Last minute change to mobility.

Exploring Malmö's visions towards more sustainable mobility by implementing mobility hubs as a niche innovation.

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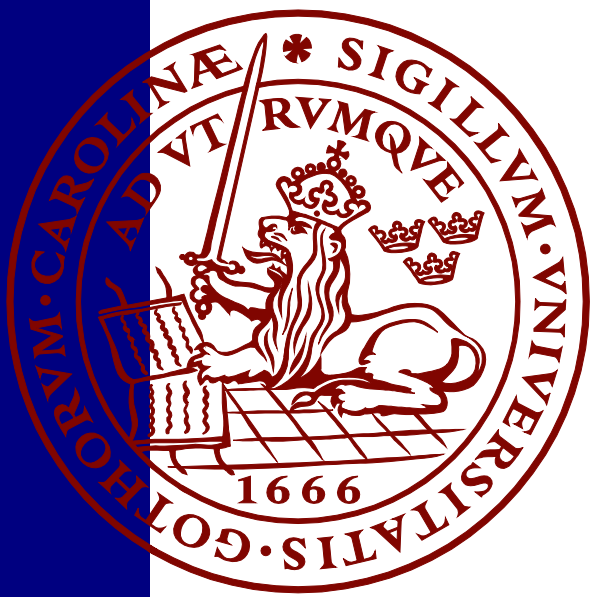

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Abstract

Like many car-dominated cities, Malmö is pressured to enable a radical shift towards more sustainable, space-efficient, and socially just mobility. This paper uses the Multiple-Level Perspective (MLP) framework to analyze the mobility dilemma on three levels: the dominant cause for change, the approach towards it, and the possible solution in the form of mobility hubs as a niche innovation. Semi-structured interviews with involved experts and official document analyses surprisingly revealed spatial challenges as the main issue. The second result lies in Malmö's acknowledgment to rethink its mobility and incorporate a more holistic approach towards it. Part of that could be the current experimentation of mobility hubs. Malmö's existing physical infrastructure, including its public transportation, provides a great starting point. These findings should encourage transportation planners and policymakers, not only in Malmö, to enable the much-needed and long-awaited multimodal shift to reduce emissions and other negative impacts of mobility drastically.

Keywords: Mobility transition, CO2 emission reduction, urban mobility, social mobility, car reduction

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III. Abbreviations

BVG	Berlin's public transport company (Berliner Verkehrsbetriebe)
CO2	Carbon dioxide
e-mobility	Electro mobility
e-scooter	Electro scooter
e.g.	for example (lt. exempli gratia)
EIT	European Institute of Innovation and Technology
EIT Climate-KIC	Knowledge and Innovation Community (KIC), working to accelerate the transition to a zero-carbon economy. Supported by the European Institute of Innovation and Technology
EU	European Union
EV	Electric vehicle
GIS	Geographic Information System
HVV	Hamburg's public transport company (Hamburger Verkehrsverbund)
ICE	Internal combustion engine
KIC	Knowledge and Innovation Community
MaaS	Mobility as a Service
MLP	Multiple-Level Perspective
ODP	OpenData Platform
P+R	Park and ride
RQs	Research questions
SS	Sustainability Science
SUMP	Sustainable Urban Mobility Plan
TT	Transition theory

1 Introduction

Cars have been the predominant form of daily transport in the last decades and have even shaped all other mobility fields (Metz, 2013; Paterson, 2007; Pritchard, 2022). Despite its many advantages, it has been shown to negatively impact social, environmental, and economic sustainability (Freund, 2014; Lucas et al., 2016; Nikitas, 2018; Pritchard, 2022). This is caused by congestion, increased health risks, resource depletion, air, and noise pollution, increasing social inequalities, and transport poverty (Anderson et al., 2017; Bell, 2019; European Commission. Directorate General for Mobility and Transport., 2021; Mattioli, 2021). Arguably most notable within the transportation sector are the still-rising emissions (EEA, 2019; Eurostat, 2022; IEA, 2021). Efforts to reduce these emissions and consequently enable a shift to existing alternative modes of transportation have largely failed in the last year's (Barr & Prillwitz, 2014; Blad et al., 2022; Camilleri et al., 2022). Against this backdrop, a large-scale sustainability transition towards less polluting modes of transportation is needed. Especially in order to meet environmental goals, such as being “climate neutral” by 2030 for Malmö (Malmö Stad, 2020; Viable Cities, 2020) and by 2050 within the European Union (EU) (European Commission, 2019). However, focusing only on emission reductions, such as through shifting to electric vehicles (EVs) or biofuels, would reinforce the dominant presence of individual car transport and increase many of its previously listed negative impacts. Especially space issues related to individual mobility are critical due to the increasing urbanization and densification of cities (Freund, 2014), which is expected to increase as predictions estimate that 70% of the world population will live in urban areas by 2050 (UN, 2019). Malmö is such a case, as it is Sweden's fasted growing city population-wise, yet its space is restricted (Malmö Stad, 2016, 2018). Therefore, a more holistic approach is needed, rooted in the necessity of addressing these large varieties of environmental, social, and spatial issues while involving the diversity of affected stakeholders in finding solutions.

Many cities face similar issues and play a crucial role in the mobility transition as they are linked to most global emissions (Creutzig et al., 2015). Malmö city is part of the EU-launched mission “100 Climate-Neutral and Smart Cities by 2030” (European Commission, 2020), spearheading innovation and experimentation toward sustainability practices for other cities to follow. This raises the importance of this case study. Furthermore, Malmö was chosen due to its approach of aiming to fix various issues by expanding its existing infrastructure through experimenting with the innovative mobility hub concept (Malmö Stad, 2022f). Focusing on Malmö, this thesis analyzes the city's approach towards enabling a wider sustainability transition focusing on promoting multi-modal transportation by introducing mobility hubs as a niche innovation, a network of physical and digital mobility

infrastructure. The aim is to enable a mobility shift and to make walking, cycling, and usage of public transport the natural choices within the city, at the expense of individual car usage (Malmö Stad, 2016, 2021b).

Large sustainable transitions, such as within the mobility sector in Malmö, are complex multi-layer challenges that need complex solutions (Geels, 2012a, 2018a). Sustainability Science (SS) often aims to unite different perspectives to help find solutions for such modern-day sustainability problems (Kates, 2011, 2016; Shrivastava et al., 2020). The extended perspective of SS can help solve the broader issue of Malmö's current mobility by connecting previously separated disciplines such as traffic planning, urban planning, politics, and social studies. More importantly, aiming to bring in potential users and policymakers as well as a more comprehensive range of actors could help implement practical solutions, which should become a new measurement for SS (Kates, 2016).

1.1 Research aims and questions

The aim of this paper is to critically analyze urban mobility in Malmö as a regime struggling to adapt to ongoing pressures. The special focus is, therefore, on the different pressures, the approach towards them, and a possible solution in form of untapped and understudied socio-technical niches: mobility hubs. Currently, Malmö city is joining other innovative cities and rethinking its approach toward mobility (Arnold et al., 2022). The variety and interlinkages of the pressures the city is facing make a new holistic approach needed (Malmö Stad, 2016). Since this is a typical case of a large-scale sustainability transition, it will be explored on three interacting levels using the "Multilevel Perspective" framework (MLP) (Geels, 2012b). The research questions (RQs) also mirror this approach as the first focuses on the large-scale pressures, called landscape level, within the MLP. The second focus is on the current practices and key actors, which comprise the regime level. The third question explores the potential of mobility hubs within Malmö, which represents the third level within the MLP framework called niche, where regime-level challenging (niche) innovations are explored:

1. What are currently the biggest issues regarding mobility in Malmö, according to key actors?
2. How does the city of Malmö approach the transition toward more sustainable mobility?
3. Which role could the innovation of mobility hubs play in the mobility transition in Malmö?

Answering these questions contributes to the vast research on mobility transitions, where mobility hubs are seen as potential solutions but are currently understudied and regarded as a niche innovation (Anderson et al., 2017; Arnold et al., 2022; Arseneault, 2022a; Coenegrachts et al., 2021; Geels, 2012b,

2019; Miramontes et al., 2017). It could provide more insight into an innovation that is not merely technological but a combination of practices, existing technologies, and new concepts outside of the traditional mobility planning (Arnold et al., 2022; Geurs et al., 2022). A specific focus is thereby on the participation and involvement of citizens since environmentally friendlier alternatives, compared to current dominant forms, exist, but adaptation and widespread acceptance is the missing link (Arnold et al., 2022). This approach goes well in hand with the origins of Sustainability Science, being problem-driven and solution orientated as well as aiming to include many different perspectives for best implementation (Shrivastava et al., 2020; Spangenberg, 2011). On a more practical level, this paper could encourage local key actors to push forward with more climate-friendly ideas and convince more people for this innovation to be implemented (Malmö Stad, 2022f).

With this approach and the limited scope of this paper in mind, I will focus on the mobility of people within Malmö as a city. Therefore, other modes of transportation, such as cargo, shipping, flying, and others, will not be included, even though they are of environmental concern. This exclusion is justified since this study focuses on the innovative approach regarding mobility patterns of people towards adopting existing, fewer polluting alternatives, through innovative mobility hubs.

1.2 Thesis Roadmap

This thesis is structured into several chapters. First, the background of this case is explained in the following chapter. This introduces the new concept of mobility hubs (2.1) and presents an overview of the current mobility in Malmö (2.2). Chapter three provides an overview of the Multi-Level Perspective framework (3) used throughout this thesis. In chapter four (4), the methodological approach of this paper is presented. The input from these chapters culminates in the analysis part of this paper in chapter five (5), which is divided into three subchapters, each answering the previously stated research questions according to the different MLP levels (landscape level 5.1, regime 5.2, niche 5.3). Chapter six (6) reflects on these results and discusses practical implementations, limitations, and further recommended research. Finally, a short conclusion summarizes this thesis in chapter seven (7).

2 Background

This chapter introduces mobility hubs as a niche innovation aiming to enable a mobility transition away from cars and towards better forms of mobility (2.1). An introduction to Malmö's current mobility situation follows (2.2). This background information is crucial for understanding mobility hubs and their potential to solve the underlying (mobility) issues Malmö faces. It, therefore, lays the ground to answer the three research questions.

2.1 Overview of mobility hubs

The concept of mobility hubs in its current form is quite new and not yet well established, making it rather a niche innovation (Arnold et al., 2022; Arseneault, 2022a, 2022b; Geurs et al., 2022; Roberts, 2019; *Smart Hubs*, n.d.). Currently, it lacks a consensus on one definition, and relatively little research exists on the topic to this date (Geurs et al., 2022; Rongen et al., 2022; Tran & Draeger, 2021). To create a much-needed overview of mobility hubs, Geurs et al. (2022) have listed 29 different definitions in academic literature and planning practice documents. Based on these definitions, they conclude that "**a mobility hub is a physical location where different shared transport options are offered at permanent, dedicated and well-visible locations and public or collective transport is available at a walking distance"** (Geurs et al., 2022, p. 10) (See figure 1). Mobility hubs are seen as a new concept of physically combining existing forms of mobility, mainly public transport, with newer forms of mobility, such as shared bikes, scooters, cars, electric mobility, and mobility as a service (MaaS) (Anderson et al., 2017; Arseneault, 2022a; Bell, 2019; Geurs et al., 2022; Miramontes et al., 2017; Rongen et al., 2022).

The aim of many mobility hubs is to make other modes of mobility attractive and therefore enable the needed shift away from privately owned cars (Anderson et al., 2017; Arseneault, 2022a; Rongen et al., 2022). This innovation of mobility hubs is necessary as previous mobility concepts such as park and ride (P+R) and multi-modal transfer points are limited and outdated and did not reduce individual mobility enough (Nes, 2002; Rongen et al., 2022). The physical existence of such large parking garages is sometimes used as a starting point to expand upon and integrate them into newer forms of mobility hubs (Arseneault, 2022b; Coenegrachts et al., 2021; Nes, 2002).

Figure 1: Mobility hub illustration

Note: This illustration showcases a simple mid-size version of a mobility hub, connecting various modes of transportation (public transport in form of bus stops, parking spaces for cars and car sharing as well as bike and bike sharing. Furthermore, it offers non mobility relate services, such as a parcel pick-up station, free WIFI, green space, and offers space for an ice cream shop. (Source: Roberts, 2019).

With these multitudes of definitions, different forms of mobility hubs have come up. These range in size from "small neighborhood hubs to large hubs at railway stations with hundreds of shared vehicles" (Geurs et al., 2022, p. 7) (see appendix 4). This variety of flexibility has led to mobility hubs becoming an emerging popular way to change urban mobility behaviors (Geurs et al., 2022). Furthermore, this could change long-term city planning in regard to "activity places and residential/location choices" (Geurs et al., 2022, p. 7). The large variety of mobility forms and new thinking in urban planning is closely linked to improving other aspects of urban life, such as the attractiveness and safety of living in the city (Arnold et al., 2022; Arseneault, 2022a; Coenegrachts et al., 2021) (see appendix 3,7,9). A short summary of some economic, social, and environmental goals and functions of mobility hubs includes advantages such as:

> a) Provides efficient and seamless integration of sustainable transportation options, b) Focuses on improving user experience of different transportation options, c) Ensures safety and security for all travellers, d) Creates a sense of place through effective and meaningful placemaking strategies, e) Allows for flexibility to embrace technological innovations and foster resiliency, f) Addresses equity by considering accessibility to and availability of transportation options in different neighborhoods, and g) Creates opportunities to form effective partnerships. (Geurs et al., 2022, p. 5)

The combination and prioritization of such benefits depend on the different policy objectives within the community and the underlying infrastructure, as well as the willingness and participation of users and involved stakeholders (Arseneault, 2022a; Camilleri et al., 2022; Geurs et al., 2022). A stronger interaction with users, potential users, businesses, and local stakeholders can be seen as a major shift in the transportation planning (Coenegrachts et al., 2021). This could be especially vital, as increased participation in the design of mobility hubs has been shown to strengthen the acceptance and usage them (Arseneault, 2022a, 2022b), in some cases even attracting new businesses and users (Coenegrachts et al., 2021) (see figure 1 & appendix 3). This helps shift towards multimodal mobility faster while improving life in the city and creating new social places (Arnold et al., 2022) (see figure 1 & appendix 3, 7).

With the large variety of designs and possible benefits, it becomes apparent that this concept can be seen as a modular system of possible combinations fitting each location and need (see appendix 9, 10). A systematic analysis of the different forms is offered by the EU-funded OpenData Platform (ODP) “SmartHubs” (Smart Hubs, n.d.). It currently lists 85 mobility hubs within Europe on its website (*Smart Hubs*, n.d.)(see figure 2).

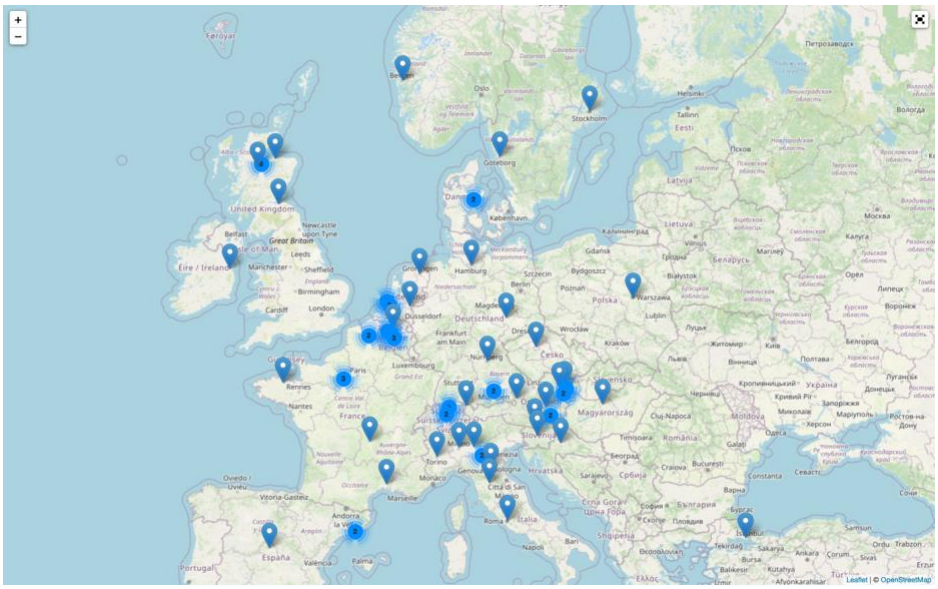

Figure 2: Overview of mobility hub locations within in Europe

Note: This map gives a rough overview of cities in Europe that have forms of mobility hubs. Source: (*Smart Hubs*, n.d.).

This chapter shows that mobility hubs are an emerging new form of combining existing modes of transportation to promote intermodal mobility while being adaptable to reduce other urban issues.

2.2 Case description of Malmö

Malmö is currently the third-largest city in Sweden and the biggest city in the Skåne region, with around 350.000 residents as of 31. December 2021 (Malmö Stad, 2021d). It is also the fastest-growing city in Sweden, which the city explains by an increase in people moving into the city, many births, and low mortality rates (Malmö Stad, 2021d). Nearly half of Malmö's population is under the age of 35. The population is also very diverse as it comprises people from more than 180 different countries (Malmö Stad, 2021d). Predictions estimated that Malmö city will reach 500.000 inhabitants by 2050 (Malmö Stad, 2021b). This growth demands space. Space for people, their homes, work, leisure, and many other activities, as well as the mobility that connects these different aspects of life (Malmö Stad, 2016). While previously the city might have expanded and grown, it now aims to grow within its current city limits (Malmö Stad, 2016). This is partly a choice, and partly a result of its geographical location, which makes expanding the city difficult (more in section 5.1.1).

Figure 3: Map of Malmö's location within Sweden and Northern Europe

Note: This map showcases Malmö's location. Source: (Invest in Skåne, 2021).

2.3 Malmö's current mobility

This chapter provides an overview of Malmö's mobility as a basis to evaluate its potential to include mobility hubs (5.3).

Even though the trend is slowly going down, privately owned cars are still the dominant mode of transportation in Malmö, accounting for around 34 %, which is followed by 26 % on bike, 17 % by bus, and 14 % on foot (see Figure 4) (Indebetou & Dahlberg, 2019; Malmö Stad, 2022c). This showcases that there is a large variety of modes of transportation in use, which is typical for a well-developed European city (Boldrini et al., 2019).

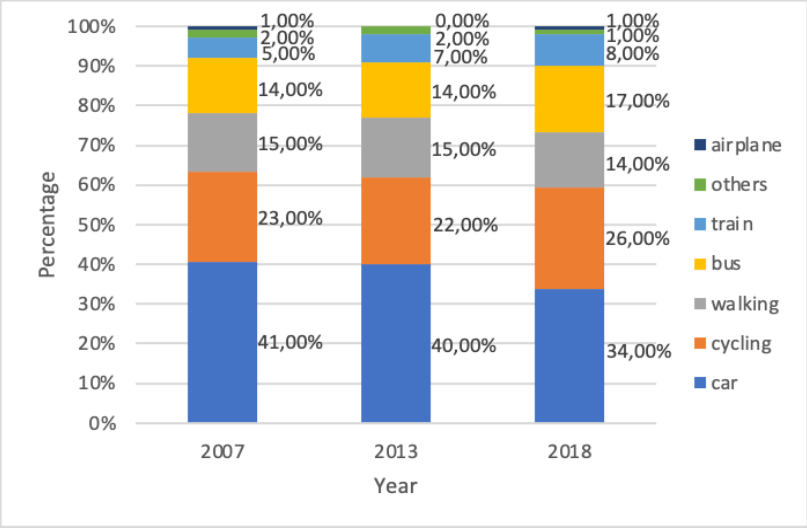

Figure 4: Distribution of modes of mobility in Malmö

Note: This graph shows the distribution of modes of transport in Malmö in 2007, 2013, and 2018. Data based on the five-year mobility survey conducted by Region Skåne, retrieved from (Malmö Stad, 2022c). Due to rounding to whole percentages in 2007 and 2018, 100 % is slightly exceeded. (Figure created by the author).

With cars having the dominant share of mobility, it is not surprising that they also make up the largest share of emissions, even though the emission rate is declining (see Figure 5). The share of overall car ownership has been constant since 1974, at around 35%, while the population grew in size (Malmö Stad, 2022d). To accommodate all these cars, parking spaces are necessary, especially taking into account that most cars stand idle the majority of the time (Boldrini et al., 2019). There are three parking companies in Malmö. “Parkering Malmö”, which is fully owned by the municipality of Malmö, runs nine large parking facilities inside the city and manages a total of over 35.000 parking spots, including outdoor spaces (Parkering Malmö, n.d.-b).

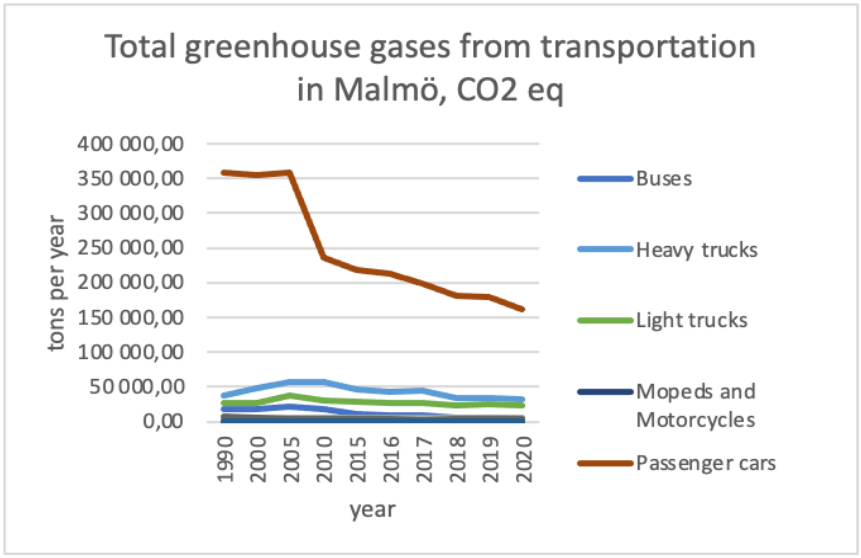

Figure 5: Total greenhouse gases from transportation in Malmö, CO2 eq

Note: The graph shows total emissions from the transport sector in Malmö from 1990 until 2020 based on data from the Swedish Meteorological and Hydrological Institute SMHI (2020). (Figure created by the author).

When it comes to bikes, the second most dominant mode of mobility, Malmö, is linked by 560 kilometers of bicycle paths, containing more bicycle pathways than any other Swedish city (Malmö Stad, 2021c). The city of Malmö is often ranked at the top of the world in terms of cycling friendliness (Visit Sweden, 2021). Since 2015, "the rate of expansion of cycle paths has been between 4 and 6 km per year" and reached 6.2 km in 2021 (Malmö Stad, 2022a). "Malmö by bike", a bike-sharing service operated by Clear Channel, offered since 2016 (Malmö Stad, 2016), a subscription-based mobility service with 100 permanent stations across the inner city (see Figure 6)(Malmö by Bike, 2021).

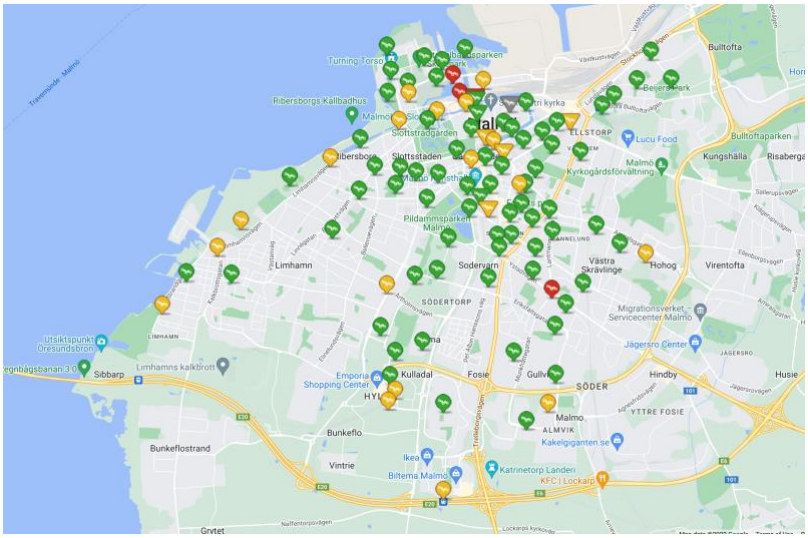

Figure 6: "Malmö by Bike" stations

Note: This map showcases "Malmö by bike" stations inside Malmö's current city limits as of 2021. Source: (Malmö by Bike, 2021).

Currently, there are eight bus lines operated by Skånetrafiken inside the city limits, called Stadsbuss (see Figure 7), while a total of 149 bus routes transit Malmö stopping at 2950 bus stops (moovit, 2022). In recent years efforts have been undergoing to replace or refit all buses with hybrid or full biogas or full electric versions, to reduce emissions (Malmö Stad, 2016, 2021c). An extra-long version, the Malmö Expressen, a 24-meter double articulating CNG/biogas hybrid bus, has replaced some traditional shorter city buses that have reached their maximum capacity (Malmö Stad, 2021c).

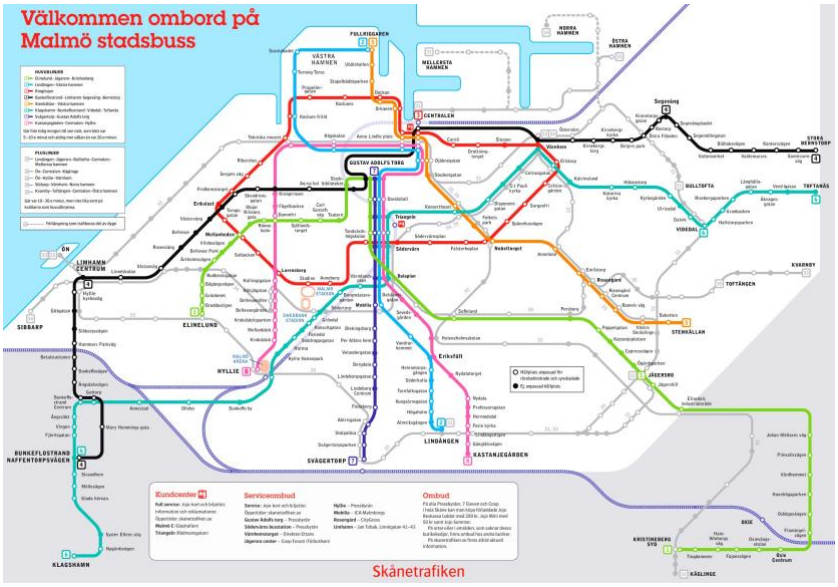

Figure 7: Malmö's Stadsbuss plan

Note: This map shows all eight inner city bus lines operated by Skånetrafiken in Malmö in 2021 (Skånetrafiken, 2021).

Malmö's largest mobility infrastructure, are its three main stations: Malmö Central, which operates long-distance and regional trains and is connected via an underground railway tunnel with the two other stations, Trianglen and Hyllie (Malmö Stad, 2021c). All three stations include major bus stations, and parking facilities for bikes and cars as well as "Malmö by bike" stations (Malmö by Bike, 2021).

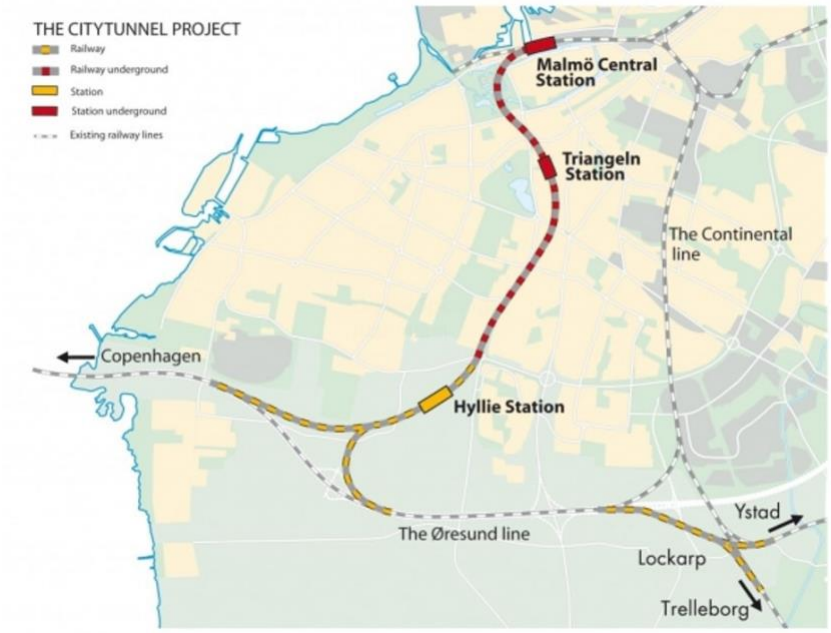

Figure 8: Location of Malmö's three main stations.

Note: This map showcases the location of Malmö's three main train stations. Source: (The Economist, 2010).

Following the most recent development, free-floating scooters can be seen as a part of the city's mobility and are now regulated to be parked in designated areas (Transportstyrelsen, 2022). Currently, rudimental parking infrastructure is being set up, but no official map was found.

In Malmö, each person makes around four trips a day on average, while this differs slightly per area (Indebetou & Dahlberg, 2019). In Limhamn, an affluent area in the southwest of Malmö, people made 4.6 trips per day, while only 3.5 trips per person per day in Tygelsjö, another neighborhood, were made. A similar discrepancy can be noted in the trip length in these two areas: ranging from 51 kilometers per day per person for the inhabitants of Limhamn and 34 kilometers for the inhabitants of Tygelsjö (Indebetou & Dahlberg, 2019). When it comes to the choice of mode of transportation, it becomes clear that car trips increase in share the further away they are from the center, while bike trips increase the closer they are to the center (Indebetou & Dahlberg, 2019). Linked to this aspect is the distribution of modes of transportation according to the length of the trip (see Figure 9). The shortest trips below one kilometer are made predominantly by foot at around 82 % (Indebetou & Dahlberg, 2019). For trips above three and below five kilometers cars make up 43% of trips (see figure 9) (Indebetou & Dahlberg, 2019, p. 26). This will be additionally influenced by social and economic factors as pointed out in the Region Skåne travel survey of 2018, stating that:

Household income reflects car ownership where low-income people have less access to a car than other income groups. In the higher income groups, from 50.000 SEK per month and upwards, it is more common to have two or more cars than one car (Hedlund, 2019, p. 17).

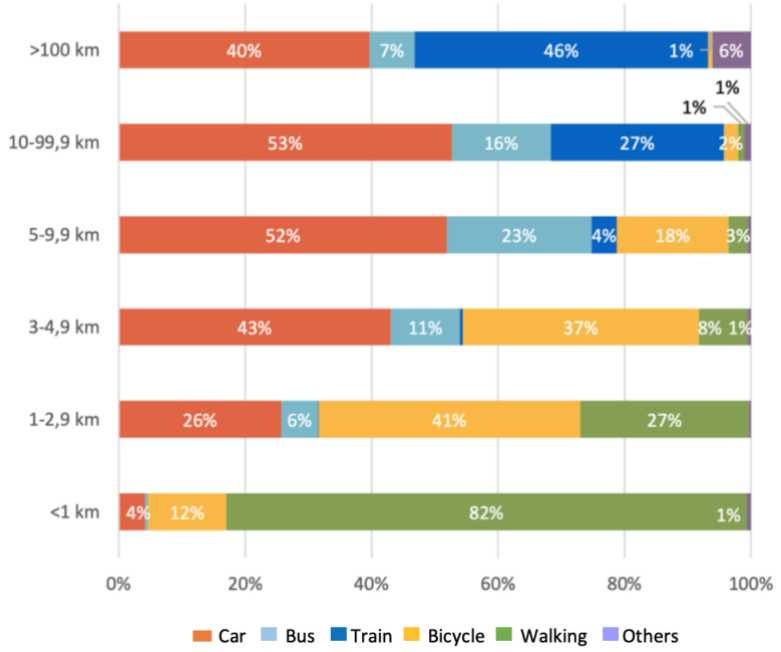

Figure 9: Distribution of means of transport for different trip lengths

Note: This graph showcases the distribution of means of transport according to different trip lengths on a scale to 100 % in different distance variations. Source: (Indebetou & Dahlberg, 2019, p. 25).

3 Theoretical Framework

This part of the paper will provide a short introduction to the Multi-Level Perspective (MLP) framework and briefly explain how it can be used for the case analysis of Malmö's mobility transition. Both theory and framework are prominent analytical tools within transition research and are well-recognized within Sustainability Science.

3.1 Multilevel-Perspective

Building on the transition theory (TT), this paper will use the MLP framework since it can help understand the „core analytical puzzle of transitions, namely stability and change" (Geels, 2012a, p. 49). It helps to break down complex sustainability transitions into interactions on different levels (Markard et al., 2012; Smith, 2007). This combination of stability and change, as well as the interaction on different levels, has made the MLP a well-established framework within TT and Sustainability Science. Sustainability transitions are usually goal-oriented and aim to solve specific environmental problems for the common good. These problems are caused by current practices within the regime. They are, therefore, to be solved by transforming these regime's (Geels, 2011). For the case of Malmö, the reduction of transport-related emissions and the shift towards more space-efficient mobility is the goal (Malmö Stad, 2016, 2018, 2021a). According to Geels, the basic understanding of the MLP framework is that transitions happen as a non-linear process because of the interplay of developments on three analytical levels: "niches (the locus for radical innovations), socio-technical regimes [the places of established practices and associated rules] and an exogenous sociotechnical landscape" (Geels, 2010, p. 495) (See figure 10). Each level has its own function and role yet is influenced and impacted by the others (Geels, 2002).

For this paper, the three categories inform the three research questions and divide them roughly into landscape pressures (RQ1), regime level response (RQ2) as well as niche innovation (RQ3). Furthermore, they influenced the research approach and study design to better understand this large-scale transition (see methodology section 4).

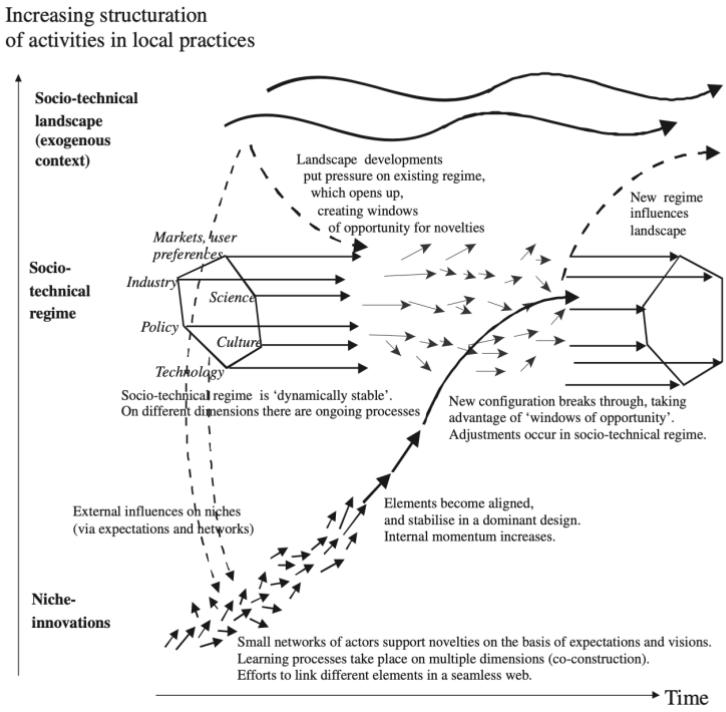

Figure 10: Multi-Level Perspective diagram

Note: Illustration of the sociotechnical transition process on three levels visualized by Geels (2012, p. 474). Niches innovations form, landscape pressures force change upon the regime, and some innovations manage to then penetrate the regime level and become part of an adapted regime.

3.1.1 Landscape

Geels (2002) uses the landscape as a metaphor for the "literal connotation of relative 'hardness' and the material context of society, e.g., the material and spatial arrangements of cities, factories, highways, and electricity infrastructures" (p. 1260). Additionally, macroeconomic factors such as oil prices, political stability, societal values, beliefs, and ideologies can be seen as another part of the landscape level (Geels, 2018). As cultures, practices, and technologies vary, and therefore the landscape varies, Geels proposes to refer to multiple landscapes (2012a, p. 57). More recently, as a societal factor and force of driving behavior, climate change has been regarded as part of the landscape level (Avelino, 2017). Changes on this level, regarding these aspects, happen very slowly and form over time (Geels, 2018). I would argue that the influence of climate change can be seen as a good example of an environmental, social, and economic factor that can be defined as a landscape. There is a growing social appreciation of the importance of addressing climate change on all levels of society, as perceived within the EU (Skeirytė et al., 2022). This evolves very slowly compared to the many decades the human impact on the planet has been studied (Capstick et al., 2015). It seems that it has become common enough to exert strong pressure at the regime level. In this case, forcing Malmö to search for mobility adaptation towards less emitting alternatives.

3.1.2 Regime

The level termed *regime* results from pressures, concerns and actions of different social groups, public and private entities as well as policy makers (Geels, 2018, p. 90). Their interactions, social frames, reward and cost structures further influence the *regime* level (Geels, 2004). For many scholars (e.g., (Holtz et al., 2008, p. 625), the regime level was first defined from a technical perspective. Geels defines it as "the rule-set or grammar embedded in a complex of engineering practices, production process technologies, product characteristics, skills and procedures, ways of handling relevant artifacts and persons, ways of defining problems-all of them embedded in institutions and infrastructures" (2002a, p. 1259). Evolving and responding to criticism regarding this limitation, some scholars redefined the regime level to also include the social aspect in addition to the technical aspect (Geels, 2011). The social aspects include "soft factors" such as "users' preferences or governmental rules and regulations as important drivers of change" (Holtz et al., 2008, p. 626) as well as "markets, consumer practices, infrastructure, cultural meaning and scientific knowledge" (Geels, 2011, p. 25). For this paper, therefore, the perspective of the socio-technological regime is used, including these aspects. I will use Holtz et al. (2008) definition consisting of five characteristics of a regime:

> 1) purpose: regimes relate to a societal function
> 2) coherence: regime elements are closely interrelated
> 3) stability: regimes are dynamically stable
> 4) non-guidance: they show emergent behavior and
> 5) autonomy: they are autonomous in the sense that system development is mostly driven by internal processes (p. 626).

Following these five criteria, I envisage viewing mobility in Malmö as one regime. The purpose (1) is to provide overall mobility in Malmö, while the coherence (2) is combining many different forms of mobility and aligning common interests and individual needs in one specific area, such as providing infrastructure and freedom of choice. It has constantly been evolving while arguably providing mobility services with little change regarding the overall concept and its actor's roles, which marks stability (3). There has been little guidance for change, as only individual parts change (e.g., from combustion to electric engines), but overall behavior (individual-centered mobility) has been maintained. Furthermore, there is also no central actor solely involved since traffic planners, mobility providers, car companies, and citizens all have different degrees of power and autonomy of each other (5).

Additional to these factors are lock-in mechanisms that reduce change from within the regime to the very minimal and only generate incremental innovations. The mobility sector is known to have many lock-in mechanisms such as "shared beliefs that make actors blind for developments outside their scope, consumer lifestyles, regulations and laws that create market entry barriers, sunk investments in machines, people and infrastructure, resistance from vested interests, low costs because of

economies of scale" (Geels, 2012a, p. 473). While change still occurs, it "proceeds in predictable directions, giving rise to stable trajectories" (Geels, 2012a, p. 473). One example of a predictable trajectory and limited innovation could be the shift toward e-mobility. This incremental change might reduce emissions and even be perceived as an innovation challenging the combustion engine mobility regime, but it reinforces the existing socio-technical system (Geels, 2010, 2018a). The current socio-technical system includes individualized road transport and arguably does not challenge the overall concept of mobility enough.

Geels (2012) argues that automobility can be seen as an individual regime:

> Automobility regimes are also sustained by habits of use, prevailing normality and mindsets, and established practices of professionals, such as transport planners, whose logic and choices help to reproduce a regime. The automobility regime is also sustained by everyday conversation and politics and by cultural associations with freedom, modernity and individual identity (p.55).

He further states that this regime can be understood as „consisting of more specific regimes" (Geels, 2012a, p. 57) as well as competing with other (less dominant) regimes. Since car trips cover short distances, competing for valid alternatives such as walking, cycling, and bus or on longer distances with high-speed trains and even airplanes (Geels, 2012a). Therefore, rail, bus, and cycling can be seen as smaller "subaltern regimes" compared to the dominant auto-mobility regime. Still, they are relatively stable regarding institutionalized usage by specific societal groups (Geels, 2018, p. 87). I would argue that there is a large part of intermodal regime users (see chapter 2.2) in urban areas such as Malmö who use different modes of transportation interchangeably and, therefore, are not strictly part of one or the other regime. Furthermore, I want to take the perspective of combining all major forms of mobility into one regime since they are all interlinked, and this paper follows the premise that a better combination could drastically improve space efficiency and lower emissions. Therefore, I will treat Malmö's mobility as one regime for this paper. This will also help reduce additional complexity, such as analyzing each subaltern regime. Geels's figure of "Integrative MLP-conceptualization of passenger mobility system reconfiguration" (2018, p. 88) (see Figure 11) could enhance the intermodal transport system aspect linking different mobility regimes and multiple simultaneous disruptions.

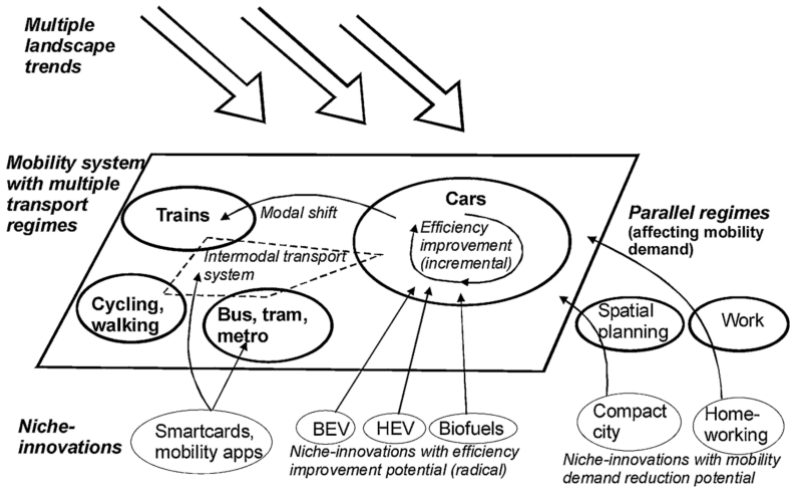

Figure 11: Integrative MLP-conceptualization of passenger mobility system reconfiguration

Note: This visualization combines the transformation of many different regimes at the same time, providing a more complex regime-level adaptation transformation, compared to the singular disruption approach (Geels, 2018, p. 88).

3.1.3 Niche

The third and last level within the MLP is niche innovation. Here, separately from market forces and established practices, innovations can be developed. This can take place in „protected spaces such as research and development laboratories, subsidized demonstration projects or small market niches where users have special demands and are willing to support emerging innovations (e.g., the military)" (Geels, 2012a, p. 53). Involved actors hope to find promising alternatives to the current regime, intending to change or even replace it eventually. On the other hand, this is not easy since the dominant regime is stable and reinforces itself through many lock-in mechanisms. Alternatives, therefore, typically face "an uphill struggle against stable systems" (Geels, 2012a, p. 51). These could be previously mentioned design practices, behaviors, cultural beliefs, and existing infrastructure that are not yet used on a large scale because they are more expensive, not in line with existing regulations, or require users to adopt new practices (Geels, 2012a). These niche innovations must be competitive within the regime's existing technologies, behavioral patterns, and systems (Geels, 2012a, p. 473).

On the other hand, when parts of the regime are challenged enough through landscape-level pressures, for example, it can create the opportunity for a niche innovation to be adopted at the regime level. This makes "niches […] crucial for transitions because they provide the seeds for systemic change" (Geels, 2012a, p. 53). Outsiders or even a few regime actors often develop and aim to incorporate these niche innovations. Usually, the more radical innovations tend to be generated on

the niche level (Geels, 2002). These attempts can lead to multiple simultaneous attempts at changing the regime, enhancing uncertainty. One example is the free-floating e-scooters in Malmö, which were almost unrestricted until national legislation stepped into (Malmö Stad, 2022e; Transportstyrelsen, 2022). Following this path of uncertainty, combined with large-scale experimentation, can bring momentum toward innovation and help re-align the regime and create new rules and standards (Geels, 2012a), as it is now the case with e-scooters (Malmö Stad, 2022e).

Regarding Malmö, it's potentially the combination of pressure to deliver fast emission reductions and providing more space-efficient mobility alternatives that will open the regime level for a niche innovation to tackle both.

4 Methodology

This section explains how the thesis was conducted. The first part describes why Malmö was chosen as a case study (4.1). The second chapter focuses on how data was collected (4.2) the third part is how and why semi-structured interviews with experts were conducted (4.3). The last part focuses on how the data was prepared to help answer the research questions in the following analysis (4.4).

4.1 Malmö as a case study

Malmö was chosen as a representative case for medium size cities facing the need to transition their current mobility towards more sustainable alternatives. It allows for a case study of a modern and innovative city facing challenges that cities of similar size are facing across the European continent and in other industrialized countries. The city has been very cooperative and proactive in an analysis of its current situation (Malmö Stad, 2016, 2018) and possible mobility scenarios that could guide decision-making for the coming years (Malmö Stad, 2022f).

A leading factor for this decision came from my participation in the 2021 Climathon in Lund. An event focused on solutions to sustainability challenges lasting for five days hosted by Lund University and EIT Climate-KIC (Blomqvist, 2021a). Traffic planners from Malmö City and mobility-related companies, such as NOBINA, Skånetraffiken, and Parkering Malmö, came together to offer various challenges related to sustainable mobility (Blomqvist, 2021b). This furthered my interest in mobility as it showed that Malmö actively seeks solutions to its mobility problem, focusing on sustainable alternatives. After winning the competition, I started with further research, including Malmö's award-winning Sustainable Urban Mobility Planning (Malmö Stad, 2016). This plan has clear targets and showcases the city's vision for its mobility transition. To achieve this transition, Malmö acknowledges the need for a holistic approach across multiple levels, including various perspectives and disciplines (Malmö Stad, 2016, 2018, 2021b). This approach is shared with Sustainability Science and makes it especially interesting since large-scale transitions have proven to work best when they include as many diverse perspectives as possible to find solutions (Spangenberg, 2011). With that in mind, a qualitative case study was designed to combine the case of Malmö, its vision, and its idea for integrating the niche innovation of mobility hubs. These aspects were combined using the MLP- framework as a theoretical and academic guiding tool. Leading to the three research questions and guiding the research, data collection, and interviews in preparation for the analysis. Having created this study approach, it was quickly apparent that there are a few relevant actors on the regime level that are putting in efforts for this transition towards mobility hubs. I included them in this research and used their insights as data points.

4.2 Data collection

My interest lies in understanding Malmö Cities' approach towards experimenting with mobility hubs as an innovation. With that in mind, I specifically choose to focus on official and publicly available documents, reports, directives, and plans (N=11). Additionally, four longer interviews with involved experts were conducted. This was especially important since the documents often provide visions and goals but cannot go into details about how to achieve these goals, nor are they as open about challenges as the direct interviews allowed. Having official goals and statements complemented with more detailed and nuanced interviews was, therefore, an insightful mix to collect data. The experts were selected based on involvement and expertise on the topic, as well as availability and willingness to conduct recorded interviews.

4.2.1 Semi-structured interviews

The conducted interviews were prepared and designed according to semi-structured interview standards (Brinkmann, 2013). This means that guiding questions were prepared, which formed a structure within the interview, having clear goals in mind as well as providing room for flexibility regarding follow-up questions (Roulston & Choi, 2018). Furthermore, it allowed to open up for discussion and a more in-depth understanding of different ideas and details that came up during the interview, which improved the overall understanding of the case (Bryman, 2016). This was especially important since not much research exists on mobility hubs, and questions and subtopics regarding the expectations came up during the interviews. Four different experts (E 1-4) fit the selection criteria and agreed to recorded interviews. Two involved experts from the traffic department pushing the idea of mobility hubs were interviewed. Furthermore, one expert from the city owned parking company “Parkering Malmö”. Since she is involved with rethinking the usage of its parking facility’s for potential transformation into mobility hubs and was a recommended source of information by the traffic planners. The Chairperson of the Environmental Committee, who is also involved with city planning, was also interviewed (see table 1).

Table 1: Overview of interviewed experts (E)

Identifier	Role	Administration	Name	Date & Time	Duration
E1	Trafikplanerare (Traffic Planner)	Property and Street Office within the Urban Development Department City of Malmö	Per Wisenborn	10.2.22 13:00-14:15	1 hour 3 minutes
E2	Ingenjör (Traffic Engineer)	Property and Street Office within the Urban Development Department City of Malmö	Karin Linnea Caesar	9.3.22 8.30-10.00	1 hour 20 minutes
E3	Mobilitetsutvecklare (Mobility Developer)	Parkering Malmö	Maja Sölve	3. 3. 22 10:15 -11:00	33 minutes, plus informal not recorded 20 minutes
E4	Deputy Mayor / Chairperson of the Environmental Committee	Environmental Committee of the City of Malmö	Simon Chrisander	21. 4. 22 13:00 - 13:45	45 minutes

Note: The table lists all participants of the four extensive interviews, including their names, roles, and respective organizations/administration.

Multiple informal discussions with E1 - E3 during the Climathon were used to guide the research, as well as one extensive initial interview conducted with E1 to gain a narrowing of the topic and a better understanding of the concepts of mobility hubs in Malmö. Then four more interviews were held, with each interview lasting at least 40 minutes, while the longest and most extensive interview (a combined interview with E1 & E2) lasted over 80 minutes. Three interviews were conducted in person and one on Zoom. All interviews were recorded with prior consent and transcribed, naturalized coded, and later analyzed (Bucholtz, 2000).

An interview guide with prepared questions based on the research questions, previous investigation, and informed by the underlying multi-level perspective framework was used (see appendix 1). While the guide helped answer all relevant questions, the semi-structured interviews allowed for more questions to emerge in the process (Yin, 2015a).

4.2.2 Documents

As the focus of this thesis lies on the City of Malmö, as a dominant regime-level actor, official and openly available documents, such as the Sustainable Urban Mobility Plan (SUMP) (Malmö Stad, 2016), the Environmental plan (Malmö Stad, 2021b), and Malmö's Comprehensive Plan (Malmö Stad, 2018), others (see Appendix 2) were used for data collection. Since these documents are either reports on the status quo or goals for the future, they helped to analyze the first research questions regarding the problem and the second question regarding the necessary change in approach. On the other hand, these documents are often (on purpose) relatively vague or unclear regarding the concrete actions to achieve stated goals. This can be related to their political nature, as expressed ambition can gather

easier political support than concrete actions (Strunz et al., 2021). Therefore, they can only be seen as part of the data, as they complement the interviews and vice versa.

4.3 Coding

Since multiple sources and data points were gathered, I used inductive and deductive coding to extract and compare the most relevant information (Bernard, 2000; Yin, 2015b). Predetermined codes (deductive) were set, informed by previous research and the hypothesis that mobility hubs could be a good solution for yet-to-determine problems. The different MLP levels were incorporated as deductive codes to combine theory and data better. They were helping to track the significant issues Malmö is facing on a landscape level by looking for pressures and reasons why change is needed (RQ1). The wording was compared and coded to work out Malmö's change in approaching these issues (RQ2). Since research question three focuses on a vision of an innovative mix of existing and new tools, coding was used to highlight the problems that mobility hubs could address and the expectations the interviewees had for improving mobility and living in Malmö.

The opposite approach (inductive), going through the raw data and determining necessary and suitable categories, was also used (Bernard, 2000; Thomas, 2006). This helped to identify the prioritization of mobility-related problems (RQ1) and the previously unknown change in approach (RQ2). Therefore, the combination of using both coding approaches was especially helpful due to the nature of semi-structured interviews, which opened up for more detailed and previously unknown in-depth perspectives. In regard to the documents, it helped to get more familiar with the information and find further aspects previously regarded as less important. Both methods were done using NVIVO12 as coding program.

5 Analysis

In this section, the previous chapters are consolidated to answer the three research questions regarding Malmö's approach toward more sustainable mobility. More specifically, section 5.1 and its three subsections address research question one regarding Malmö's most pressing mobility issues based on the official document review and the interviews. Section 5.2 builds upon those results and presents additional key findings regarding the approach towards a shift in sustainable mobility, which is mainly derived from the official documents and supported by some interviews. The last section, 5.3, focuses on research question three, combining the MLP framework with the insights from the previous research questions to answer whether the innovative idea of mobility hubs can be seen as a potential breakthrough in line with the framework and Malmö's goals.

5.1 Malmö's mobility challenges (RQ1)

The focus on the challenges Malmö's mobility is facing is in line with the MLP perspective, as most of these challenges are pressures on the landscape level. To distinguish between different pressures, the chapter is divided into four sub-sections. This is necessary since Malmö is facing various problems that are all linked to mobility.

5.1.1 Spatial Issues

According to all interviewees, limited space is the biggest problem the City of Malmö currently faces. This is mostly due to population growth (E1, E2, E4) and the need to densify the city within existing city borders (E4, Malmö Stad, 2018). Consequently, Malmö has to work on a solution to use the space more efficiently. This implicitly "creates both possibilities and challenges for the city and its traffic system" (Malmö Stad, 2016, p. 12). Malmö is Sweden's fastest-growing city , and predictions estimate 500.000 inhabitants by 2050 (Malmö Stad, 2022f). This can be attributed to the global trend of urbanization and migration patterns. These trends can be seen as larger exogenous landscape level pressures out of control of the local municipality (Geels, 2002).

The restrictions to grow inwards are not entirely voluntary. Towards the northern and western parts of the city is the ocean, which is very difficult and expensive to build in. Additionally, it is politically contested on a local and national level since the environmental damages would be too severe (E4). To the east and the south of Malmö lies one of Sweden's and Europe's most fertile agricultural land (Malmö Stad, 2021). Constructing there is not desired, and attempts are often challenged in courts by various institutions such as the County Administrative Board, *Länsstyrelsen* (E4). This takes up resources and creates legal issues making construction attempts further unlikely (E4). Loss of

biodiversity and environmental degradation is further cited as too high, as stated by the politician interviewed in the context of this paper (E4). Additionally, the agricultural use of the land has a high economic value for food production within the country, as it is Sweden's most productive state in the sector (Malmö Stad, 2021b).

These reasons are arguably additional landscape pressures outside the city's control, as larger national interests restrict Malmö's mobility regime development. This culminates in Malmö city restricting itself to rethink its current space usage to grow inwards. Regarding mobility, space-inefficient individual-owned car usage, as shown in figure 11, takes up a lot of space (Malmö Stad, 2016). This is a very typical phenomenon many cities around the world are facing (Bell, 2019; Freund, 2014; Zavitsas et al., 2010). This leads Malmö to push for multimodal resource-efficient mobility as it would enable "more people to abandon their cars in favor of transportation with a low environmental impact such as walking, cycling or public transport" (Malmö Stad, 2016, p. 6).

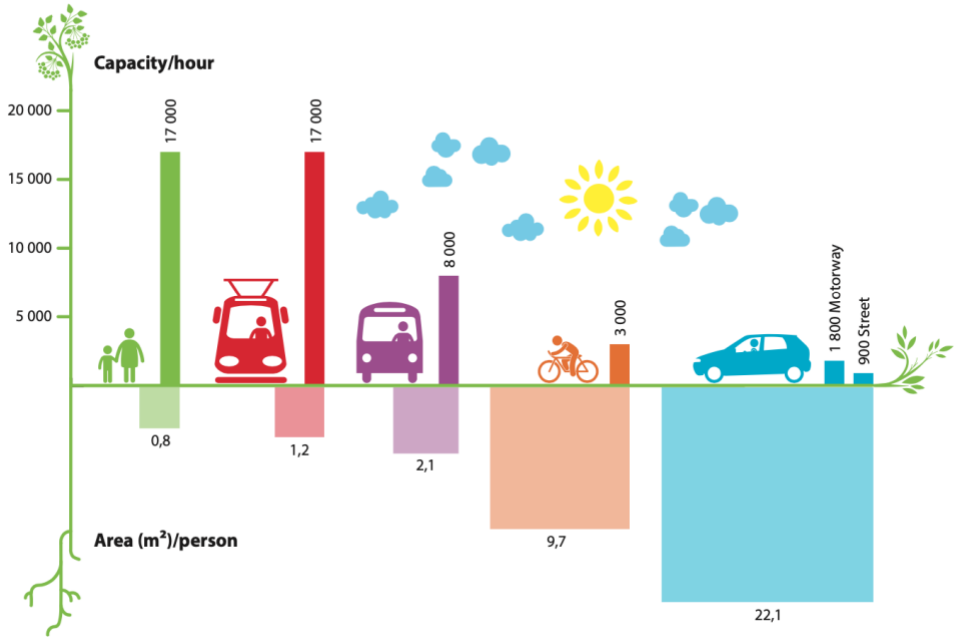

Figure 12: Flow capacity per hour and space in Malmö

Note: This graph shows large differences in spatial needs by mode of transportation within Malmö. Source: (Malmö Stad, 2016, p. 28).

5.1.2 Emission reduction goals

Another issue named in all interviews (E1-E4) and is even more dominant in public documents is the drastic reduction of emissions, following local, national, and international standards and goals (Malmö

Stad, 2016, 2018, 2021a, 2021b). This can also be attributed to the landscape-level pressures of climate change and its perception (Avelino, 2017; Capstick et al., 2015; Skeirytė et al., 2022). This pressure highlights that current and past approaches within the regime are not adequately adapted and need to change toward more sustainability (Malmö Stad, 2021a). Although these pressures were not named as the sole motivation to change Malmö's mobility (E1, E2), they are still considered one of the underlying factors for change as Malmö aims to become climate neutral by 2030 (Malmö Stad, 2021a, 2021b). Political pressure is arguably linked to larger changes within society and culture on a landscape level. This may have resulted in Malmö applying to the EU mission of becoming a leading experiment with the aim of climate neutrality by 2030 (European Commission, 2020). Which can be seen as additional landscape pressures on regime-level actors to find innovative solutions and translate them into action. This is linked to goals being clear on high political levels while being vague on how to achieve them (E1). Another explanation, according to the two traffic planners (E1, E2), is that Malmö's air pollution is currently well below the national and international emission thresholds and therefore does not face much national or international attention, which was not always the case (E2, E4). In other cities, such as Paris, high local pollution rates linked to combustion engines have acted as landscape-level pressures on that mobility regime, forcing more efforts into emission reductions (Cariolet et al., 2018). Three of the interviewees stated that an emission reduction by switching towards EVs would not solve Malmö's current space inefficiency problems (E1, E2, E3). While e-mobility is often praised as a more sustainable alternative compared to internal combustion engines, the inefficiency of using individually owned cars in urban areas, combined with an average time of 23 hours being parked (Boldrini et al., 2019) would remain. Additionally, heavy investment into new infrastructures, such as charging points, as well as local electricity production, would be needed and would take years to build (E1, E2, E3). Furthermore, it would compete for space with other modes of transportation (Boldrini et al., 2019; Freund, 2014). In Malmö, the expected emission from reducing car traffic and transforming mobility within the city is seen as a co-beneficial result of solving the more pressing local space-related efficiency (E1, E2). It must be observed whether both goals and regime will align in time.

5.1.3 Segregation & Social Inclusion

Focusing on indirect issues linked to mobility, it becomes noteworthy how Malmö views itself regarding diversity and inequality. On the one hand, it's very proud of its large diversity and the coexistence of many different cultures (Malmö Stad, 2021d). On the other hand, Malmö acknowledges that it is a very segregated city (Commission for a Socially Sustainable Malmö, 2013). Since the diversity is not equally spread around the city, the income and wealth inequalities are high, and average life expectancy is notably impacted by area (Malmö Stad, 2022b).

These issues are all linked to mobility as the current lack of access could be reduced through better mobility and integration within the city. Segregation within Malmö is manifested by its infrastructure and design, such as roads or the location of business areas and other elements. They act as “barriers and limit people’s opportunities to travel within the urban environment” (Marianne Dock & Johansson, 2014, p. 15). The interviewees (E1, E2, E3, E4) also point out that social differences and inequalities are of concern and new approaches to address them need to be found. Another challenge here is the unequal distribution of citizens' involvement and participation. Wealthier areas, for example, set up more protests when it comes to restricting their parking spaces (E1, E2). Whereas citizens in less wealthy areas do not complain to the traffic department, nor organize themselves to demand needed improvements (E1, E2). This shapes political decision-making and reduces mobility improvements to specific areas instead of providing a holistic approach within the city (E1). This is important as lack of mobility reduces inclusion, access to education, better jobs, social life, and healthcare, making it harder to break a reinforcing circle (Lucas, 2012; Lucas et al., 2016; Mattioli, 2021) (E1, E2, E4).

Furthermore, the differences in income are notable in travel behavior as it is one of the strongest factors determining “how much and in what way people travel” (Malmö Stad, 2016, p. 19). This situation results in “an imbalanced modal split, where car traffic is the dominating mode of transport” (Malmö Stad, 2016, p. 20) of the wealthier. In return, this “limits citizens’ empowerment and their possibility to move in everyday life” (Malmö Stad, 2016, p. 20), especially if they lack access to good mobility, reinforcing segregation and inequalities. A key element to change lies in creating a system of excellent public transport connecting different areas better with each other and fostering inclusion (Malmö Stad, 2016, 2018, 2021b, 2022b). This highlights again the required magnitude of the shift from current forms of mobility needs to have.

5.2 Malmö’s approach towards more sustainable mobility (RQ2)

These problems showcase that there is currently enough pressure on the status quo of Malmö’s mobility regime for it to change. This is especially evident since solutions and alternatives exist as established technologies or practices, such as bike riding, walking, and public transport. Therefore, to address the space issue, a drastic change within the regime is necessary.

5.2.1 Widening the approach toward mobility planning

Analyzing and coding official documents from Malmö City, its different departments, and the interviews showcased that a shift in approaching sustainability concerns is happening (Malmö Stad, 2016, 2018, 2021b). Summarizing the most important aspects, the following key aspects are to be

mentioned from the documents: linking urban development and sustainable transport based on economic, social, and environmental sustainability (Malmö Stad, 2018, 2021a, 2021b). Therefore, it seems as if there is a large shift on the regime level, understanding that a shift to interdisciplinary and more holistic approaches is needed (Malmö Stad, 2016). Within the traffic department, it goes further than reversing traditional car-friendly policies: rethink the whole approach toward mobility and find new solutions (E1, E2, E3).

The environmental plan states that "all members of society are important and share a common responsibility" and goes even further as saying that "either we undertake this journey together, or not at all" (Malmö Stad, 2021b, p. 3). While the individual choices of Malmö's people have a great impact on the environment and the climate (Malmö Stad, 2021a), this statement neglects the large differences and influences people have. In the case of Malmö's mobility, this can be easily traced back to the previously mentioned inequalities, the segregation within the city, and the differences in dominant modes and frequency of transportation use and access (Hedlund, 2019; Indebetou & Dahlberg, 2019). Therefore, the approach to solving mobility issues must focus on providing sustainable and easy-to-choose alternatives to reduce car travel and car ownership for all (Malmö Stad, 2021c, 2022d) and making it easy for residents to live and move sustainably in Malmö (Malmö Stad, 2021a). This includes the goal of changing the city so that walking, riding a bike, and using public transport becomes the first and natural choices for travel (Malmö Stad, 2016, 2021b). Malmö points out that providing better choices will lead to an increased change in the modal share (Malmö Stad, 2016). The new approach should transform mobility to be "human-centered" and "improve health, safety and social cohesion" (Malmö Stad, 2018, p. 13).

5.2.2 Aiming for more civil participation

The most promising idea for Malmö is to strengthen the participation of citizens and to understand their motivation and needs in order to shift to better and more sustainable modes of transportation within the city (Malmö Stad, 2016, 2021a). Its new approach consists of "enabling people to influence how the city and traffic system are designed" (Malmö Stad, 2016, p. 22). Previous responses to a traffic survey show that "80% of the inhabitants are in favor of inner city traffic that is more restrictive towards car traffic and parking than today" (Malmö Stad, 2016, p. 22), the new approach would also look to engage with citizens towards implementing this wish (E1, E2 Malmö Stad, 2021a, 2022f). The interviewees stated that the decreasing response rate of traditional traffic surveys would not be ideal for future decision-making, and new ways of getting people involved are needed (E1, E2). Furthermore, currently, most traffic planning decisions are made by technical committees that are largely run by a small number of men (E1). While they are democratically elected, it is not guaranteed that they can

consider all the different needs of a population (E1, E2). A change towards bigger and more diverse decision-making bodies could improve this situation and fully shift towards more sustainable, inclusive, and better mobility. This is not new in traffic planning, and “there is a rich literature on user and stakeholder participation processes in mobility planning” (Geurs et al., 2022, p. 5) Malmö could benefit from. Furthermore, Viable cities and the municipality are currently exploring different digital methods to facilitate actor co-creation (Malmö Stad, 2021a).

5.3 Potential role of mobility hubs in Malmö (RQ3)

Considering Malmö’s new approach to providing better and more space-efficient sustainable mobility options away from the car, two questions might have arisen: how to best implement a fast, reliable, easy, and inexpensive solution? The second question focuses on how to enable a shift in travel behavior and convince the public to switch fast enough toward better mobility alternatives.

The traffic department points out that using existing infrastructure and aiming to change the perception of it as well as developing it with participation from the public, could solve both issues (E1, E2, E3). This fits the approach of aiming to involve more people in the transition and would reduce additional construction costs, save time and support the target of increasing the modal split towards more walking, cycling, and public transport at the expense of car usage (Malmö Stad, 2016). One idea is based on the park and ride concept, where different modes are linked to each other through infrastructures first introduced to Malmö in 2010 in Hyllie (Malmö Stad, 2016, p. 15). Typical examples are the train stations being connected with large car and bike parking facilities. This is where the innovative idea of mobility hubs wants to build on (Malmö Stad, 2022f). This follows two approaches: connecting and improving existing hubs, such as Malmö Central, Trianglen, and Hyllie, while offering better access to more alternative modes (E1, E2).

The second approach is to create smaller hubs all over the city by repurposing existing smaller infrastructure (E1, E2, E3). As part of this approach, Parkering Malmö, the city-owned parking company, is tasked with finding new approaches to using their infrastructure (E1, E2, E3, Parkering Malmö, n.d.-a). This approach aims at expanding the usage further than and away from solely providing traditional car parking services (E3). One example is in the currently developing Hyllieäng, an area in Malmö. Here a collaboration between Parkering Malmö and “OurGreenCar”, a car-sharing provider, will provide a shared car and bike pool to residents housed in a newly developed garage around spring 2024 (Parkering Malmö, n.d.-b). Until the completion of that garage, the “Mässan” parking garage, owned by Parkering Malmö, will be used, explains Maja Sölve, Mobility Developer at Parking Malmö (Parkering Malmö, n.d.-b).

Having these two approaches in mind, the traffic department is currently conducting a GIS (Geographic Information System) analysis to figure out where to best implement mobility hubs and in which capacity (E1). Additionally, another large-scale survey, aiming at gathering the people's needs and wishes for improved mobility, is being prepared (E1, E2). The focus is naturally on space-efficient, environmentally friendlier, and socially more inclusive mobility solutions (E1). Input from these studies will be used to conduct a 1½ yearlong large-scale test phase (E1, E2, Malmö Stad, 2022f).

Another aspect of this innovative approach is the idea of visually connecting mobility throughout the city, making it more prominent and the city more attractive (E1, E2). Additionally, it aims at shifting travel behavior and showcasing the variety of mobility options and raising awareness for them. This could be enhanced by giving mobility hubs individual characteristics according to the local needs by involving citizens in the design (E1, E2). The hope is that it would increase public interaction and participation as well as create personal connections (E1). While it can be in the form of design, it can also be outside of traditional mobility and traffic-related options (Arnold et al., 2022). Examples could be tiny libraries, bike workshops, delivery pick-up stations, exhibition spaces, small urban gardening areas, public bathrooms, cargo-bike/e-bike, e-scooter, traditional bike, and car sharing stations, and many more ideas that would potentially come up (E1, E2). Some of these "services" are already part of mobility hubs in other cities (Anderson et al., 2017; Geurs et al., 2022; Miramontes et al., 2017; Rongen et al., 2022). These should be guided by their interaction with and participation of local stakeholders such as residents and businesses, schools and kindergartens, local associations, and many more (E1, E2, Coenegrachts et al., 2021). This approach could help strengthen inclusiveness and reduce segregation as "several social and economic aspects indicate positive effects by improving links between different neighborhoods and bridging barriers of different kinds" (Malmö Stad, 2018, p. 2). This would result in using existing space more efficiently and with more functions, compared to traditional car reserved space. This change could be visually strengthened as its occasionally done with some bike stands around the town (Cyclehoop, 2022; Wirdelöv, 2020), as seen in figure 13. The space of one parked car is visually maintained while it is converted into a bright bike stand, which could be seen as another niche innovation. Taking more space from car-related mobility and encouraging other forms of Malmö is a priority target for its mobility and urban planning. Making this switch more visible is seen as an essential part of it (Malmö Stad, 2016).

Figure 13: Car Bike Port in Malmö

Notes: Bike stand in bright orange shaped like a car in Friisgatan 14, Malmö, Sweden. (Source: Photo by author)

Malmö is at a great point to systematically approach its mobility and link existing infrastructure, such as its stations, bus, and bike network, and the new scooter parking points and their vast amount of parking spaces. Parkering Malmö has already conducted a study on a possible rebranding towards more functions away from solely car parking (E3). This includes prioritized spaces for car sharing, bike parking, and even non-mobility services (E1, E3).

6 Discussion and Limitations

This section reflects on the approach toward this topic, the previously presented results, and the implications and limitations of the thesis and discusses potential future research.

6.1 Reflection on answering research questions

A constant challenge within mobility planning is shifting mobility behavior towards more sustainable and efficient modes of transportation (E1, E2, Luo et al., 2021; Miramontes et al., 2017; Moradi & Vagnoni, 2018; Mundaca et al., 2022). For Malmö, the most pressing issue to pursue this transition is related to its limited space, due to strong population growth and the restriction on only expanding within its current city limits. Furthermore, pressures outside of the cities' powers, include the need to tackle climate change by reducing emissions. While many cities have been facing similar issues, policies to fundamentally change mobility have shown little progress. The transport sector is the only one within the EU where emissions are still rising since 1990 (European Parliament, 2019). Since over 70 % of these emissions are linked to road transport and the majority to the dominant fossil fuel-driven car, alternative modes of transportation are needed. Yet the solution lies not only in technical alternatives, such as biofuels or EVs. Many established and new alternative forms exist, especially within urban areas (Bell, 2019). The issues often lie within the dominant regime and its established practices making it difficult for new forms, such as niche innovations, to be established (Geels, 2018). Mobility hubs are a niche innovation currently being introduced in developed cities (Arnold et al., 2022; Geurs et al., 2022; Miramontes et al., 2017). Case studies on local levels are important to find examples of successful transitions, which could then become new mobility standards.

This paper has shown that Malmö City and its traffic department, as dominant actors within the mobility regime, are aware of the mobility-related issues it is facing, particularly linked to privately owned cars. Answering RQ1 made it clear that the main issue is caused by different landscape pressures culminating in limited space availability within the city borders, which is in conflict with space inefficient individual car usage, which is in line with other cities and existing research (Boldrini et al., 2019; Freund, 2014). This issue explains Malmö's overarching theme of shifting traffic away from cars and towards making walking, cycling, and using public transport natural choices within the city (Malmö Stad, 2016, 2018, 2021b). While other cities are mainly focusing on emission reductions, such as Oslo, by strongly incentivizing e-mobility (Ajanovic & Haas, 2016). Malmö considers the space-related issues that remain when switching engines and not travel modes. The traffic department acknowledges that e-mobility has to play a role in the sustainability transition but is aware of multiple additional issues (E1, E3). These would be increased electricity demand (E2), which is at times already critical in Skåne

(Palm, 2021). In addition, congestion, a stronger division into those who can and cannot afford new electric vehicles, and most critically limited space issues would remain. Furthermore, there is the fear that e-mobility might encourage more motorized individual journeys as it is believed to be more sustainable (E1 & E2).

Answering RQ2 showed that Malmö is changing its approach to address these issues. While the primary goal seems to be using the space more efficiently, many more goals are connected to this transition. These include reducing emissions, and segregation, transport poverty, and improving the attractiveness of living in the city while increasing citizen participation in the process (E1, E2, E3, E4, (Malmö Stad, 2016, 2018, 2022f). Aiming at solving problems on a local level could work out, as cities like London have shown in regard to their mobility improvements, such as the introduction of their Oyster card (Geels, 2018; Kamargianni et al., 2016).

Malmö aims to find ways to address needed mobility changes within the different areas, and include feedback and participation of locals (E1, E2). This should speed up the transition and improve its successful regime adaptation. With rising pressures of limited space and increased emissions, the need to change becomes stronger with each year passing by (Malmö Stad, 2018, 2021d). The coming years will show, whether changing the approach will be successful, but since previous methods have not reduced emissions enough and have created or at least reinforced segregation, spatial issues, and inequalities and looking for a more holistic view of mobility and its related possibilities could prove right. With that in mind, it should be studied whether a stronger change in modal split can be achieved according to Malmö's 2030 goals as set per Sustainable Urban Mobility Plan (SUMP) area (Malmö Stad, 2016, p. 33). Further ways of measuring a successful transition should be considered away from traditional mobility services in line with the more holistic approach, including social aspects, diversity of users, number of increased interactions, and many more (Bell, 2019).

One way of incorporating this approach into the mobility regime is through the innovative mobility hubs concept, as previously analyzed regarding RQ three. It was shown that Malmö has an extensive network of public transportation, including bus lines and stops, and larger train stations, "Malmö by bike" as a sharing service with many points along the city and a vast amount of car parking areas and facilities and upcoming e-scooter parking points (see background chapter, appendix 11). Overlapping their locations shows many shared points that can be categorized as simple, not yet developed, or organized mobility hubs, which is the case for many well-developed cities {Citation}. Building on it, Malmö City can connect the different parts and incorporate more mobility innovations within the mobility hub concept. This is typical for cities starting to use mobility hubs (Bösehans et al., 2021; Nes, 2002; Roberts, 2019; Rongen et al., 2022). They need to be visually and functionally connected to

convert them into a network of mobility hubs (see Appendix 11). Furthermore, they should all be incorporated into a digital platform to increase ease of use (Roberts, 2019). The Skånetraffiken app could be a baseline for that, as discussed with the software engineer responsible for the app (O. Persson, personal communication, November 2022). Alternatively, another third party could develop one app and connect many different mobility providers and services into one. Berlin's public transport company (BVG) created one called Jelbi, and Hamburg's public transport company (HVV) app is called hvv switch. Both combine traditional public transport with newer forms of mobility such as car, bike, and scooter sharing, shuttle services, taxi services, and many more from various mobility partners (BVG Jelbi, n.d.; HVV SWITCH, n.d.).

6.2 Contextualizing with previous literature

These findings are typical for well-developed European cities, that introduced mobility hubs, such as München, Bremen, and Hamburg (Arseneault, 2022b; Czarnetzki & Siek, 2022; Gray, 2017; Miramontes et al., 2017) and have been looking for ways to reduce the dependency on cars or motorized individual modes of transport. Furthermore, Malmö's approach of customizing mobility hubs to address different needs is encouraged as the functionality and design of mobility hubs should serve underlying policy objectives and be customized (Rongen et al., 2022). Malmö's approach to including its citizens is another important part reflected in some literature, pointing out the social benefits as it improves adoption rates, better access for a larger pool of users, and helps meet future demand (Bell, 2019; Tran & Draeger, 2021).

6.3 Reflection on the applied theoretical MLP-framework

Using the MLP-framework helped to structure the paper and understand external pressures (RQ1) on Malmö which are forcing the city to change its approach of improving mobility (RQ2) and the possible solution of using the innovative mobility hub concept to address existing issues (RQ3). Reducing the complexity to three levels and further combining all mobility modes into one regime for a holistic view helped to limit the scope of this large topic. Furthermore, focusing on one key regime actor enabled to analyze all three levels from Malmö's viewpoint. This was intentional, as they are the ones trying to figure out how to use mobility hubs, which was ultimately the underlying interest of this paper.

Nevertheless, it needs to be considered that this transition is far more complex than perceived in this paper. Using the MLP framework for mobility transitions often focuses on individual regimes, such as the automotive regime, public transport, or even a sub-regime like the bus regime (Geels, 2018). This brings in more complexity as it allows to focus on power differences, cultural preferences, and mobility

behaviors for each regime as well as their respected actors. Furthermore, it became clear that there are many different niche innovations already influencing the mobility regime of Malmö. These include e-scooters, which now, through new regulations, have arguably left the experimentation phase and have become part of the established regime. The car-shaped bike stands could be seen as another innovation, as they are used to change mobility behaviors towards more sustainable and space-efficient forms of transportation (see figure 13) (Wirdelöv, 2020).

6.4 Limitations

Limiting the thesis to Malmö Stad as a key actor and source narrowed the perspective on mobility. On the other hand, it helped to understand the top-down approach to improving mobility with mobility hubs. Doing a large survey with residents in possible mobility hub locations was considered. Yet the recommended scope of at least 1000 participants, as well as the language barrier and the uncertainty of the location, ruled it out. Furthermore, a survey by the city was planned, making it redundant. Another possible approach was focusing on other stakeholders such as climate organizations like Fridaysforfuture Malmö or other local associations and businesses. Aiming at understanding Malmö's approach and focusing on the possible implementation of mobility hubs, this option was also rejected. It could have resulted in different problems and prioritization of approaching them. This will hopefully be addressed when implementing mobility hubs and involving the public. Since this is part of Malmö's approach, it could be further supported and studied.

Since a large focus is on the reduction of car traffic within Malmö's city borders, a literature review of successful policies in other cities with that goal in mind could have been conducted and then fitted for Malmö's case. This was done by Kuss & Nicholas (2022), focusing on implementation possibilities of car reduction practices for Lund. This approach was explored, yet the innovative mobility hubs approach would have been neglected. The research would have been arguably redundant as Lund and Malmö are too similar, and many policies can be applied to both cities.

6.5 Reflection on future research

This paper can encourage Malmö's traffic department to embrace their wider approach to improving mobility, including more non-traditional planning innovations, specifically mobility hubs, and encourage citizen participation as early as possible. Since mobility hubs are a niche innovation and not yet part of the mainstream public transportation networks around the world, more research should focus on how to implement them and share long-term experiences, which is in line with existing literature and a selected number of guiding documents (Arnold et al., 2022; Arseneault, 2022b; Aydin

et al., 2022; Bell, 2019; Bösehans et al., 2021; Geurs et al., 2022; Roberts, 2019; *Smart Hubs*, n.d.). Further research needs to focus on how to increase user diversity. Some studies have shown that it's largely young and wealthier males who use early versions of mobility hubs (Arnold et al., 2022; Miramontes et al., 2017). Malmö's approach of including the local population already in the planning and experimentation phase could show different results and should be studied. Within mobility hubs literature, no examples of citizen participation during design and conceptualization were found.

6.6 Reflection on practical applications

This paper has shown that a city like Malmö can and needs to rethink its mobility infrastructure to reduce car traffic for various reasons and promote public transport and other more sustainable modes. This is in line with international climate targets, and EU mobility goals (European Commission, n.d., 2019). Furthermore, it fits into Malmö's role as one of 100 Climate-neutral cities by 2030. As some German cities have been experimenting and developing mobility hubs, such as Berlin, Bremen, Hamburg, and München, Malmö joins them and helps bring mobility hubs from the niche level to become established praxis within the regime level. The benefits are that it is an easy and fast implementable solution since it builds upon existing public transport, promotes walking, and cycling, and systematically includes newer shared mobility concepts (see Appendix 11). These are well-established but need a strong boost, similar to the broader term of multimodal transport. This is promising since it does not rely on new, not yet developed technical solutions, such as autonomous vehicles. It builds on existing technologies and reflects modern habits while improving and enhancing their usage. Includes and strengthens public participation, which is key for achieving this fast transition and brings in many other benefits apart from less emission-intensive mobility. As mentioned before, it can integrate different areas of the city better, reduce inequalities, and provide more space, as it is easier to implement.

More research into actual CO2 emission reduction linked to mobility hubs is needed. Furthermore, it needs to be established whether it will be of significant importance in time to meet existing climate goals. A combination of successful policies to reduce car usages, such as proposed by Kuss and Nicholas (2022) and mobility hubs, could be applied to Malmö.

Furthermore, future research could focus on the potential of creating rural hubs and linking them to urban hubs (Frank et al., 2021). Since Malmö has a lot of traffic associated to commuting a similar approach could reduce associated issues.

7 Conclusion

This paper has shown that there is a large shift happening in Malmö's traffic department. Analyzing official documents and conducting semi-structured interviews with involved actors revealed why a new and more holistic approach towards more sustainable mobility is needed. Limited space issues within the city borders, the need to address emissions and reach emission reduction goals, and the urgency to reduce segregation and make the city more attractive to live in demanded that shift. One main issue connecting these problems is space inefficient individual car usage, which consequently is a priority reduction target. Since changing established practices, such as the dominant car usage, is difficult, reforms often struggle. Malmö city hopes to make its public transport and newer, more sustainable forms of mobility more attractive while disincentivizing the usage of private cars. To achieve this, the innovative mobility hub concept is introduced and should build upon existing mobility infrastructure while using space more efficiently and promoting more sustainable mobility. To improve adaptation, the participation of citizens is desired, yet unclear to what extent or in which form. Ideas include involving the public in the design process and catering mobility hubs to local needs, exceeding traditional mobility services. This aligns with other early mobility hub adopters and focuses on improving existing infrastructure rather than betting on new technologies. This socio-technical approach can be fruitful when implemented correctly and strengthened through diverse public involvement. Malmö city is clearly on the right track to improve its mobility and make it more environmentally friendly. It remains open to how fast it will show results and how much it will contribute to solving the list of issues, yet new ways of measuring success should be developed. This is a typical process of large-scale sustainability transition, where current practices do not sufficiently deal with too many problems, and many niche innovations, such as the mobility hub, are created to try to solve problems and become part of the new regime, the new standard. While these decisions might be difficult since their impact is not fully known, it is inevitable that a sustainability transition within mobility is needed.

This is especially true for the traffic planners of Malmö, who try to envision long-lasting solutions far longer than any political career and potentially for generations to come and socio-technical regimes to shift and norms to change. This huge responsibility might tempt to slow down the large decision. Still, a swift and drastic change in emissions, especially in rich urban areas such as Malmö, is key to solving the climate crisis using as many different perspectives could help make it last the longest. Hopefully, this can serve as a basis for further research into existing concepts and practices and be used as a case study to copy for other cities to follow, in line with Malmö's ambitions and within the EU Mission of 100 climate-neutral cities by 2030.

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9 Appendices

Appendix 1

Exemplary interview guideline

Interview-guideline

Potential Guiding Research Questions: How can mobility hubs/zones enable a transition towards more sustainable and inclusive mobility in Malmö?

Preliminary coding (deductive thematic analysis) following sub-research questions:

1. About Malmö's current mobility, current state (transition theory), problems, larger issues, pressures (Landscape level)
2. About Malmö's approach, vision and goals, approaches, changes, challenges (regime level)
3. Innovation Mobility zones/hubs, niche innovation ideas, what will it solve, what changes (niche level)

Structure	Exemplary Questions
1. Warm-up / Introduction	Thank you for taking the time What is my aim?
2. Basic intro questions:	What is your name and role regarding mobility in Malmö? How long have you been working on this topic? What is your current goal for improving Malmö's mobility and making it more environmentally friendly?
3. Landscape/pressures	In your words, what is the current problem Malmö is facing regarding mobility? What are Climate-related issues? What needs to be done? And why? Historical pressures? Political? Are the organizations, and social movements demanding improved mobility?
4. Regime level/Challenges	How do u approach the problems? What needs to change to improve? What are the challenges in Malmö? What role do the local government and politics play?
5. Niche level/Mobility hubs	What role do mobility hubs/ zones play? What changes with mobility hubs/ zones? What are the criteria for implementing a mobility zone? How do you approach implementing mobility hubs? What are the obstacles to using mobility zones? What is the time frame for implementing mobility zones? How is the planning of mobility zones in line with reaching national and local sustainability goals? (Malmö 2030 …)
6. Data and Methodology	What are the current measurements for mobility usage in Malmö? How will you measure the improvements? What would be a success, regarding the usage of Mobility zones?

Appendix 2

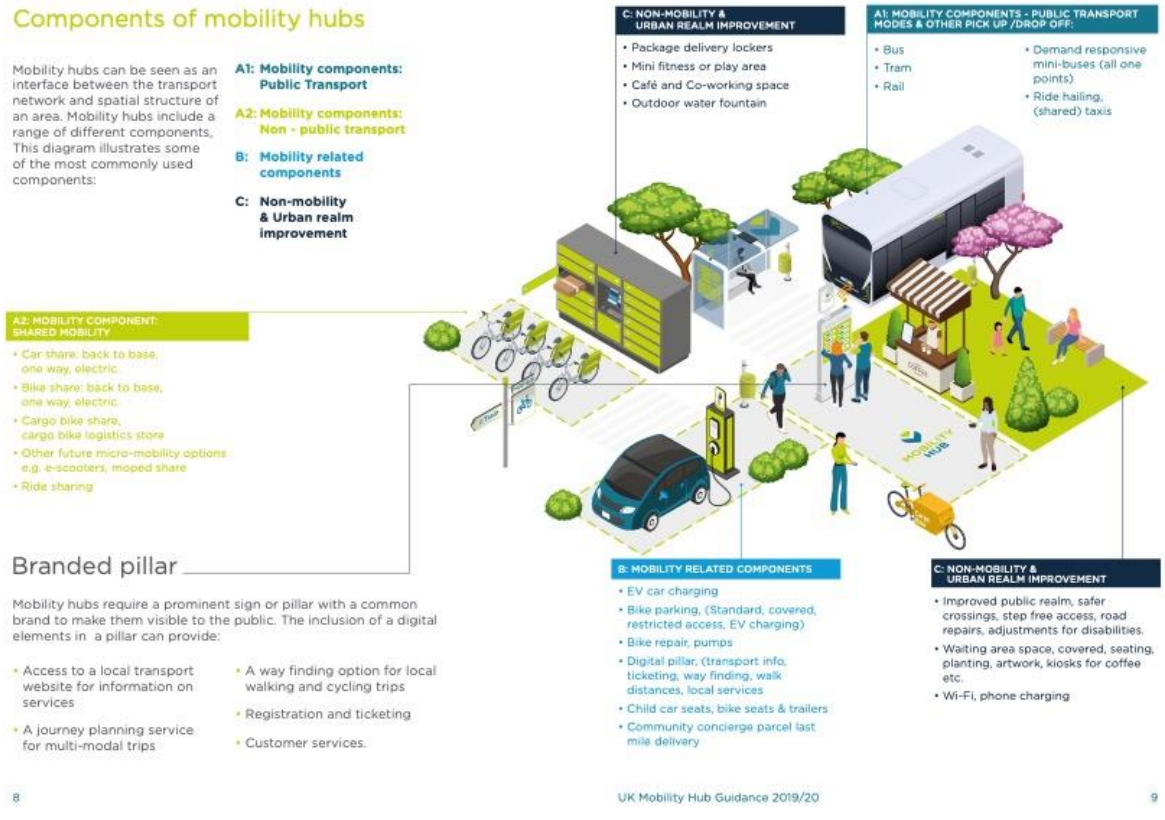
List of official documents

Number	Name	Kind	Author	Date	Language
1	Commission for a Socially Sustainable Malmö	Directive	Malmö Stad	2010	English
2	Approach for Commission for a Socially Sustainable Malmö	Report	Malmö Stad	2011	English
3	Comprehensive Plan for Malmö	Comprehensive Plan	Malmö Stad	2018	English
4	Environmental Programme for the City of Malmö	Planning document	Malmö Stad	2021	English
5	Klimatkontrakt 2030 (translated by the author)	Climate contract	Viable cities, Malmö Stad, Energimyndigheten, Vinnova, Formas, Tillväxtverket, Trafikverket	2021	Swedish
6	Så reser vi i Malmö kommun, Resvaneundersökningen (translated by the author)	Survey	Region Skåne	2018	Swedish
7	Malmö sustainable urban mobility plan	Mobility plan	Malmö Stad	2016	English
8	Malmö's path towards a sustainable future Health, welfare and justice	Commission	Malmö Stad	2013	English
9	Strategy 2030 Agenda City of Malmö	Strategy	Malmö Stad	2018	English
10	The city's spatial impact on health	Report	Malmö Stad, Marianne Dock, Bertil Johansson, Håkan Kristersson	2012	English

Number	Name	Kind	Author	Date	Language
11	Travel habits in Malmö 2018 Survey	Report	Trivector, Lovisa Indebetou, Lina Dahlberg	2019	English

Appendix 3

Illustration with exemplary components of a mobility hub (Roberts, 2019)



Appendix 4

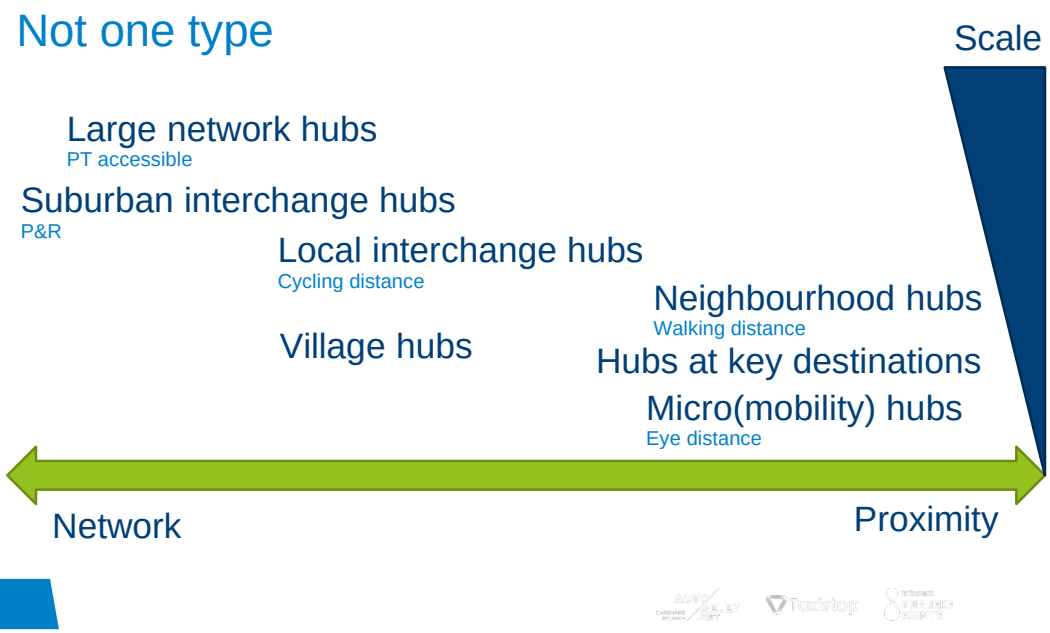
Photo of a decentralized (small) mobility hub in the inner-city of Hamburg (Czarnetzki & Siek, 2022)

Appendix 5

Illustration of a larger mobility hub located outside of dense urban areas.

Appendix 6

Illustration of scale differences of mobility hubs (Meuleman, A. 2021)

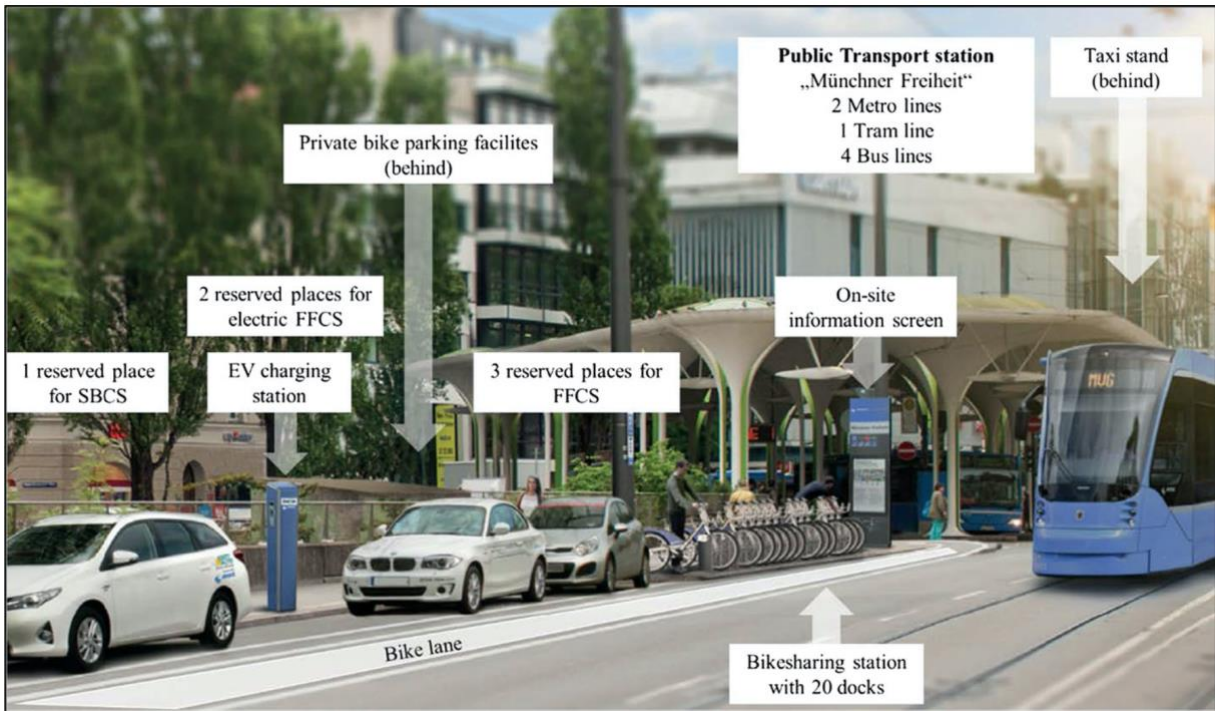


Appendix 7

Illustration of six success factors as part of the Mobility hub guidance (Roberts, 2019)

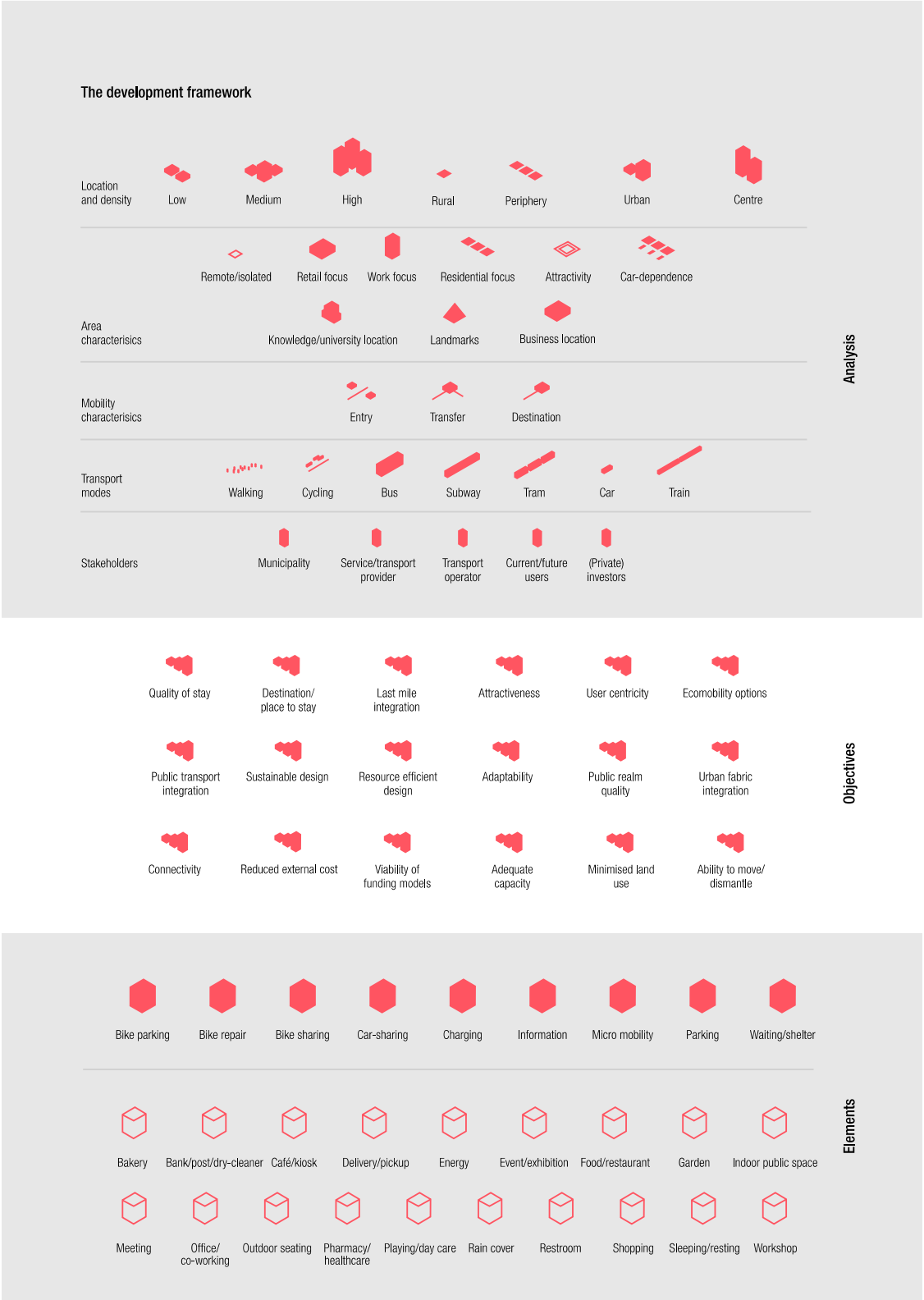
Appendix 8

Mobility hub example München (Miramontes et al., 2017)



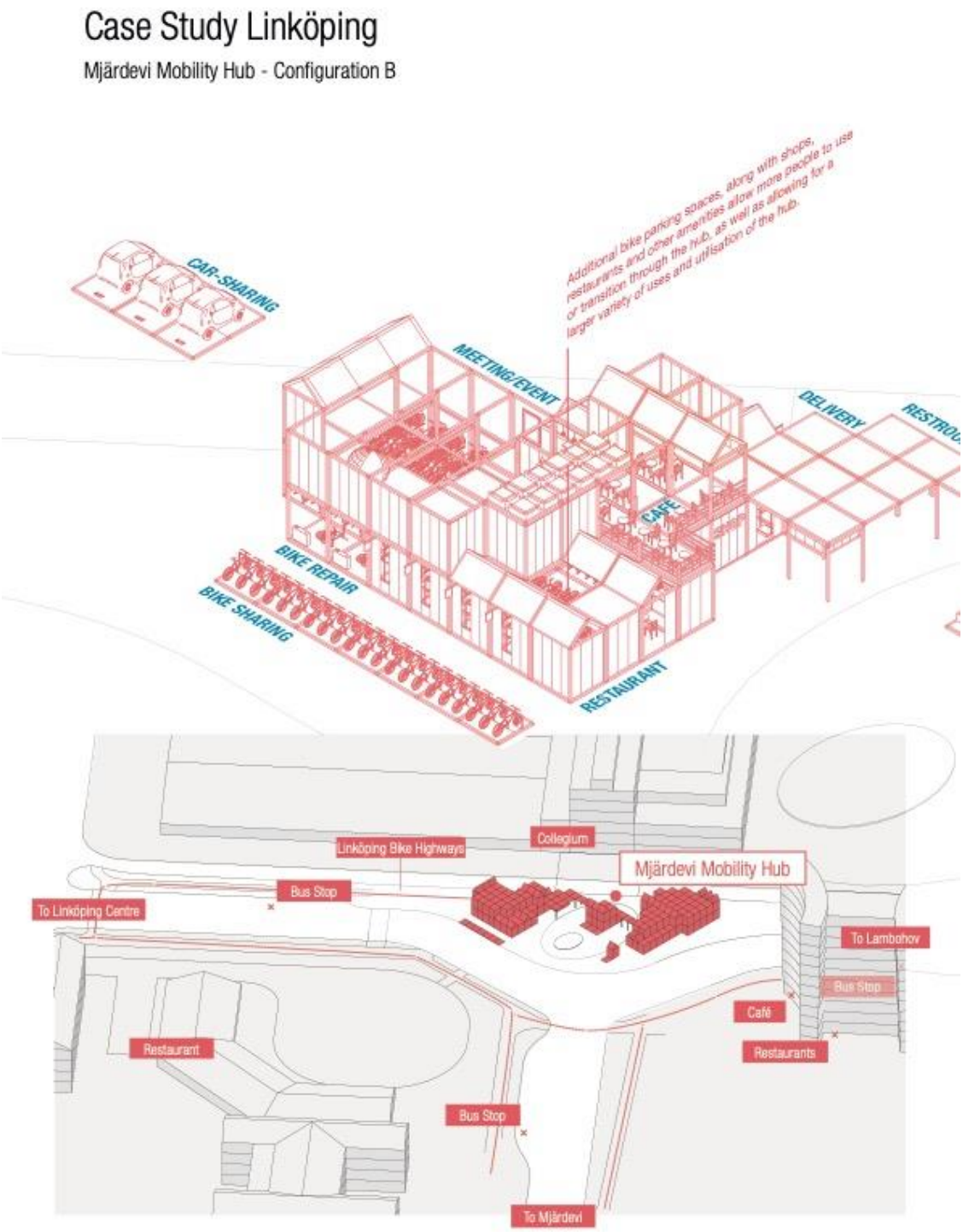
Appendix 9

Example of a modular approach to mobility hub development



Appendix 10

Example of Mobility hub concept case study



Appendix 11

Examples of mobility infrastructure in Malmö suitable for mobility hub network (own creation)