germany and Switzerland shows that residents adopt four types of strategies. They take full advantage of cycling and public transport and use mobility and transport services. They favour proximity and transit accessibility in their everyday life, and rely on their community. Moreover, a favourable social (legal and social norms) and spatial context (infrastructures and built environment) are necessary to enable people to live without a private car.

1   Introduction: from the 'system of automobility' to a 'new post-car system'

For decades, the automobile was regarded a symbol of progress and cities had to be adapted to motorised traffic (Jeekel, 2013). Urry (2004) coined the term 'car system', or 'system of automobility', to highlight the fact that the car is more than just a vehicle, but has a socio-technical system built around it, an assemblage of technologies, regulations and infrastructures as well as planning policies, various markets, practices, meanings and symbols.

The negative aspects of the car, however, have become more and more prominent: use of public space, air pollution, noise, safety risks, energy consumption, greenhouse gas emissions, etc. As a result, a growing number of cities, including Oslo, Paris and Madrid to name but a few, is implementing restrictions on the car (Nieuwenhuijsen & Khreis, 2016; Ortegon-Sanchez et al., 2017) and this trend has been reinforced with the sanitary crisis. There are also several trends moving in the direction of a less car-based transport system, represented, for example, by less car-oriented young adults (Rérat, 2018), a cycling renaissance (Pucher & Buehler, 2017) and the idea that 'peak car' may have been reached in Western countries (Goodwin & Van Dender, 2013). Other scholars, however, are more sceptical and highlight the "resilience of automobility" (Schwanen, 2016)

Overcoming "automobile dependence" (Newman et al., 2009; Newman & Kenworthy, 1999) requires the definition of an alternative whole system, a 'new post-car system' that provides the same flexibility, comfort and secure personal mobility as a car, but in a low-energy, low-carbon world (Dennis & Urry, 2009). A post-car system would draw on the technological developments of the car, which would not disappear but would be redefined (new fuel systems, new materials, smart vehicles and digitisation). Additional – and more central – changes to the organisation of mobility will involve de-privatising vehicles, introducing new transport policies and planning principles (that includes infrastructure changes and urban forms), new living, work and leisure practices, as well as 'disruptive' innovations (Dennis & Urry, 2009). Such innovations may include, for example, the idea of integrating mobility offers (or MaaS, 'mobility as a service') (e.g. Geels et al., 2012).

Car-free housing developments act as real-world laboratories for a post-car world as residents commit voluntarily to living without a private car in their everyday life, in the long term (unless they move to another location). These households may be regarded as having decided to quit, or not to enter, the system of automobility. By doing so, they show how a post-car world is possible without technological innovations of the car. Such developments are still rather rare, but their number is increasing. While a few studies have analysed these housing developments through the lens of planning (Foletta & Henderson, 2016), research is scarce on how car-free households cope with the absence of a private car in a still very car-centred society (Lagrell et al., 2018; Sattlegger & Rau, 2016). There is thus an important research gap, which this paper aims to fill by addressing car-free households' strategies, and the contextual conditions, for car-free living in Western European urban areas. In other words, this paper seeks to identify the factors facilitating the de-motorisation of households and the implementation of a post-car system based on the example of residents of car-free housing developments. They could inform planning and mobility policies.

Section 2 contains a literature review on the two aspects of a car-free mobility system. Section 3 then presents the nine case studies on which this paper is based and explains the methodology, which included a survey (N=571) and interviews (N=50). Section 4 discusses the four types of mobility strategies among residents, Section 5 the social and spatial elements of the context, and the conclusion highlights how these together form a post-car system.

2   A conceptualisation of a post-car system

Our definition of a post-car system includes two dimensions that are detailed in the following subsections: the strategies developed by households to live without a private car, and the spatial and social context that makes car-free living possible. We will apply this reading grid in the empirical part in order to identify the requirements of car-free living over the long term.

2.1   Mobility strategies: mobility capital and practices

Our understanding of daily mobility distinguishes realised spatial movements (mobility practices) from 'potential mobilities' (Kellerman, 2012), i.e. the individual's mobility capital. Drawing on the concepts of 'motility' (Kaufmann, 2011; Kaufmann et al., 2004) and 'spatial capital' (Lévy, 2003), we define mobility capital as an individual's access to the mobility options and the competences necessary in order to be mobile.

The term 'access' is used to refer to the different mobility modes available to an individual and to the ownership of vehicles (e.g. types of bicycles) or the purchase of mobility services (e.g. transit season ticket, carsharing subscription). Three types of competence are needed in order to make use of a mobility offer (Flamm & Kaufmann, 2006): physical abilities (e.g. riding a bike, walking a certain distance), acquired skills (e.g. driving licence, knowledge of a region), and organisational skills (e.g. knowing how to plan and organise movements, or where to find information). These skills are particularly important for car-free living, as the use of different transport modes is generally more demanding and complex than monomodal car use (Canzler, 2016; Laakso, 2017).

The idea of mobility capital links to the practices and strategies adopted by individuals (and households) that enable them to be mobile. According to other researchers (Lagrell et al., 2018; Rau & Sattlegger, 2018), and based on de Certeau (1988), strategies represent the individuals' leeway, as well as intentional and reflexive decisions taken in order to control and appropriate space and time. Strategies relate to minority practices in a dominant system and, in the context of a 'hegemonic car culture' (Sattlegger & Rau, 2016), refer to the ways in which people are mobile without a private car. This approach has been translated into 'accessibility strategies' in a study of voluntarily carless families with young children, which found that they largely use proximity-oriented strategies and combine the practices of everyday life (Lagrell et al., 2018).

2.2   The social and spatial context: a territory's hosting potential

The concept of a territory's 'hosting potential' is proposed by Kaufmann (2012), who highlighted the importance of a particular context for access and competences to be mobile. A territory's hosting potential is defined as its "specific ability to accommodate the projects of either individual [...] actors" (Kaufmann, 2012) or, more recently, under the term 'hospitality potential', as "a range of possibilities in terms of mobility" (Kaufmann et al., 2018, p. 200). The environment's receptiveness relates to the notion of 'affordance' (Gibson, 2014) which derives from the verb to afford, meaning both to provide and to be able to do something. Affordance is relational in that it links the suitability of a context for a particular use with the intentions and capabilities of potential users.

Affordances first refer to 'material artefacts' (Kaufmann, 2012), which include the available networks of transport modes (trains, buses, cycling routes, etc.) and telecommunication, and the built environment (e.g. density, distances, diversity of functions). It also includes immaterial aspects, i.e. the social, cultural, political and economic contexts which play an important role

in mobility, ranging from laws influencing human activities to social or cultural norms, or 'mobility cultures' (Kellerman, 2012; Klinger et al., 2013).

In other words, the hosting potential relates to the context that makes car-free living possible. There are important differences in hosting potential between countries and areas; for example, cities are generally better suited to living without a private car, due to their higher density and more developed alternative transport modes, which explains why motorisation rates are lower in cities than in the rest of the European territory. Local perceptions of the car also vary: while the car has to some extent lost part of its prestige in cities and among certain populations such as young adults (Puhe & Schippl, 2014), it still represents a symbol of freedom and autonomy in many areas. These varying attitudes also affect hosting potential for car-free living.

3   Nine case studies and a mixed-methods approach

This paper analyses residents in car-free housing developments who commit to living without a private car. Their tenancy or mortgage agreement includes the commitment not to park a car within the development or in the surroundings. Within the developments, parking is usually only available for visitors.

Nine projects were studied: five in Switzerland and four in Germany (Table 1). They are diverse in terms of number of dwellings and location (within the city and in cities of different sizes) and tenure status (renters, owners, cooperative members)[1]. Three developments are completely, and two partially, cooperative housing, a 'third way of housing' that represents an alternative to renting and ownership. It allows residents to maintain some control (e.g. self-management or participation during the planning process) and, generally, as the projects are not run for a profit, to live at a lower cost. Two of the developments (Giesserei and Stellwerk60) are car-reduced rather than car-free, i.e. parking spaces are available for about one fifth of the households. This paper is based only on car-free residents (those without a private car).

The case studies are located in Germany and Switzerland, which both have a high motorisation rate: there were 555 cars per 1,000 inhabitants in Germany and 537 in Switzerland in 2016, while the average in the EU-28 was 510 (Eurostat, 2018). Furthermore, in Germany, car manufacturers play an important economic and political role (Canzler, 2016). Nonetheless, the proportion of car-free households is gradually increasing, from 18% in 2008 to 22% in 2017 in Germany and from 19% in 2005 to 22% in 2015 in Switzerland (Follmer, 2018; OFS / ARE, 2017). This is mainly due to the biggest cities: in Bern, for example, 57% of the households live car-free, in Zurich 53%, in Berlin 51% and in Hamburg 43% (infas, 2018; OFS / ARE, 2017). Both countries are also characterised by highly developed public transport and cycling and walking infrastructures (Buehler et al., 2016).

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[1] For details on the nine case studies as well as the methods, see Baehler (2019).

Name	Town (country)	Population of the town[2]	Motorisation (cars per 1000 habitants)	Location	Type of residents	Year of completion	Number of dwellings	Response rate of the survey	Households interviewed
Burgunder	Bern (CH)	133,798	381	Outskirts	Renters	2011	80	68%	7
FAB-A	Biel/Bienne (CH)	54,640	390	Central	Cooperative members	2014	20	80%	
Giesserei	Winterthur (CH)	110,912	405	Outskirts	Cooperative members	2013	145	48%	
Oberfeld	Ostermun-digen / Bern (CH)	17,546	401	Suburban	Cooperative members	2014	94	78%	8
Sihlbogen	Zurich (CH)	409,241	343	Outskirts	Renters	2013	140	36%	5
Klein Borstel	Hamburg-Ohlsdorf (DE)	1,810,438	426	Outskirts	Owners; cooperative members	2008	62	66%	9
Saarland-straße	Hamburg-Barmbek (DE)	1,810,438	426	Central	Renters; owners; cooperative members	2000	141	48%	12
Stellwerk60	Cologne-Nippes (DE)	1,075,935	437	Central	Renters; owners	2006	426	38%	
Weißen-burg	Münster / Westphalia (DE)	311,846	452	Central	Renters	2001	136	28%	9
TOTAL							**1,244**	**46%**	**50**

Table 1: Characteristics of the car-free housing developments (data from 2017, sources: Switzerland: Federal Statistical Office; Germany: Federal Statistical Office and Federal Office for Motor Vehicles)

To investigate car-free residents, a mixed-methods approach was adopted. A two-phase explanatory design (Creswell & Plano Clark, 2007) combined a quantitative survey (for an overview) and qualitative interviews (for deeper understanding of the results). In 2016, a self-administered paper questionnaire was distributed to all 1,244 households in the nine

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2 The Swiss municipalities are the centres of bigger urban regions (except Ostermundigen, a suburban municipality). Bern, for example, is at the core of an urban region with about 410,000 inhabitants and Biel/Bienne of one with about 100,000 residents.

developments. It included questions on the household's and its members' profiles; values; housing choice; reasons for living without a car; important characteristics of car-free housing developments; access to transport modes; mobility practices; holiday and leisure activities. The survey responses were analysed with SPSS both at the general level and for each development individually. The results presented here refer to all nine developments unless important and relevant differences are observed.

The response rate was 46% overall (see Table 1). It was much higher in collaborative housing than in the rather conventional developments and especially in those including subsidised housing. In these two housing types, residents may be less interested in or satisfied with car-free housing and less prone to answer the survey and there are more residents with a lower education or migrants with language barriers.

In our survey almost all residents (94%) state that they live car-free voluntarily. Their motivations are practical (e.g. they have no need for a car) or more personal (e.g. environmental convictions, preference for other modes). Residents tend to have a high level of education but an average income level, and half of the households are families. A majority of the residents have strong social and ecological values, but there is a diversity including all types of residents, particularly in non-collaborative housing[3]. These results contrast with car-free households in general, where low incomes, young adults and elderly people are overrepresented (Haefeli & Arnold, 2015; Mattioli, 2013).

In 2017, 50 of the respondents who left their contact details in the questionnaire were interviewed, in all housing developments except the two car-reduced ones (owning a car would be possible there) and the very small project in Biel/Bienne. Face-to-face interviews were conducted with one member of each household except for four couples where both partners were present. Interviewees covered a diversity of profiles in terms of tenure status, household types and age. The interviews took place mainly at the interviewees' dwelling and lasted on average one hour. They were recorded, transcribed and finally coded with MAXQDA. A 'structured qualitative content analysis' (Kuckartz, 2016; Schreier, 2014) was used to code the answers and the discourse of car-free households: the qualitative material was summarised into thematic categories (strategies and characteristics of the context) which were not only based on theory (deductive) but also emerging from the empirical material (inductive).

Similar to the survey, the interviews addressed the residents' motivations, mobility and other everyday practices, mobility capital and the context necessary for car-free living. While the questionnaire addressed mainly factual elements and the present, the in-depth interviews allowed to get a more precise understanding of the residents' practices, their evolution and underlying motivations. They also allowed to identify the strategies and the important characteristics of car-free developments that are detailed below.

4   Strategies to live car-free

This section identifies the strategies for car-free living, which can be grouped into four types: using (augmented) alternative transport modes (4.1) and mobility and transport services (4.2), favouring car-free accessibility and proximity (4.3), and strategies relating to the community of car-free residents (4.4).

To understand the strategies used by car-free housing residents in order to cope with the

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[3] For further details on motivations and profiles, see Baehler & Rérat (2020).

absence of a private car, we analysed their mobility practices (commuting, shopping, leisure, holidays) as well as their mobility capital in terms of access and competences.

4.1 (Augmented) alternative transport modes

To be mobile without a private car implies of course a reliance on alternative transport modes, i.e. walking, cycling and public transport, which play an important role that can be identified in terms of access (e.g. vehicles or season tickets), skills and practices (Table 2).

Households owning at least one conventional bicycle (N=485)	91%
…more than one conventional bicycle per person	48%
…one conventional bicycle per person	19%
…less than one conventional bicycle per person	24%
Households owning at least one e-bike (N=487)	13%
Households owning at least one cargo bike (N=487)	5%
Residents (16+) owning a regional 'flat rate' public transport pass (N=808)	39%
…in Switzerland	29%
…in Germany	48%
Residents (16+) owning a national 'flat rate' public transport pass (GA / BahnCard 100) (N=808)	21%
…in Switzerland	39%
…in Germany	3%
Residents (16+) owning a national railway discount card (Half-Fare card / BahnCard 25/50) (N=808)	59%
Residents (18+) holding a driving licence (N=765)	84%
Residents (18+) with a carsharing subscription (N=791)	44%

Table 2: Residents' access to transport modes (for the two cases with important differences between the two countries, both values are given)

The bicycle is of fundamental importance, particularly in the 'cycling city' of Münster, but also in the other developments. More than 90% of the car-free households own a conventional bicycle. Nearly half of them have more than one bike per person, which is explained by the ownership of various types of bikes that can be used according to needs and circumstances:

> I have four bicycles, for different purposes: a folding bike, recently an e-bike, a
> beautiful sprung one, an old museum piece.[4]
> Man, 60, living alone, Saarlandstraße

The bicycle's flexibility, independence and velocity in an urban context are among the most important motivations mentioned by interviewees, as well as more personal ones (e.g. exertion, enjoyment or ecological awareness):

> It's the most convenient transport mode in the city. You can get anywhere.
> Woman, 50, childless couple, Weißenburg
> I just really like cycling. I think it's a great combination of relaxation [and] training.
> Woman, 45, couple with children, Klein Borstel

As the name of this strategy indicates, not only the classical, but also the augmented forms of alternative transport modes are used to live without a private car. In particular, two types of bicycle need to be highlighted: cargo bikes and e-bikes. 5% of the households own a cargo bike, but the interviews show that they are often shared between residents. Similarly to bicycle trailers, cargo bikes increase transport capacity and are often considered as better adapted than a car for transporting children or groceries in the city:

> We bought a cargo bike when our son was born. That is actually a substitute for a
> car, to transport things, for shopping.
> Woman, 35, couple with children, Burgunder

E-bikes represent another way of augmenting the transported load, whilst also extending the ability to cover longer distances or hilly routes. Cycling also demands certain physical abilities and is facilitated by knowledge of the city's bicycle routes. Furthermore, many residents mentioned specific equipment enabling them to cycle in any weather and all year round, such as high-quality rainwear or particular tyres for cycling on snowy roads:

> Rain, of course, doesn't bother me at all, I have my rain gear.
> Woman, 55, living alone, Saarlandstraße

The second main alternative to a car is public transport: all residents use public transport for longer distances, although they may use a bicycle for local trips. To facilitate access to public transport, many of the residents purchase a 'flat rate' regional or national pass (Table 2). While in Switzerland, reflecting the size and structure of the country, 39% of the residents have a 'GA travel card' (allowing the use of nearly all public transport lines in the whole country, including urban buses and even ships, representing, thus, a partial 'MaaS' offer), only 3% have the equivalent in Germany, where 48% of the residents hold a regional pass enabling them to travel as much as they want within their urban area. With frequent use of public transport, they acquire knowledge and skills (e.g. timetable knowledge, configuration of the network, organisation of stations, connections between lines):

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[4] All quotes from the interviews were translated from German by the authors.

> Furthermore, I have a transport pass for the whole area. I can get on anywhere […]
> that's super comfortable, I can get on any bus.
> Woman, 75, childless couple, Saarlandstraße

Finally, a common strategy is to adopt inter- or multi-modal practices. Most residents combine public transport and cycling or walking, either using different modes for different activities or destinations, or using multiple modes within the same journey (e.g. cycling to the nearest railway station and taking the bike onto a train). To reach their place of work or education, 43% of the residents reported the use of multiple transport modes (inter- or multimodal practices) while 25% each are only cycling or using public transport:

> In everyday life a mix of cycling, public transport, walking, the three main things.
> Man, 45, couple with children, Saarlandstraße
> Distances within 1-2km mostly on foot, if it's 3km I take the e-bike, if it's even further the bus or train.
> Man, 70, childless couple, Oberfeld

As the above quotation shows, walking is also an essential part of multi- or inter-modal mobility, enabling individuals to make use of shortcuts, for example, or to avoid waiting for a bus to ride one or two stations. This of course implies a good knowledge of the city. Some residents also reported that they frequently walk long distances.

> I walk a lot. I also like to do that, so I sometimes say to myself, no, this distance, that is not so far now, 3km there and 3km back, I can do that well also on foot.
> Woman, 55, couple with children, Klein Borstel

This first strategy includes both dimensions of mobility capital. It shows that most residents have access to (various kinds of) bicycles and public transport (and a season ticket) as well as all types of competences to use them: physical abilities to cycle and walk but also the necessary organisational skills to combine the alternative transport modes which, as mentioned above, is more complex than monomodal car use (Canzler, 2016; Laakso, 2017).

4.2 Mobility and transport services

The second type of strategy we identified is the use mobility or transport services to travel or to transport goods. This includes different types of car use, as 84% of the adult residents hold a driving licence, even if the interviews showed that not all of them still drive. 44% of all adult residents have a carsharing subscription[5], 60% use carsharing cars (whether subscribed or not) and about one third borrow a car from friends or relatives from time to time. Finally, rental cars are also used in particular cases, mainly for holidays. However, 90% of the residents drive less than once a month (Table 3). They do so mainly to transport big or heavy things or, to a lesser extent, to visit friends or relatives and for leisure activities:

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[5] This relates to 'classical', station-based carsharing. While in Germany there are many different providers, in Switzerland, there is basically only one ('Mobility Car Sharing'), providing over 3,300 cars at more than 1,400 stations, not only in urban regions, but also at railway stations all over the country.

> Mostly for bigger things, for normal shopping we never need a car. I would really say holidays, ski tours, and transporting large or heavy things.
> Woman, 35, couple with children, Burgunder

	Never	Less than once a month	About 1-2 times a month	About once a week	More than once a week
Daily shopping (e.g. food)	88%	8%	2%	2%	0%
Particular shopping (e.g. big or heavy things)	29%	66%	4%	1%	0%
Visiting relatives or friends	52%	39%	8%	1%	0%
Leisure activities	51%	40%	7%	2%	0%
Professional reasons	74%	16%	5%	3%	2%

Table 3: Reasons and frequency of car use (N=469 to 477)

To live car-free does not mean never using a car, but renouncing ownership of a private car and having a limited use of shared cars. The use of other mobility services, such as taxis or lift-sharing services, is rare and applies only to certain specific situations:

> If there's ever actually a very urgent issue or if I have to hurry somewhere, then I take a taxi.
> Woman, 65, living alone, Klein Borstel

The smartphone appears to be a crucial tool in facilitating access to and use of these services, but also for all other transport modes and for car-free mobility in general:

> The smartphone is totally cool when you don't have a car. […] It's so normal [to have a smartphone] that I don't even think about it. That is a relief, of course.
> Man, 40, couple with children, Weißenburg

(Mobile) communication and information technologies also enable individuals to obtain real-time information such as public transport timetables, location and availability of shared vehicles, maps and also weather forecast and rain radars (the latter are particularly important for cycling and walking). Apps also enable access to different mobility services and thus facilitate inter- and multi-modal mobility, as well as helping individuals to cope with uncertainties when travelling without a private car. Moreover, with digital devices they are able to make use of travel time on public transport.

Digitalisation has also facilitated delivery services, on which many residents rely for the transportation of heavy goods. Online shopping can be particularly helpful given the car-centred location of many specific shops. However, many residents stated that they rarely shop online, for social and ecological reasons, while vegetable- or fruit-basket subscriptions from regional organic farms are popular. A strategy for holiday travel is to send luggage ahead by

post or train, so that they can travel easily by public transport without having to carry heavy suitcases.

This second strategy also combines both dimensions of mobility capital (i.e. access and competences) to make use of mobility services. Access refers for example to carsharing subscriptions and acquired skills to the driving licence and knowledge about mobility services (which also refers to organisational skills). This strategy also highlights that a post-car system implies de-privatising cars and may rely on the use of shared vehicles when needed (Dennis and Urry 2009).

4.3   Car-free accessibility and proximity

The third strategy relates to the importance of the spatial dimension of lifestyles that are organised around destinations easily accessible without a car. A major aspect is proximity, as this ensures accessibility on foot, by bike or by urban public transport. Indeed, the location of the housing project and its accessibility by alternative transport modes to the car represent central criteria in the housing choice of car-free residents.

This strategy also applies to the workplace. In the German case studies, at least 86% of the residents work in the city they live in, revealing a logic of proximity. The situation is different in the Swiss projects, as these are located in smaller cities but close to other cities. Up to 60% of the residents commute outside the urban region in which they live. In this case, what predominates is accessibility to the national railway network.

For activities other than work, residents are generally able to choose the locations where they are performed. For shopping, the proximity of grocery shops or supermarkets is favoured by most car-free households. In some housing developments there are even small shops or weekly market stands from organic farms. Furthermore, shopping is often combined with other everyday trips, such as on the way home from work:

> Mostly on the way back home from work, at [two supermarkets nearby].
> Man, 45, couple with children, Oberfeld

Leisure activities, besides those taking place in the dwelling, include in many developments an important amount of time spent with neighbours. This is particularly the case in cooperative housing, where different community activities take place (yoga, film screenings, children's activities, etc.), which may be formally organised or more spontaneous:

> We have a quite active social life here with the neighbours.
> Woman, 75, childless couple, Saarlandstraße

Outside the development, leisure activities take place in places either connected by public transport or accessible by bicycle:

> We do bicycle trips or cycle somewhere to the forest or to the lake, or the
> surrounding area, to the canal. Well, you simply search accessible destinations.
> Woman, 50, couple with children, Weißenburg

Finally, even for holidays, car-free accessibility plays a role for most residents. While some rent a car or even fly for holidays, most interviewees avoid using cars and planes, for environmental

reasons. The majority of residents also favour proximity for holidays, although on a different scale, as most stayed in their country or at least in Western Europe:

> Most of the time we really go on holiday more or less in the surroundings, in Switzerland, where you don't rely on a car even during the holidays.
> Man, 40, couple with children, Burgunder

This third strategy highlights the competence to plan activities and to choose destinations according to the accessibility on foot, by bike or by public transport. These households are mobile but they adopt 'new living, work and leisure practices' that are independent from cars (Dennis and Urry, 2009). It reflects the strategies found in other studies on car-free households, including communicative, organisational but also accessibility aspects, in particular "accessibility by proximity" (Lagrell et al., 2018; Rau & Sattlegger, 2018).

4.4   Community activities and neighbourly help

The last strategy relates to a community of like-minded neighbours collaborating to cope with certain difficulties that the absence of private cars could entail. Such aspects are identified not only in collaborative housing projects. First, as mentioned above, mobility equipment (e.g. bicycle trailers) is often shared with neighbours; digital solutions, such as web platforms or mailing lists, may facilitate sharing. Communication tools also allow people to announce when they are renting a van to drive to a DIY store or garden centre, and to offer to share the trip or to bring goods to their neighbours:

> It also happens that someone borrows a car and says "I'm driving to Ikea on the weekend, does someone need something?" You're always thinking collectively because you know that journeys are difficult for everyone. [...] We have a [web communication platform] for everything, deliveries and so on, we try to do this together.
> Woman, 50, couple with children, Klein Borstel

Second, in most cooperatives, the residents facilitate grocery shopping in the housing development, either with a weekly market stand from an organic farm, a small grocery shop or different forms of grouped delivery:

> We often buy and get things delivered together, we have our food coop and once a month the organic shop stuff is brought. This also worked very quickly. The apple truck comes once a month and brings us apples and apple juice from an organic farm. Within a few months we had organised this, so that the basic things are just here.
> Woman, 50, couple with children, Klein Borstel

Third, as mentioned previously, some social activities take place within the developments and therefore do not generate any travel. Moreover, neighbourly help is much more developed due to the fact that the absence of cars results in more social interaction when residents move around on foot or by bicycle.

This last type of strategy shows that access and competences not only exist on the personal level but other people's – i.e. the neighbours' – mobility capital also play an important role for car-free living. Thus, this strategy links to the other dimension important for car-free living which is presented in the next section.

5   A territory's hosting potential for car-free living

This section discusses the hosting potential of a territory enabling car-free living, including material artefacts (5.1) and immaterial aspects (5.2).

Strategies adopted by residents are closely related to the spatial and social context and its suitability to live car-free. The elements presented here – or affordances – are based on the residents' evaluation of what is important for car-free living. As a preamble it has to be noted that about two thirds of the households estimate that their housing project is very suitable for living without a private car (and nearly 30% that it is suitable).

5.1   Material artefacts

The survey revealed three types of material artefacts which need to be present for car-free living according to the residents: those relating to mobility, those relating to the surrounding neighbourhood, and those relating to the housing development (Table 4).

Of primary relevance for mobility is infrastructure in the development as well as its location and, particularly, its accessibility, relating to both bicycles and public transport. Residents require short distances to urban public transport lines with a high service level, as well as easily accessible vehicles and platforms, and safe and attractive cycling routes to the city centre and other important places. In most cities, the existing cycling infrastructure is insufficient, but even in Münster with its extensive and long-established network, residents raised deficiencies, e.g. for cargo bikes.

Within the development, there must be high quality bicycle parking, i.e. a sufficient number of covered and secured spaces, including for cargo bikes and trailers:

> Good bicycle parking facilities are of course also important, we have planned here
> that everyone has an easily accessible place.
> Woman, 50, couple with children, Klein Borstel

Other elements are bicycle workshops and the (informal) sharing of cargo bikes and accessories. Interviewees also feel that carsharing should be available, if not in the development then no more than a short walking distance away.

In the surrounding neighbourhood, local supply (mainly for grocery shopping) is considered a basic condition for car-free living, as well as recreation areas:

> I'd say at least that food can be bought nearby on foot is the absolute criterion for
> this car-free life.
> Woman, 40, couple with children, Weißenburg

Most residents also want a larger car-free or at least car-reduced area around their development, to benefit more from the absence of cars. Other services, such as restaurants are less important, as they are less often used or concern fewer households. However, given the high presence of families, schools and nurseries are important, and many developments even include a nursery.

	Very important	**Important**	**Rather important**	**Rather not important**	**Not important**	**Not at all important**	**Total**
Max. 5 min. walk to bus or tram stop	52%	31%	14%	2%	1%	0%	100%
Safe and easily accessible bicycle parking facilities in the development	49%	30%	13%	4%	3%	2%	100%
Proximity to local train station	49%	29%	14%	4%	2%	2%	100%
Safe and direct foot and bicycle paths around the development	40%	36%	17%	5%	2%	0%	100%
Max. 5 min. walk to shops for daily needs	35%	39%	18%	5%	2%	1%	100%
Proximity to local recreation area	28%	34%	26%	11%	1%	0%	100%
Carsharing site in the development	20%	23%	20%	17%	13%	8%	100%
Max. 5 min. walk to nurseries and schools	17%	25%	14%	11%	16%	16%	100%
Proximity to long-distance train station	14%	26%	32%	19%	8%	2%	100%
Proximity to city centre	13%	31%	36%	13%	5%	1%	100%
Max. 5 min. walk to services	12%	27%	33%	22%	6%	1%	100%
Mobility services in the development	6%	15%	25%	27%	19%	10%	100%
Max. 5 min. walk to restaurants, cafés, bars	4%	14%	27%	35%	15%	4%	100%

Table 4: Importance of a housing development's characteristics for living car-free

The most important material artefacts are summarised by this inhabitant:

> These are basic prerequisites for a car-free development: the connection to the public transport system, in particular to the railway station for long-distance traffic, and a complete supply in the different sectors.
> Man, 55, childless couple, Weißenburg

These results highlight what types of areas are suited for car-free living and the affordances to develop in urban and transport planning. They refer to the developments themselves (e.g. bicycle parking) but also more broadly to the walking, cycling and public transport networks and to the urban form (e.g. density, compacity, mixed-used areas).

5.2   Immaterial aspects

Immaterial aspects are also crucial for car-free living in addition to the spatial context. On a general level, there are still many laws favouring cars and car owners, including parking requirements for new housing developments. Negotiations with local authorities were necessary to avoid the construction of parking spaces.

Less clearly defined, but as important, are prevailing social norms related to car-free living. Today in both countries, to own a car is still perceived as "normal", particularly for families, and not to join the dominant mobility system is seen as a choice that requires justification. In this context, a group of households living car-free creates a sense of community and empowers the residents. Car-free housing is also seen as contributing to the trend of de-motorisation observed in big cities and extending it to other social groups and to smaller urban centres, partaking in the legitimation of this way of life:

> That was interesting, the reaction of people with cars. It was really a question for them, how we live without a car, especially with two children. […] When you live in a housing project like this, I feel empowered here by this environment.
> Woman, 45, couple with children, Klein Borstel

In other words, car-free living needs a certain 'mobility culture' in which not owning a car is regarded as being (at least) as normal as owning one. Car-free developments make more visible the on-going trend towards de-motorisation in big cities and shows that this choice is also possible and attractive in other contexts. They may contribute to define and to legitimate new social norms regarding mobility.

6   Conclusion

Due to its negative impact, the car is questioned in a growing number of cities. Debates about reducing greenhouse gas emissions and mitigating climate change also urge for a move away from automobile dependence and to foster a post-car system (Dennis & Urry, 2009). Car-free housing developments can be regarded as real-world laboratories for low-carbon communities (Foletta & Henderson, 2016). They illustrate a mobility transition based on the redefinition of mobility practices, new social norms and new models of urban and transport planning but not on a technological fix (e.g. electric cars). Our research, based on a questionnaire survey and in-depth interviews in nine car-free housing developments in Germany and Switzerland, identifies the components required for the implementation of a post-car system on the scale of a neighbourhood.

Residents adopt four strategies to be mobile while not owning a private car. First, they rely on alternative modes. They exploit the potential of cycling by using various equipment (cargo bikes, e-bikes, etc.). A majority have a regional or national pass giving access to a wide range of public transport, as well as good knowledge of networks, routes and timetables. Second, they use mobility services such as delivery (e.g. of luggage or of goods). Although not privately owned, the car is not totally absent, as residents may use (formally or informally) shared or rental cars. Digitalisation also facilitates car-free living by providing information (e.g.

timetables, weather forecasts) and facilitating access to services (e.g. location and availability of vehicles). Third, living without a car implies the adoption of activities that can be reached on foot, by bike or by public transport. The criteria of car-free accessibility and proximity for shopping, leisure and other activities are central in such lifestyles. Fourth, the community of car-free residents provides cooperation and mutual aid in sharing equipment, organising delivery and providing social activities.

The context has to provide affordances to make car-free living possible and attractive. As the analysed car-free housing developments show, this is crucial in the perspective of widening the population of car-free households beyond the ones that are more prone or predisposed to do so (due to their values and attitudes). The context includes material and immaterial aspects. Material artefacts refer to mobility infrastructures (public transport, cycling and pedestrian networks), the surrounding neighbourhood (local supply of shops and services for everyday needs) and the development in itself (bicycle parking and workshop, green spaces, meeting spaces). Social aspects refer to the adaptation of the legal framework and of alternative social norms that legitimate car-free living.

The results identify four principles of a post-car system. First, alternative transport modes to the private car must be developed. These modes include cycling, walking and public transport, but also mobility services such as carsharing, taxis or delivery for less regular needs. Second, alternative modes must be spatially and functionally organised within a system (e.g. with regard to pricing). This concerns public transport as well as other services (carsharing, bikesharing, etc.) according to the principle of Mobility as a Service (MaaS). Third, the built environment must make alternatives to the private car attractive. This implies reforming parking requirements, reducing the volume and speed of car traffic and designing neighbourhoods that are dense and big enough to develop amenities (e.g. schools and grocery stores) while also proposing recreation areas. Proximity should be promoted so that it can be integrated into residents' lifestyles. Such a principle is also put forward by increasingly influential models such as the '15-minute city' in which daily urban necessities (work, home, shops, entertainment, education and healthcare) are within a 15-minute reach on foot or by bike (Moreno, 2020). Fourth, measures could target individuals by showing how car-free living is possible through various strategies and skills. These four dimensions together form a system which encourages residents to live without a private car in a pragmatic way and without being restricted in their everyday life. They could inform planning policies to promote car-free housing and more generally to reduce the motorisation of households.

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