Smart Cities and Mobility Stations

Lessons learned from the Smarter Together in Vienna and Munich

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Smart Cities and Mobility Stations: lessons learned from the *Smarter Together* in Vienna and Munich

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ABSTRACT

With an increasing urban population and urban problems arising from this unplanned growth, several projects aimed at promoting sustainable urban development have emerged. Smart mobility strategies, such as shared mobility and mobility stations, represent some of the solutions to promote changes in travel behavior. Despite its beneficial impacts, however, the implementation of such infrastructure is criticized for not contributing to current urban issues, as well as often disregarding knowledge about urban space and its functioning.

In this context, the *Smarter Together*, a joint research and innovation project funded through the European Union program H2020, was implemented. The project selected three lighthouse cities to test and upscale innovative solutions: Vienna, Munich, and Lyon.

This master thesis presents the main characteristics of the mobility stations systems implemented in Vienna and Munich in the scope of the project *Smarter Together*. Its main goal is to share what can be learned from their experiences while approaching critically the concept of smart cities. This master thesis identifies important aspects to take into account when planning, implementing, and operating mobility stations, and provides an understanding of smart cities and smart mobility that goes beyond the adoption of technology. Several methods were combined for the development of this master thesis, such as quantitative secondary data, observational studies, application of survey forms, explorative expert interviews, and literature review.

This work has demonstrated that the *Smarter Together* has a cutting-edge scope and contributed greatly to research and innovation, by creating living laboratories to test the application of technology in the urban environment. However, from the perspective of the mobility stations assessment, many caveats were made. In short, many lessons could be learned and are presented throughout this work aiming at contributing to the improvement of the mobility stations implemented in the project areas in Munich and Vienna, as well as for inspiring other cities in Europe and worldwide.

Keywords: mobility stations, mobility points, smart cities, smart mobility, Smarter Together.

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CONTENTS

LIST OF ABBREVIATIONS

AIT	Austrian Institute of Technology
BMUB	German Environmental Ministry
CDCs	City Distribution Centers
EU	European Union
GB*	Association for urban renewal in Vienna (Gebietsbetreuungen Stadterneuerung)
ICT	Information and Communications Technology
MaaS	Mobility as a Service
MCTS	Munich Centre for Technology in Society
MGS	Association for urban renewal in Munich (Münchner Gesellschaft für Stadterneuerung)
MVG	Public transport operator in Munich (Münchner Verkehrsgesellschaft)
MVV	Transport and Tariff Association (Münchner Verkehrs- und Tarifverbund)
SWM	Public Utility Company in Munich (Stadtwerke München)
TUM	Technical University of Munich
UCCs	Urban Freight Consolidation Center
VKT	Roadway Vehicle-Kilometers Traveled

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1. INTRODUCTION

The population living in cities more than tripled between 1960 and 2005, and it is expected that 70% of the world's population will live in cities by 2050. The constant growth of the urban population and the urban problems arising from this process have led government organizations, institutions, businesses, and civil society to seek the development of projects that can promote sustainable urban development while maintaining the economic competitiveness of municipalities. In this context, the relationship between technology and society has been a key issue. (Bassi, 2017, p. 4; Harrison, 2017, p. 18)

Among many urban problems arising from unplanned growth, cities worldwide are dealing with the lack of space within their city centers as well as with the resulting traffic congestions. In this scenario, smart mobility strategies have been adopted worldwide to promote changes in travel behavior. Among smart mobility strategies, there is shared mobility and the implementation of mobility stations.

Mobility stations are places or locations where different mobility offers and services are available. They usually include a shared mobility alternative, such as shared bikes, scooters, and cars, and they aim at promoting the integration between those and the public transport to change travel patterns.

Although many studies show that mobility stations and shared mobility can positively impact urban mobility and promote changes in travel behavior, many authors question the concepts of smart city and smart mobility, as well as the use of technology in the urban environment, stating that these not only do not contribute to current urban issues but also intensify some of them. Moreover, many times the application of those concepts is criticized for disregarding the knowledge about urban space and its functioning.

1.1. Background

The *Smarter Together* is a joint project funded through the European Union program H2020 and it aims to improve cities' capacity to implement smart city solutions through networking. The program selected three lighthouse cities – Munich, Lyon, and Vienna, which are supposed to implement activities and upscale solutions, inspiring other cities in Europe to develop similar projects. Those three cities implemented different activities in specific districts and monitored the results to upscale solutions at the city level. Mobility stations were implemented in the scope of the *Smarter Together* both in Vienna and Munich. Lyon implemented an electric car sharing system as well as charging stations for electric vehicles, but did not define them as mobility stations. Besides the three lighthouse cities, the *Smarter Together* selected three follower cities – Santiago de Compostela, Sofia and Venice, which will replicate the key findings from the lighthouse cities, implementing them in different urban and institutional environments. Venice, as a follower city, already plans to replicate the experience of mobility stations. (Smarter Together, n.d.)

1.2. Scope and Research Questions

This thesis presents the main characteristics of the mobility stations systems implemented in the scope of the project *Smarter Together* in the cities of Vienna and Munich. Its main goal is to share what can be learned from their experiences, concerning planning, implementation, and operation. Besides presenting positive and negative aspects of the experiences held in both cities, this study will also compare them, by suggesting possible reasons for higher utilization in a particular context and indicating better approaches for the follower cities, as well as for other cities worldwide.

Furthermore, this master thesis approached critically the concept of smart cities and how it is handled by the project *Smarter Together*. It questions the actual contribution of mobility stations to creating and promoting smart cities, as well as the role of technology in the urban environment.

It consists of a mixed-method research, which combines quantitative secondary data, observational studies, application of survey forms, explorative expert interviews, and literature review.

The expected contributions are 1) to identify important aspects to take into account when planning, implementing, and operating mobility stations; and 2) to provide an understanding of smart cities and smart mobility that goes beyond the adoption of technology.

1.3. Outline

This thesis is composed of nine parts. The first one, this introduction, presented the motivations, background, goals, and research questions. The second part shows the state of the art of smart cities, smart mobility, shared mobility, city logistics, and mobility stations. Section three describes the case studies – the mobility stations implemented in the scope of the *Smarter Together* in Vienna and Munich. Part four explains the methodology used in this research and the reasons why the methods were chosen. Chapter five presents the main data gathered and the analysis made during this study, regarding both Vienna and Munich. Chapter six summarizes the characteristics of the systems and findings, comparing the mobility stations in Vienna and Munich. Part seven is the core of this work and presents the discussion regarding the research questions defined. Finally, part eight provides guidelines for further development of mobility stations based on the lessons learned from the experiences in Vienna and Munich, while part nine presents the limitations of this work as well as recommendations for further research.

2. THEORETICAL FRAMEWORK

New development strategies and urban practices aim at improving cities and reducing their environmental footprint through the use of Information and Communications Technology (ICT).

This chapter presents the state of the art of a few concepts essential for the development and the comprehension of this study, such as smart cities, smart mobility, shared mobility, city logistics, and mobility stations.

2.1. Smart Cities

According to Albino *et al.* (2015, p. 2) and Papa and Lauwers (2015, p. 545), the terms smart mobility and smart cities appeared both at the beginning of the Nineties. At that time, the name was given to point out a city with systems dependent on technology and innovation. Nowadays, studies have defined the term smart cities in many other different ways, considering it as a strategy to promote better cities.

BSI (2014, p. 12) defines a smart city as "effective integration of physical, digital and human systems in the built environment to deliver a sustainable, prosperous and inclusive future for its citizens."

Silva *et al.* (2018, p. 697) state that it concerns "an urban environment that utilizes ICT and other related technologies to enhance performance efficiency of regular city operations and quality of services (QoS) provided to urban citizens."

Albino *et al.* (2015) present and analyze several other different definitions for the term. The authors refer to it as a fuzzy concept, which is not always consistent. Moreover, they present the five components of a smart city, which are: governance, people, environment, economy, living, and mobility. (Lombardi *et al.*, as cited in Albino *et al.*, 2015)

As discussed by M. de Jong *et al.* (2015), often planners and developers use the term smart city interchangeably with other terms, such as sustainable cities, green cities, livable cities, digital cities, knowledge cities, information cities, resilient cities, eco-cities, and low carbon cities. There is currently an astounding number of initiatives and new terms, all reflecting the current concerns in sustainable urban planning. Although there are interrelationships among the terms, the distinction between the terms is crucial, as they have conceptual differences and, therefore, do not share the same meaning. According to the authors,

> Each of the city categories harbors a different view of what the city is and how it works, with respect to the role of citizens and the way they relate to the governance of the city, with respect to the interactions between the city and its natural environment, and with respect to the role of urban infrastructure systems and services in the city's economy and livability. (M. de Jong *et al.*, 2015, p. 36)

Moreover, M. Jong *et al.* (2015, p. 36) draw attention to the rapid emergence of the smart city as a term to approach investments in sustainable urban infrastructure, which

intensifies the competition among cities for tech-companies and high-skilled professionals, as well as the city dependency on private investments. The author questions whether smart cities are capable of promoting social equity and environmental progress.

It is essential to highlight that the concept of smart cities comes mostly from engineers and urbanists, which results in a technocratic vision of the city – the same that has been historically applied to urban environments since the emergence of modernism. In this sense, social sciences could bring a substantial contribution to the topic and aspects worth considering. (Bassi, 2017)

As stated by Harrison (2017, p.30), "(…) interdisciplinary collaboration between technical and social sciences seems key to developing smarter "smart cities"."

Furthermore, Murgante and Borruso (2015, p. 14) highlight that "very often the concept of smart city is strongly related to the wide dissemination of mobile applications, completely forgetting the essence of a city, with its connected problems."

Likewise, Bassi (2017, p. 14-15) states that often the smart city concept "does not tackle any of the city issues at its roots, but rather promote a further digital divide exacerbating the existing separation between different realities within the same city." The author is concerned that smart cities would promote stronger segregation of inhabitants by delivering technologies to only certain groups of society. However, he also sees it positively, as some current projects "allow people with a different logic, to coexist and to share the same space."

Harrison (2017) advocates the bottom-up approach as the best manner to deal with the implementation of smart technological solutions. The author encourages higher consideration in the different lived experiences of residents and the recognition of the diversity of users. Aspects such as physical abilities, age, gender, ethnicity, or educational background directly affect the way someone will engage with technology in urban space. Taking these aspects into account when designing and implementing smart city solutions would result not only in a more inclusive approach but also would prevent lower utilization rates of the systems. As stated by the author,

> (…) focusing primarily on the technologies or not taking the diversity of human experience into account can result in low levels of adoption or even complete failure of a project. (Harrison, 2017, p. 22)

Smart city solutions are often designed by making assumptions about the users without really getting to know them. In this scenario, the author highlights that "a need for more "local" knowledge remains prevalent and much of the hype around smart cities continues to be connected to innovative technologies." (Harrison, 2017, p. 23)

Besides, nowadays, some people criticize the concept of smart cities because they consider that it is "greenwashing". "Greenwashing" is a term used to describe a form of commercial propaganda or publicity in which environmental sustainability is deceptively used to promote the perception that products, aims, or policies are environment-friendly. As stated by Abdoullaev *et al.* (2011, p. 4),

> We need to tackle a sustainable future community in all the possible complexity and wholeness, timely identifying all sorts of confusion, misrepresentation,

> misunderstanding, commercial propaganda, empty promises, partialities, or even a new type of "brainwashing": "greenwashing" or "smartwashing". (Abdoullaev *et al.*, 2011, p. 4)

Despite the critiques, smart city projects have emerged worldwide in the past decades. At the beginning of 2013, there were approximately 143 ongoing or completed self-designated smart city projects. Among these initiatives, North America had 35 projects; Europe, 47; Asia 50; South America 10; and the Middle East and Africa 10. (Lee *at al.*, as cited in Albino *et al.*, 2015, p.13)

In 2016, Berrone and Ricart analyzed 181 cities aiming at evaluating the smartness of cities worldwide. The results have shown New York City, London, and Paris as the smartest cities in the world, followed by San Francisco, Boston, Amsterdam, Chicago, Seoul, Geneva, and Sydney. Moreover, the study demonstrated that the 50 smartest cities distribution worldwide is significantly bounded within Europe and the USA. The study took into account many different aspects that, according to the authors, are important in smart cities. New York City, for example, ranked high in economy, human capital, governance, and technology, but, on the other hand, ranked poor in social cohesion. Differently, Paris was recognized to be comparatively strong in social cohesion and urban planning. (Berrone and Ricart, as cited in Silva *et al.*, 2018, p. 707)

2.3. Smart Mobility

Smart mobility is one of the components of the smart city. Albino *et al.* (2015, p. 9) define it as "the use of ICT in modern transport technologies to improve urban traffic." According to Benevolo *et al.* (2016, p. 24), the ICT applications are "an attractive solution to many of the problems of the transport sector":

> In the road sector it is possible to record reductions in journey times (15–20 %), in energy consumption (12 %) and in emissions of pollutants (10 %), as well as increases in network capacity (5–10 %) and decreases in the number of accidents (10–15 %). Significant results have also been achieved in the fleet management and logistics processes of goods and in the exercise of public passenger transport. (Benevolo *et al.*, 2016, p. 24)

Nowadays, with rising income levels, buying a car is part of a consumption pattern, even if it means owning a vehicle that spends most of its time unused. However, consumption patterns continuously change and, therefore, "innovative solutions can actually challenge some of these consumption patterns while still meeting the need for mobility." (EEA, 2016, p. 60)

Okuda (2012, p. 141) discusses the conflicts of goals in urban transport, in which each individual chooses the most suitable mode of transportation according to its comfort and desires. Those choices sometimes differ from what society as a whole would need. The smart cities are required to consider both interests and provide balance:

> In terms of mobility, while people place a priority on comfort and want their transportation to run smoothly, there is also the perspective of society as a whole, which needs transportation to operate sustainably for reasons of safety, practicality, and continuity. Unfortunately, these objectives often conflict, creating situations in which a means of transportation chosen by someone for their own reasons is not necessarily the best choice for society. What is desired for the smart cities of the future is the ability to take full account of both of these points of view and create a balanced transportation infrastructure. (Okuda, 2012, p. 141)

Benevolo *et al.* (2016) mention six categories of the most essential smart mobility objectives: reducing pollution; reducing traffic congestion; increasing people's safety; reducing noise pollution; improving transfer speed; and, reducing transfer costs.

Although smart mobility has positive goals for the city and is capable of changing travel patterns and city life, there are currently some criticisms about its application. The need for a greater focus on citizens instead of being based on technology infrastructure and the economic interests of private stakeholders are among some critiques.

Papa and Lauwers (2015, pp. 545-547) classify smart mobility in techno-centric or consumer-centric. According to the authors, both classifications show the "gap between 'smartness' and sustainability and quality of life aspects." Therefore, there is a "need of a new integrated approach", considering both human needs and also infrastructure.

Techno-centric smart mobility is based on the idea that infrastructure represents the key to building up smart mobility. Therefore, its main focus is on infrastructural innovation.

According to Papa and Lauwers (2015, p. 544), academic research and industrial applications use the term smart mobility to refer to "a potential of optimizing infrastructure, services, and urban behavior through the deployment and utilization of networks." Despite transportation development, Papa and Lauwers (2015, p. 546) point out some risks of techno-centric smart mobility:

> By increasing the quality of driving or the efficiency of the road systems, the car demand and use will increase as well. In other term, new possible car euphoria could spread in cities. Some disadvantage consists in the risk that they will increase car ownership and car use because it will become easier to use them and they will ultimately be more useful. This may in turn encourage urban sprawl and ultimately total private vehicle use. (Papa and Lauwers, 2015, p. 546)

Papa and Lauwers (2015, p. 546) affirm that technologies "are intended as 'enabling tools', but insufficient to make 'smart' an urban context, only by themselves."

On the other hand, **consumer-centric smart mobility** is characterized by a strong emphasis on the human side. The problem with this one, according to Papa and Lauwers (2015, p. 547), "is the risk of a higher separation from the physical planning." Furthermore, since the consumer-centric smart mobility has no integration with urban planning and design measures, Papa and Lauwers (2015, p. 547) questions if the chosen strategies are indeed going to impact the "transition towards sustainable living environment."

Though ICT plays a central role in smart mobility, it is crucial to consider the citizens in its planning. According to Albino *et al.* (2015, p. 3), "the smart city concept is no longer limited to the diffusion of ICT, but it looks at people and community needs."

Moreover, Albino *et al.* (2015, p. 6) state that some authors criticize smart mobility because corporate-designed cities "eschew actual knowledge about how cities function and represent empty spaces that disregard the value of complexity, unplanned scenarios, and the mixed uses of urban spaces." On the other hand, the authors acknowledge that "technology could be used in cities to empower citizens by adapting those technologies to their needs rather than adapting their lives to technological exigencies". In this sense, they affirm that some confusion that exists about the smart city concept "comes from the top-down and company-driven actions taken for creating a smart city."

In conclusion, smart mobility represents an opportunity to change travel patterns and citizens' behavior. However, to tackle the current urban problems, policies need to use it as a strategy for the well-being of people.

2.4. Shared Mobility

The term shared mobility refers to the systems that provide the shared use of vehicles, bicycles, scooters, or other travel modes. Cohen and Shaheen (2016, p. 4) define it as "an innovative transportation strategy that enables users to have short-term access to a mode of transportation on an as-needed basis."

Three factors can be listed as contributing to the emergence of shared mobility systems around the world: cost savings; the convenience of locations, use, and access; and, environmental awareness. (Novikova, 2017)

Despite its advantages, the emergence of shared mobility has brought new challenges into the city planning discussions. These systems require decisions on "locating stations, choosing the number of vehicles per station, moving vehicles between stations, inciting users to change their destination" (Laporte *et al.*, 2015, p. 342). Several cities already suffer from the massive implementation of these models and policies.

One of the benefits frequently associated with shared mobility – both bike sharing and car sharing – is the discouragement of car ownership and the resultant reduction in traffic congestion. Previous studies have tried to understand the impacts of these systems in car ownership in different cities around the world and, especially, in Europe. A synthesis of the results of these studies is presented in chapters 2.4.1 (Shared bicycles) and 2.4.2 (Shared cars).

2.4.1. Shared bicycles

Castro Fernández (2011, p. 200) points out the main benefits that can be achieved through the use of bike sharing: "1) making intermodal trips with public transport more attractive, 2) increasing bicycle use, and 3) increasing traffic safety." Concerning the increase in bike use, bike sharing is the gateway to the adoption of more sustainable modes of transport. Fulton *et al.* (2017, p. 13) affirm that these systems can "introduce many new people to urban cycling, who eventually acquire their own bicycle."

Bike sharing systems "often operate as part of the city's public transport system" (Midgley, 2009, p. 23).

Castro Fernández (2011, p. 42) affirms that bike sharing emerged in 1965 and since then it has considerably changed. Nowadays, it can be grouped into four generations, which evolved with the development of technologies in the field, offering more security for the system as well as more flexibility for its users.

> The fourth-generation is the model that is being adopted nowadays by many cities worldwide and its "technologies and amenities are still evolving." They are the enhancement of the third-generation by implementing features that support better user metrics, such as flexible, solar-powered docking stations or 'dockless' bicycles; demand-responsive bicycle redistribution innovations to facilitate system rebalancing; dynamic pricing to encourage self-rebalancing; multimodal access; billing integration (e.g., sharing smartcards with public transit and carsharing systems); real-time transit

> integration and system-data dashboards; and GPS tracking. (Cohen and Shaheen, 2016, p. 16)

The main difference between the third and the fourth generation is the emergence of dockless systems, also known as free-floating systems, which do not require docking stations. The main advantage of this model is its flexibility, once users can park anywhere inside a determined area.

According to Wilke and Lieswyn (2018, p. 3), "compared to docked systems, dockless systems are easier and cheaper to implement." However, there are several problems concerning dockless bike sharing, "from footpaths cluttered with broken bikes, to bikes being dumped in waterways in large numbers" (Wilke and Lieswyn, 2018, p. 3).

Moreover, another emerging innovation is the adoption of electric bicycles. The advantages of electric bikes are, according to Cohen and Shaheen (2016, p. 15), assistance to riders and the reduction of the effort required, enabling them to extend travel distances and to cycle in areas of steep terrain and varied topography. Besides, it makes cycling more accessible for all, including those with physical limitations.

Castro Fernández (2011) developed his doctoral thesis on the contributions of bike sharing to sustainable mobility in Europe. He highlights, however, that the reduction of car traffic cannot be exclusively attributed to bike sharing. Other important reasons accompanied the implementation of these systems. In Paris, for example, priorities for non-motorized and public transport were established in the Paris Master Mobility Plan. More than 6,000, more than 3,000, and nearly 2,000 daily car trips were replaced by bike sharing, respectively, in Paris, Barcelona, and Lyon (substituting from 0.15% to 0.18% of urban daily car trips). In German cities, such as Berlin, Munich, and Stuttgart, these numbers are almost insignificant, with less than 30 car trips replaced by bike sharing. Concerning car traffic, in Paris, "from 20% to 46% of users state that they drive less their cars since they became members of Vélib'" and "a decrease of around 5% of car traffic was reported in the city" after one year the system was implemented. In Lyon, car traffic decreased by 4% after 20 months of the implementation of the bike sharing system. (Castro Fernández, 2011, p. 80-82)

As highlighted by Castro Fernández (2011, p. 197), even though bike sharing has achieved a lot in a very short time, it "is still a very small part of European mobility." Moreover, according to the author, the study developed has confirmed that bike sharing contribution to reducing car traffic is low. Besides, surveys conducted in Kassel, Mainz, Nuremberg, and Ruhrgebiet asked bike sharing user's which mode of transport they would have used in case the bike sharing system was not available. Among the conclusions, it was stated that bike sharing does not have a high effect on the decision to get rid of a car. Conversely, it mainly replaces trips by public transport and walking. (Rabenstein, as cited in Miramontes, 2018, p. 96-97)

On the other hand, the influence of bike sharing on reducing public transport vehicle occupancy seems to be more significant. According to Castro Fernández (2011, p. 197), "a synergy with public transport through intermodality has been observed." Castro Fernández (2011, p. 198) also affirms that intermodality with public transport is one of the main potentials of bike sharing to improve mobility. An evaluation of public bike

sharing systems in Ruhrgebiet, Nuremberg, Stuttgart, and Usedom demonstrated that users of bicycle sharing have the pass of the public transport system in a more significant proportion (twice as much) than non-users, and bike sharing users travel, on average, more often with public transport. (BMVBS as cited in Miramontes, 2018, p. 95)

2.4.2. Shared cars

Car sharing is a solution for those that do not own a car but would like to use it occasionally, without the costs and responsibilities of ownership, such as parking, maintenance, taxes, and insurance. Those are usually provided by an operator company that maintains the fleet of cars, while the users only pay a fee when they use a vehicle.

The main benefit associated with car sharing is the more efficient vehicle use. Moreover, "environmental benefits can be achieved if the car share vehicles on average have lower emissions by being of newer model year" (Fulton *et al*., 2017, p. 13) or even if the fleet is composed of electric vehicles, as in many cities worldwide.

According to Cohen and Shaheen (2016, p. 11), the first car sharing experience is mentioned as being a cooperative called *Sefage* which started in 1948 in Zurich, Switzerland, as has continued operating for 50 years, until 1998. Worldwide, however, these services as we know today, including free-floating and peer-to-peer car sharing, have emerged only in the late 2000s.

Miramontes (2018, p. 78) classifies the car sharing services in five different types:

- Station-based roundtrip carsharing: It is a system with one or numerous stations in which there are parking spots assigned for each car of the fleet. Users must return the vehicles to the same station in which they picked them up previously.
- Station-based one-way carsharing: It is also a system with one or several stations, but it differs from the roundtrip one because the user can return the vehicle to a different station, in a different location. Therefore, not needing to return to the station in which the vehicle was picked up.
- Zone-based carsharing: A system that usually does not define parking spaces, but rather a parking zone, an area in which the users can both pick up and drop off the vehicles, not necessarily in the same location.
- Free-floating carsharing: A fleet of shared vehicles that can be picked up and dropped off anywhere inside the operating area.
- Peer-to-peer carsharing: fleet of vehicles owned by many different individuals who share it with unknown users. It is a system organized through a platform operated by a third party.

Meijkamp (1998) evaluated car sharing schemes in the Netherlands by applying questionnaires to the system's participants and asking about their behavior both in the previous year and in the research year. Meijkamp (1998, p. 241) observed that, when comparing the mileage before and after the implementation of the system, there was an average reduction of 33%. When considering only the "substituters" – "people for whom the car sharing car is a substitution for their own vehicle" – the reduction was 65% in car

mileage. The author also noticed that car sharing users were more likely to cycle or to use public transport than in the year before.

Despite showing that car sharing had a positive impact on travel patterns, especially for those that previously owned a vehicle, 71% of respondents were identified as people that did not own a car before the implementation of the system. In fact, 9% of respondents were using car sharing as a second car and only 21% were classified as "substituters". (Meijkamp, 1988, p. 242)

As stated by Prettenthaler and Steininger (1999, p. 444), "two groups have to be distinguished": The ones that had access to cars before membership (due to ownership or within family direct access) reduce their car mileage. On the other hand, car mileage increases among those that only can afford to use a car through sharing systems.

Likewise, Efthymiou *et al.* (2013) conducted a survey in Greece, in which he identified the characteristics of prospective shared mobility members. According to the author, those belonging to the low-mid income class and younger than 26 years old are prone to become members of car sharing systems. Moreover, "the models suggest that car sharing may attract people that currently use bus, tram or trolley for trips to work or school" and those "that currently use taxi for their trips to social activity." Bike sharing, on the other hand, tends to attract those that previously would go on foot. (Efthymiou *et al.*, 2013, p.72)

The results of the studies presented above are indeed relevant; however, many people currently use it to criticize car sharing systems. In general, there is a fear that such systems may compete with public transportation and non-motorized modes, leading to an unwanted scenario of greater participation of the automobile in the modal split. This misconception must be analyzed very carefully because allowing all citizens to eventually use a car without having to purchase it is a positive characteristic. The fact that many public transport users use car sharing systems indicates an alternative and a possibility that users will not migrate to private transport in the future. Previously, the purchase of a car was part of a consumption pattern. As users of public transport acquired higher levels of income, it was a tendency for them to purchase a car. Although from this perspective, car sharing does not solve current problems, it prevents those issues from expanding in the future, avoiding the constant increase of the car fleet and the car as an object of consumption and desire. A long-term perspective considering the renewal of generations indicates that the tendency is that owning a car may become an obsolete desire, as long as different possibilities are available.

Moreover, car sharing users usually combine it with other different modes of transport and, especially, with public transport. According to Miramontes (2018, p. 201), a survey conducted with users of the mobility station implemented as a pilot project at the public transport station Müncher Freiheit, in Munich, demonstrated that public transport was still the most used mobility service among the users of car sharing: around 70% of car sharing users use public transport at least once a week. Besides, 22% of car sharing users claim to have gotten rid of a car.

Miramontes (2018, p. 82-89) analyzed several studies that previously evaluated the effect of car sharing systems in North America, in Europe and, more specifically, in Munich.

As the author identified, all studies have demonstrated a decline in car ownership among users and an overall decline of Roadway Vehicle-Kilometers Traveled (VKT) by car. Moreover, there was an increase in the use of non-motorized transport modes. Consequently, there is a reduction in personal emissions, in demand for parking space, and the number of vehicles on the road. For more details regarding the different evaluated studies, see Miramontes (2018).

In Munich, specifically, surveys among STTATAUTO users were conducted in 1996 and 2002. These surveys demonstrated that 21% and 14% of users no longer were car owners as before, respectively in 1996 and 2002. Likewise, 35% and 34% of users avoided buying a car, respectively in 1996 and 2002. Besides, there has been a decline in VKT among users of about 60%. (MVV, as cited in Miramontes, 2018, p. 85)

2.5. City Logistics

The transportation of goods is essential to enable certain economic and social activities in the urban environment, as it connects suppliers and customers. However, freight vehicles are often disturbing, because they usually share the highly saturated street space with public and private vehicles, contributing to congestion and environmental issues, such as air pollution and noise.

According to Crainic (2014, p. 183), "the term city logistics has been coined to emphasize the need for a systemic view of the issues related to freight movements within urban areas."

A study developed in France demonstrated that "freight vehicles consume, on average, 30% of the city street capacity, two-thirds representing parking for delivery and pick-up operations." Moreover, freight transportation represents between 13% and 20% of the total vehicle kilometers traveled within the cities (Patier, as cited in Crainic, 2014, p. 181).

2.5.1. City Distribution Centers

More than defining and regulating traffic and parking areas for freight vehicles, it is important to organize and coordinate it as a system. As stated by Crainic (2014, p. 182), "one should consider that all stakeholders and movements are components of an integrated logistics system." By coordinating all stakeholders and their movements this idea aims to optimize freight transportation systems in cities while minimizing their impacts on the urban environment.

Aiming at solving the issue of freight transportation in urban areas, the concept of City Distribution Centers (CDCs), also known as Urban Freight Consolidation Center (UCCs), has emerged in the early 1970s and has become more popular during the last decade. These concepts refer to a physical logistic facility located nearby an urban area in which large freight vehicles can dock an unload their cargo, which would then be sorted and consolidated into smaller vehicles, often environmentally-friendly, responsible for delivering them at their final destinations. It aims at reducing the amount and the size of the freight vehicles inside the urban perimeter. (Browne *et al.*, 2011, p.1; Crainic, 2014, p. 183)

Moreover, Crainic (2014, p.184) points out that the CDC concept is similar to that of intermodal logistics platforms. For him, the CDCs can be understood as intermodal platforms with improved functionality to provide coordinated and efficient cargo movements within the urban area, and, for this reason, they are important to improve urban logistics.

According to Browne *et al.* (2011, p.1), CDCs, and UCCs promote a win-win situation, in which all stakeholders can benefit.

> The logistics companies dropping their loads at the UCC benefit by avoiding the need to enter congested urban areas and thereby saving time and costs. Those receiving goods from the UCC benefit in terms of delivery reliability. In addition to

> consolidation and final delivery, a range of other value-added logistics and retail services can also be provided at the UCC including off-site stockholding, consignment unpacking, preparation of products for display, and price labeling. These can benefit receivers by reducing their on-site space requirements, saving time by reducing the tasks that have to be performed onsite, and enhancing productivity and sales in core activities. (Browne *et al.*, 2011, p.1)

2.5.2. Last-mile delivery

Besides the emergence of the CDCs and UCCs, another important factor has changed the way goods move around the urban area in the past years. The expansion of online shopping and e-commerce led to an increase in direct deliveries to the final consumer and raised the need for some changes in the so-called last-mile delivery. The final stage of the supply chain is often inefficient and costly. As stated by Deutsch and Golany (2018, p. 251),

> Many stages in the process of transporting goods to consumers have undergone significant improvements over the years and are now handled in an efficient and cost effective manner (…) the final stage in the process – that of bringing the goods to the doorstep of the consumer – is often the least efficient, and the most expensive and polluting part of this process, comprising up to 28% of the total cost of delivery (Goodman; Spiegler; as cited in Deutsch and Golany, 2018, p. 251).

Deutsch and Golany (2018, p. 251) identified the reasons for the high costs and low efficiency of goods delivery in the last mile, which can be summarized as low scale delivery, i.e., only one package per address; difficulty in finding the address sought; and, difficulty in finding the consumers at home to receive the products.

The last-mile delivery issue has been under research for over 60 years. Among the solutions indicated and developed there are the optimization of routes, the adoption of environmentally-friendly vehicles (e.g. cargo bikes, electric vehicles, autonomous vehicles, and drones), the creation of collection and delivery points, and, finally, the design of a connected logistic system that moves parcels in modular containers. (Deutsch and Golany, 2018, p. p. 252)

2.5.3. Parcel lockers

One of the solutions to the last-mile delivery issue is the design and implementation of parcel lockers systems. Parcel lockers can be defined as lockers with electronic locks and variable opening codes, located both in residential blocks and in shopping centers where different consumers can collect their parcels at certain times of operation at their convenience. (Deutsch and Golany, 2018, p. 252)

Parcel lockers have the potential to benefit the urban environment as well as the logistic operators, the retailers, and the consumers. Benefits achieved through the use parcel lockers are the decline of freight traffic in urban areas, the reduction of the amount of failed deliveries (and, consequently, less spending on vehicles and personal staff), and

the possibility to offer convenient delivery locations consumers, which will obtain flexibility in collection hours and security for their parcels. (Deutsch and Golany, 2018, p. 259)

A quantitative study developed by Giuffrida *et al.* (2016) demonstrated that parcel lockers are more sustainable in comparison to home delivery from both an economic and environmental perspective. However, in urban areas, considering only the ecological perspective, the convenience of the parcel locker, both for deliverers and consumers, is valid only if the distance necessary for the customer to reach the parcel locker does not exceed 0,94 km. From an economic perspective, the parcel locker is convenient for customers as long as they do not need to travel more than 3.5 km to pick up their products – after exceeding this limit the parcel locker becomes convenient only for logistics operators.

Morganti *et al.* (2014) developed a study on the parcel lockers in Germany. According to the authors, the first parcel lockers in the country were introduced between 2001 and 2002. Since then, the network has increased. According to DHL (as cited in Morganti *et al.*, 2014, p. 185), in 2009, 90% of the German population was within 10 minutes of a parcel locker. The parcel locker network from DHL is, as stated in the Apex Insight (2019), "the oldest and most successful parcel locker network in the world" and "the largest locker network in Europe, with 3,500 locations." Besides DHL, there are currently four more service providers in the German market: Hermes, DPD, GLS, and UPS, representing more than 36,000 parcel lockers available in the country. However, despite the dense parcel locker network, about 90% of the consumers in Germany prefer to have their orders delivered at home. (Morganti *et al.*, 2014, p. 185-186)

2.6. Mobility Stations

A mobility station is a place or location where different mobility offers and services are available. They usually include at least one shared mobility alternative (described in chapter 2.4), thus enabling intermodality and multimodality.

Multimodality is a travel behavior in which different modes of transport are used within a specified period according to an open and subjective decision of the most optimal available option; intermodality is the ability and possibility to combine different modes within a single trip (Miramontes, 2018, p. 42).

While in Germany the most commonly used term is mobility station (in German: *Mobilitätsstation*), they are often also referred to as mobility points, especially in Austria, and as mobility hubs, especially in North America. According to Miramontes (2018, p. 55), the different terms "refer to practically the same idea." However, the author highlights that in North America there is a sharper focus on the integration of land use and transport in comparison to the concepts adopted in Germany and Austria.

Recently, a project with a similar concept is being implemented under the term eHUBS - *Smart Shared Green Mobility Hubs*. This project, along with the *Smarter Together* (described in chapter 3.1), is EU-funded in the scope of the *Interreg North-West Europe*. According to the project website, "eHUBS are on-street locations that bring together e-bikes, e-cargo bikes, e-scooters and/or e-cars, offering users a wide range of options to experiment and use in various situations." This project is currently being implemented simultaneously in seven pilot cities: Amsterdam, Arnhem, and Nijmegen, in the Netherlands; Leuven, in Brussels; Kempten, in Germany; Manchester, in England; and, Dreux, in France. The cities have ambitious plans and more than 15 eHUBS are planned only in Amsterdam, while Neuven plans 50 eHUBS for the next three years. (Interreg North-West Europe, n.d.)

2.6.1. Mobility Stations in Germany

Miramontes (2018) developed extensive research on the mobility stations implemented in Germany, comparing them and presenting their characteristics, goals, and success factors.

The first two mobility stations implemented in Germany were in the City of Bremen, in 2003. The system was named *mobil.punkte* and it provides parking spaces for car sharing, as well as bike racks, nearby public transport. An information board draws attention to the stations. Moreover, people owning a seasonal public transport pass are provided with better rates to use the car sharing system. The implementation of the mobility stations in Bremen was a positive experience, as demonstrated by the decision to keep implementing other mobility stations in the following year. In March 2016 there were already 24 mobility stations in Bremen. (BBSR, BSAG, Luginger, as cited in Miramontes, 2018, p. 44-58)

Only after ten years of the implementation of the first mobility stations another example in Germany is found. In 2013 a system called *switchh punkt* was implemented in Hamburg. The first station, implemented at the public transport station Berliner Tor (metro and suburban rail station), offers parking spaces for car sharing and rental cars, a bike sharing station, a bike garage, a taxi stand, and a customer service center. The stations are highly visible, due to information boards, corporate design, and green-colored parking spaces. There is a single registration process for all the different services offered at the mobility stations. To enable the use of the system, a physical card and a mobile application are available. In March 2016 the system *switchh punkt* already had nine mobility stations. (Luginger, switch, as cited in Miramontes, 2018, p. 45-58)

During the past years, other mobility stations projects emerged in many different cities in Germany. Miramontes (2018) presents a description of the ones located in Munich, Offenburg, Leipzig, Würzburg, and Nuremberg. It is essential to highlight that the mobility stations in these cities were evaluated by master students supervised by the author and in the framework of the author's dissertation. Besides the evaluated ones, other mobility stations are found in different cities around Germany, such as Berlin, Wolfsburg, Hannover, Meschede, Offenbach, Fellbach, and Mettingen (Kindl *et al.*, as cited in Miramontes, 2018, p.56-58).

Figure 1 presents a timeline of some of the mobility stations in Germany and, more specifically, in Munich.

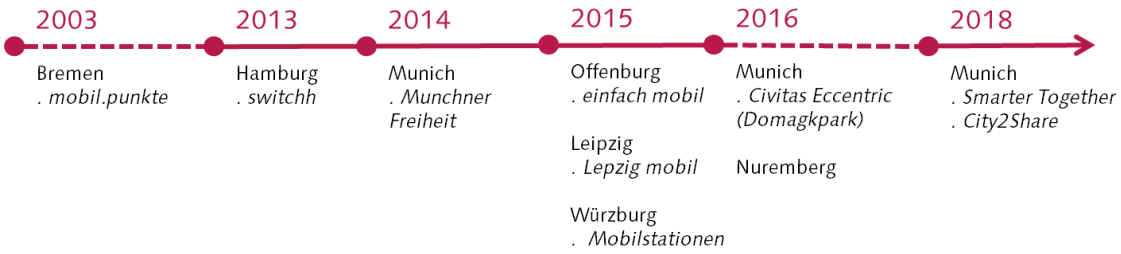

Figure 1. Timeline of some of the mobility stations in Germany
Source: Own illustration, 2020, based on Miramontes (2018, p. 59-60)

As shown in Figure 1, besides the implementation of the *Smarter Together*, in 2018, another mobility station project was implemented in Munich in that same year, the *City2Share*. All public mobility stations in Munich will be presented in detail in subchapter 3.2.1.3 (Mobility stations in Munich).

Miramontes (2018, p. 61) presented a table with an overview of the services offered at the mobility stations in Germany. For that, she considered the mobility stations implemented in the cities of Bremen, Hamburg, Munich, Offenburg, Leipzig, Würzburg, and Nuremberg. In common, all cities provide bike parking facilities, as well as station-based car sharing. Moreover, except for Bremen, all of them provide bike sharing systems. The connection with public transport was also not only seen in the mobility station implemented at Domagkpark, in Munich, as it is located on private ground. Charging stations, taxi, and free-floating car sharing, were seen only in a few cities. Until that time, electric cargo bikes, e-bikes, and e-scooters were exclusively provided in the private mobility station implemented at Domagkpark.

Concerning the registration process, only the services in Hamburg and Leipzig enable the use of different services through a single registration process. (Miramontes, 2018, p. 64)

Although there are already several mobility stations implemented in Germany, there are not so many studies concerning the perceptions of the mobility stations and their acceptance. One of the existing evaluations was conducted in Bremen, two years after the implementation of the two first mobility stations. The results demonstrated that 30% of users got rid of their own vehicle after becoming carsharing members, and 55% claimed to have given up on a planned purchase. (Freie Hansestadt Bremen, as cited in Miramontes, 2018, p. 71). Moreover, mobility stations in the cities of Würzburg and Offenburg were investigated by Heller (2016) and Pfertner (2017) in the scope of the dissertation written by Miramontes (2018). In both cities, the results show that there is a multimodal mobility behavior among users. Users that have declared to have become customers of a mobility service due to the mobility stations are 26% in Offenburg and 59% in Würzburg. In both cities, around 80% of users have agreed that the mobility station contributed for making their own cars unnecessary. Likewise, there was a good acceptance of the systems and the majority of users stated that they would like to have more mobility stations. (Heller, Pfertner, as cited in Miramontes, 2018, p. 77)

For more details regarding the analysis in Bremen, Hamburg, Offenburg, and Leipzig, see Luginger (2016). Likewise, concerning the evaluation of the perception of the mobility stations in Offenburg and Würzburg, see Heller (2016) and Pfertner (2017),

respectively. As for the evaluation of the private mobility implemented in Domagkpark, see Alarcos (2017). For a detailed analysis of the mobility stations implemented as a pilot project in Münchner Freiheit, in Munich, as well as an overview of the mobility stations listed above, see Miramontes (2018).

2.6.3. Mobility Stations in Austria

As previously mentioned, in Austria, most of the documents written in English use the term mobility points. In Vienna, the Urban Mobility Plan Vienna STEP2025 presents a description of them:

> "A mobility point is meant to give uncomplicated and fast access to low-emission mobility around the clock. It can be a central facility in a new urban development area or strengthen structures in existing neighborhoods. A variety of vehicles and services can be booked and used. This way, mobility services can be bundled in a well-structured way in one place, which is particularly important in new urban development areas." (Magistrat der Stadt Wien, 2015, p. 66)

In Austria, mobility stations projects are quite more recent than in Germany. In 2016, a first public mobility station was launched in Graz and, a private mobility station was launched in Vienna. In Graz, the system is named *Tim*, which nowadays has seven mobility stations in the city, besides some other car sharing and taxi stations. Besides Graz, from 2019 onwards, *Tim* is available in Linz and other cities in Styrian Central Region (*REGIOtim*). In Vienna, the first mobility station was implemented by the company *MO.Point* and has expanded since then, with now more than five private stations in the city. A public mobility station system was first launched in Vienna only in 2018, as part of the project *Smarter Together*, which will be further addressed in this work. Figure 2 presents a timeline of some of the mobility stations in Austria.

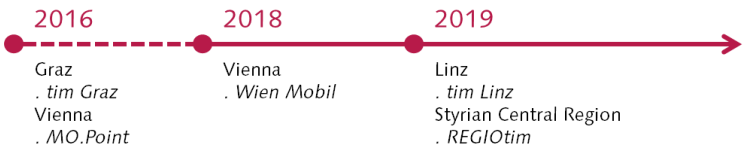

Figure 2. Timeline of some of the mobility stations in Austria
Source: Own illustration, 2020.

As stated above, Graz's first mobility station was implemented in September 2016 as part of a project named as *Tim*, and, since then, the city's mobility stations have increased significantly, with 3 new stations being launched in 2017 and 3 more in 2018. After only three months of operation, they had registered more than 100 users and after six months they reached more than 600 users. (Tim, 2019, p. 12)

The *Tim* mobility stations in Graz offer electric station-based carsharing, conventional station-based carsharing, electric charging stations, conventional long-distance rental cars, and e-taxi stations (Figure 3). A digital information board is also available at the mobility station at Schillerplatz (Figure 4), however, information boards are not installed anymore due to underutilization and often misuse or vandalism. The system is mostly focused on station-based car sharing, therefore, there are parking spots for each automobile and different colors and icons enable the users to distinguish from parking spaces intended for recharging a private electric car, or electric car sharing spaces or conventional car sharing spaces. (Figure 5) Moreover, the stations are mostly close to

public transport and bike racks. Although it is currently a car-focused system, some other infrastructure is planned, such as shared cargo vans, cargo bikes, and parcel lockers.

Figure 3. Mobility station at Schillerplatz, in Graz
Source: own photograph, 2020.

Figure 4. Digital information board at Schillerplatz, in Graz
Source: own photograph, 2020.

Figure 5. Parking spot for electric car sharing nearby Andreas Hofer Platz, in Graz
Source: own photograph, 2020.

The project was originally funded by the Austrian Ministry of Transport, Innovation, and Technology with the environmental approach as the primary motivation for the investment. The project requires subsidies, and car sharing is seen as not profitable, with only 1/3 of the system's costs covered by users. (Hofer, 2020)

Concerning the utilization rates of electric car sharing bookings, it is similar on all days of the week, though there is a small drop of trips on Sundays. The conventionally operated vehicles, on the other hand, are mostly booked from Thursday to Saturdays. Moreover, electric car sharing is most used during regular office hours (from 8 am to 5 pm) with significant decreases during the off-peak hours, and in the night hours (from 9 pm to 6 am), the system is mostly not used. As for car rental, it usually starts early in the morning, with a downward trend for the rest of the day. (Tim, 2019, p. 92-95)

An interview was conducted between 2016 and 2018, with 61 users of the Tim system, in which 28% were identified as frequent users. Moreover, to answer questions concerning the mobility behavior of users, an extensive survey of 108 persons was conducted. The following aspects are highlighted considering these:

- Users represent a homogeneous group with a high level of education and predominantly with a medium to high income. The majority of low earners are students at the end of their education and with corresponding future income expectations.
- The overall satisfaction of the respondents is high, with aspects as independence from a private car, comfort, and flexibility for parking mentioned as positive.
- Many users owned a car before but chose *Tim* as a cheaper and better alternative.
- Almost 2/3 of members need to walk less than five minutes to reach the car sharing system and 1/4 takes a maximum of ten minutes to reach the station.
- Almost 40% of users ride their bicycles to reach the mobility station and about 30% of users always use public transport to reach it.
- In general, the users become more multimodal and travel more than before: Walking increases slightly by about 3%, the use of bicycle and public transport by about 7%, and car use by 78%; 64% of members had no car available before.

(Tim, 2019, p. 96-105)

Tim takes into account three main criteria to define the best location to implement a station: 1) scalability, i.e. if the space is large enough to increase the number of services/vehicles available, in case of need; 2) availability/accessibility, i.e. people can easily access/reach the service; and, 3) visibility. Besides private mobility stations, *Tim* also works with private investors for housing development, offering car sharing services. In this case, the stations are placed inside the buildings. It is a partnership with the entrepreneur, that in many cases even build the stations in the buildings by themselves. (Hofer, 2020)

The *Tim* system is recognized as a successful case of mobility station in Austria and, therefore, since 2019, two new branches of the project have been implemented: the *Tim* Linz, in the City of Linz, and *REGIOtim*, in the Styrian Central Region. *Tim* Linz already offers five mobility stations and REGIO*tim* offers four mobility stations outside Graz, but many more are planned for the next years. (Tim, 2020) According to Bauchinger *et al.*

(2020), REGIOtim is a project of the Interreg Europe and focused on Peripheral Access. Therefore, it aims at implementing mobility stations in the peripheral surrounding of Graz.

Concerning Vienna, the first mobility station was implemented in 2016 in the social housing project named as Perfektastraße 58. It was planned, implemented, and has been operated by MO.Point, a private company. The stations offer electric bikes, electric cargo bikes, and electric cars, which are placed inside one of the buildings (see Figure 6 and Figure 7). Even though the mobility station is not in the public space, the services are not exclusive to residents, and anyone can register to the system, which works with both a physical card and a mobile application. According to an interview conducted with one of the founders of the MO.Point in the scope of this master thesis, the mobility station in Perfektastraße 58 was implemented as a pilot project. Despite the convenient location, next to public transport (Subway Line U6), it was stated that this mobility station is not so much used. (Wiltschko, 2019)

Figure 6. Sign to the first private mobility station in Vienna (inside the building)
Source: own photograph, 2019.

Figure 7. Sign to the first private mobility station in Vienna (inside the building)
Source: own photograph, 2019.

Later, many other private mobility stations have been implemented as part of real estate and urban developments in Vienna. They were implemented both inside social housing projects, and inside commercial and business centers. In Vienna, *MO.Point* is the leading operator of the private mobility stations and is the one currently providing a wider variety of services, such as e-car sharing, e-bike sharing, e-scooters, and e-cargo bikes. The real estate pays for the station inside the buildings; however, it would also be essential to provide infrastructure nearby public transport, enabling intermodality. The motivation to

install a mobility station in real estate developments can vary, as it can be a mitigating measure to offer fewer parking spaces than required in the urban regulations, as well as a strategy to make a real estate venture more attractive and modern. In some cases, according to the contract with the municipality, providing mobility stations is binding. (Wiltschko, 2019; Franz, 2020; Kirchberger, 2020)

Concerning the public mobility stations in Vienna, they started being implemented in 2018. The first public mobility station is the one located in Simmeringer Platz, which was implemented in the scope of the *Smarter Together*. All public mobility stations in Vienna are part of a system named as *Wien Mobil Station*. These stations will be presented in further detail in subchapter 3.2.2.4 (Wien Mobil Station: the public mobility stations in Vienna) and in subchapter 3.2.2.5 (The mobility station at Simmeringer Platz).

3. CASE STUDY

In 2015, the cities of Lyon, Munich, and Vienna were selected for the EU-funded program *Smarter Together*. Different smart solutions were planned for the housing development chosen areas. Among those, mobility stations were implemented in the scope of the project by the cities of Munich and Vienna, which represents the primary case studies of this thesis.

This chapter presents information on the *Smarter Together* project, as well as the mobility stations implemented in both cities: Vienna and Munich. The context in which the mobility stations were implemented, such as the smart mobility scenario in the selected cities will also be described.

3.1. The *Smarter Together* project

The *Smarter Together* is a joint project in which the cities of Lyon, Munich, and Vienna – denominated as lighthouse cities – together with 28 partners from research and industry were awarded 25 million euros for the implementation of smart actions. Besides, cooperation with three follower cities – Santiago de Compostela, Sofia, and Venice – is planned. The project aims at implementing and testing sustainable and innovative solutions in housing development areas, improving the quality of life in the neighborhoods. The lighthouse cities received the funds in September 2015, while the projects were implemented in the timeframe of three years, between 2016 and 2018. Later, during 2019 and 2020, the actions performed in the scope of the project should be monitored and evaluated. This project is funded within the EU program Horizon 2020. (Neumann *et al.*, 2016, p. 965)

Horizon 2020 is a collaborative program for research and innovation in the timeframe from 2014 to 2020. It is the most significant EU Research and Innovation program, with approximately 80 billion euros of funding. In addition to the direct public funding, the projects implemented in the scope of this program also attract private investment. (Fabián and Krištofová, 2015, p. 1)

As listed by Fabián and Krištofová (2015, p. 3) the main priorities of the *Horizon 2020* regarding transport are: make it more sustainable; make it seamless by providing better mobility, less congestion, more safety, and security; keep it competitive by maintaining Europe as a global leader in the transport industry; and, make it research responsive by supporting policy-making and by targeting socio-economic and behavioral research.

Regarding the *Smarter Together*, Neumann *et al.* (2016, p. 965) state that its main challenge "is related to the so-called co-creation approach":

> All involved cities, research institutes and industrial partners as well as external stakeholders seek to jointly create solutions and methodologies for innovative and replicable city development, based on lessons learned and strong knowledge exchange. (Neumann *et al.*, 2016, p. 965)

Indeed, one of the work packages of the *Smarter Together* is called Co-Creation for Smart City Solutions. Wendt and Dübner (2017, p.104) affirm that one of the challenges of this work package is to "disseminate generated knowledge in between the project and over its borders to perform a co-creation process actively and to provide a set of recommendations for co-created and integrated smart city solution for cities." As previously mentioned, besides the three lighthouse cities, the project has three follower cities, and the project, as stated the authors (p. 107), "seeks to develop methods, solutions, and processes that are transferable to all kind of other cities."

Mendes *et al.* (2019, p. 17) present information on the implementation of the *Smarter Together* and discuss the challenges involved in the co-creation approach. Concerning society, a "long term collaboration instead of single-event consultation is necessary to develop a common language between all participants." (p. 16)

One of the challenges imposed by the *Smarter Together* is that its solutions "depend on individuals making one highly consequential decision" (p. 17). This challenge is the case, for example, of the mobility stations:

> (…) in order to achieve an increase in the usage of CO2-friendly modes of transport by implementing mobility stations, people not only have to change their behavior (…), but also decide to register for the rental services and thereby again disclose personal information. These very specific single decisions of a great number of individuals are fundamental for meeting the project aims. At the same time, the mere registration process which individuals need to undertake, represents extra work and thus creates a barrier. (Mendes *et al.*, 2019, p. 17)

To tackle this issue, Mendes *et al.* (2019, p. 18) suggest user exploration and experience before having to make a choice. Moreover, the types of registration should be provided in consideration of the different user profiles. They should also give the user the possibility to decide about the data collected and the providers' use. Likewise, the author points out the importance of combining both top-down and bottom-up approaches to learn about people's needs. In this context, typical community engagement techniques (such as "opinion polls, statistical analysis of socio-demographic data and one-time participation events") are mentioned as strategies that, many times, only:

> (…) confirm previously made assumptions, generate unrealistic expectations by asking about visions, desires and aspirations in a too general manner and/or are incapable of distinguishing between people's overt positions and underlying needs. (Mendes *et al.*, 2019, p. 20)

These assumptions could be tackled by empowering participants through skills training, which would enable them to have a thorough understanding of the project and to become critically engaged. (Mendes *et al.*, 2019, p. 23)

Furthermore, the project also relies on long-term cooperation with different stakeholders. In this context, the author highlights the importance of selecting reliable partners and finding the right balance "between public interests, project aims, and economic necessities." (Mendes *et al.*, 2019, p.19)

Regarding the project areas, the three lighthouse cities have chosen neighborhoods within their urban perimeter to implement the *Smarter Together* project. Lyon selected the domain named Lyon Confluence, "one of the largest urban redevelopment projects in France". Munich focused on two neighborhoods bordering each other: Neuaubing-Westkreuz, "a district in need of redevelopment", and Freiham, a new district that was "still under construction." As for Vienna, the neighborhood chosen was Simmering, which is "a worker's district with large housing estates." (Neumann *et al.*, 2016, p. 967-970) As stated by Wendt and Dübner (2017, p.103), "even though the three lighthouse cities seem to be very different, they do face very comparable challenges and problems."

Further details about the *Smarter Together* in Munich and in Vienna can be seen in subchapters 3.2.1.4 (*Smarter Together* in Munich) and 3.2.2.3 (*Smarter Together* in Vienna). The project implemented in Lyon will not be discussed in this thesis, as it did not include a mobility station, which is the main focus of this work.

3.2. The selected cities

The cities in which mobility stations were implemented in the scope of the *Smarter Together* were selected as case studies: Munich and Vienna. Therefore, this chapter presents the aspects concerning urban mobility, smart mobility approaches, and the mobility stations in these cities.

3.2.1. Munich

Munich is Bavaria's capital and most populous city. It is located in the south of Germany, and with about 1,559,354 inhabitants, it is the third-largest city in the country. (München Stadtportal, 2020)

3.2.1.1. Urban mobility in Munich

In 2008, the modal split in Munich would show that the share of public transport was only 21%, whereas by car 37%. Concerning the non-motorized modes, the modal split share of walking was 28% and by cycling 14%. In comparison with other major cities in Germany, such as Berlin and Frankfurt, the modal split share of public transport in Munich is considered low. In contrast, the share of the automobile is deemed to be high. (EPOMM, 2008; Ahrens, 2015, p. 86)

Despite the relatively low share of public transport in the modal split, Munich offers an extensive network of suburban railway, metro, tram, and bus systems, which are operated by *Münchner Verkehrsgesellschaft mbH (MVG)*, except for the suburban railway, which is operated by *DB Regio*. The services of these are integrated into a single tariff system, which is managed by the *Münchner Verkehrs- und Tarifverbund (MVV)*. (Miramontes, 2018, p. 105)

Concerning the motorization rate, between 2006 and 2016, the number of automobiles has increased more than the population. The current motorization rate in Munich is 454 automobiles/ 1,000 inhabitants. (Miramontes, 2018, p. 110)

Moreover, in 2013, 43% of city residents owned public transport pass was and about 80% of the Munich population held at least one functioning bike in 2008. (Landeshauptstadt München, infas, as cited in Miramontes, 2018, p. 111)

3.2.1.2. Smart mobility approaches in Munich

According to Neumann *et al.*, 2016 (p. 968-969) the Smart City strategy in Munich has principles such as quality of life, individual development, and participation in shaping the own living environment. Moreover, it "puts additional emphasis on the integration of intelligent technologies (energy-efficient buildings, sustainable urban mobility, intelligent energy management systems, etc.) which support the transition to a post-fossil city."

Furthermore, an initiative named *Modellstadt 2030* was established in 2017, aiming to improve the quality of life and the quality of mobility in Munich. The measures to achieve the objectives were defined both in the provisioning infrastructure framework and in the regulatory framework. Concerning the infrastructure, the actions listed are shared mobility, electrification, connectivity with assistance systems, and self-driving vehicles. Regarding the political and organizational measures, they are special lanes with minimum vehicle occupancy and adaptation of the legal framework. (Miramontes, 2018, p. 118)

Regarding the shared mobility, the first car sharing system known in the city of Munich was implemented in 1992 by *STATTAUTO*. (STATTAUTO, as cited in Miramontes (2018, p. 119) Later, over the years, new shared mobility services emerged. Miramontes (2018) presents a table (p. 120) that summarizes the development of shared mobility services in Munich. It shows the companies that joined the market in the city over the past years, as well as those that, for different reasons, left and stopped providing the services. Moreover, another table presented in the dissertation (p. 122) gives an overview of the existing shared mobility services in Munich. According to the author, there are currently more than 13 providers of shared mobility services in Munich, among car sharing, bike sharing, and scooter sharing. Besides, services as peer-to-peer car sharing platforms, as well as ride-sourcing services such as *Uber* and *Clevershuttle* are also available in the city.

The leading smart and shared mobility systems currently available in Munich are listed below:

- *MVG Rad and MVG eRad*: Hybrid[1] bike sharing system operated by *Nextbike*;
- *Call a Bike*: free-floating bike sharing system operated by *Deutsche Bahn*;
- *STATTAUTO*: the main station-based car sharing system;
- *ShareNow*: the main free-floating system;

[1] Hybrid bike sharing is, according to Miramontes (2018, p. 90), "a combination of both station-based and free-floating (…)."

- *TIER*: the main e-scooter system.

A part of the *MVG Rad* fleet of bicycles is electric (named as *MVG eRad*). Moreover, both *ShareNow* and *STATTAUTO* have a part of the fleet with an electric propulsion system.

Concerning Mobility as a Service (MaaS)[2], in Munich two services are offered: the website MVG multimobil and the smartphone application MVG More. Both provide real-time information on public transport, bike sharing, car sharing, and charging stations. Through the MVG More app, it also aids in renting or booking a bicycle or a car from the existing sharing systems in the city. (Miramontes, 2018, p. 128) Nowadays the platform includes information on *MVG Bike*, *MVG eBike*, *TIER*, *ShareNow*, *STATTAUTO*, taxi, and e-charging stations. The system *Call a Bike* is not shown on the platform. Moreover, recently, in the scope of the *Smarter Together* project, electric cargo bikes named *MVG eTrikes* were implemented and they are also not visible in the *MVG more* nor in the *MVG multimobil*. To have information or to book an *eTrike*, a specific app should be downloaded.

3.2.1.3. Mobility stations in Munich

Before the deployment of mobility stations, Munich already offered other types of intermodal infrastructure, such as *P+R (Park and Ride)* and *B+R (Bike and Ride)* facilities. Moreover, in 2012, a housing development implemented for the first time a station in which different modes of transport were offered: car sharing, electric bike sharing, and a cargo bike. (Raffl, as cited in Miramontes, 2018, p. 130)

Only in 2014, however, the first infrastructure denominated as a public mobility station was implemented in Munich. It was a pilot project at the subway station Münchner Freiheit, which also enables integration with bus and tram systems. (Miramontes, 2018, p. 131) Since its implementation, the station has slightly changed (i.e. car sharing spots signs and road marking). The mobility station at Münchner Freiheit currently offers six free-floating car sharing parking spots and one charging station (Figure 8), *MVG Rad* conventional bike sharing with 24 docks and one bike repair facility (Figure 9), and a digital information board. For further details regarding the mobility station at Münchner Freiheit, including an assessment of users' acceptance and perception, see Miramontes (2018).

[2] MaaS refers to a strategy to integrate different mobility offers into a single platform that enables the user to get real-time information on different modes of transport and to use and pay for all services. (Miramontes, 2018, p. 97)

Figure 8. Carsharing spots and charging stations at Münchner Freiheit, Munich
Source: own photograph, 2020.

Figure 9. Bike sharing and bike repair facility at Münchner Freiheit, Munich
Source: own photograph, 2020.

A few years later, in 2016, a private mobility station was implemented in Domagkpark, a new housing development area located in the north of Munich, as part of the project *Civitas Eccentric*. This private mobility station was located inside a building (Fritz-Winter-Straße 3). For further information on this private mobility station, see Alarcos (2017), which presents an evaluation of the performance of the mobility station based on a survey conducted among the inhabitants of the district.

Nowadays, there is also a public mobility station in Domagkpark, located at the Gertrud-Grunow-Straße. The public mobility station was visited in 2020, and it currently offers information boards (not digital), a charging station, free-floating car sharing parking spots, MVG Rad bike sharing system, and a bike repair facility (see Figure 10 and Figure 11). Other public mobility stations are planned for the area in the scope of the *Civitas Eccentric*.

Figure 10. Bike sharing at Domagkpark, Munich
Source: own photograph, 2020.

Figure 11. Car sharing parking spots at Domagkpark, Munich
Source: own photograph, 2020.

Later, in September 2018, a new mobility station was implemented in Munich, as part of the project the *City2Share*, which is funded by the German Environmental Ministry (BMUB) as part of the subsidy program "Renewable Mobility – Funding Electromobility

Research." It is as a pilot project in Zennetiplatz, a square located in Isarvorstadt, a central district in Munich. It was implemented together with several community engagement activities, events, and a petition. (City2Share, n.d.) Nowadays, besides the mobility station in Zennetiplatz (Figure 12 and Figure 13), three other mobility stations were implemented in the scope of the project City2Share: Goetheplatz (Figure 14 and Figure 15), Kidlerplatz and Am Glockenbach. The stations offer charging stations, parking spots for free-floating car sharing, STATTAUTO station-based car sharing, bike repair facilities, and bike sharing. Different than the mobility stations in Münchner Freiheit and Domagkpark, these mobility stations also offer the *MVG eRad*, an electric bike sharing system.

Figure 12. Bike sharing and digital information board at Zennettiplatz, Munich
Source: own photograph, 2020.

Figure 13. Charging station and parking spots for car sharing at Zennetiplatz, Munich
Source: own photograph, 2020.

Figure 14. Bike repair facility and bike sharing at Goetheplatz, Munich
Source: own photograph, 2020.

Figure 15. Station-based car sharing at Goetheplatz, Munich
Source: own photograph, 2020.

Finally, in August 2018, four mobility stations were launched in the district of Neuaubing-Westkreuz as part of the project *Smarter Together*. Nowadays, the project offers a total of eight mobility stations, which will be presented in more detail in subchapter 3.2.1.5 (The mobility stations within the *Smarter Together*) and evaluated in chapter 5 (Results and Analysis).

The location of all current mobility stations in Munich is presented in Figure 16. It should be noted that the mobility stations in Munich, although from different projects and funding, have systems operated by the same operators and are integrated with each other,

as well as with other bike sharing stations and existing car sharing systems, which are spread throughout the city of Munich.

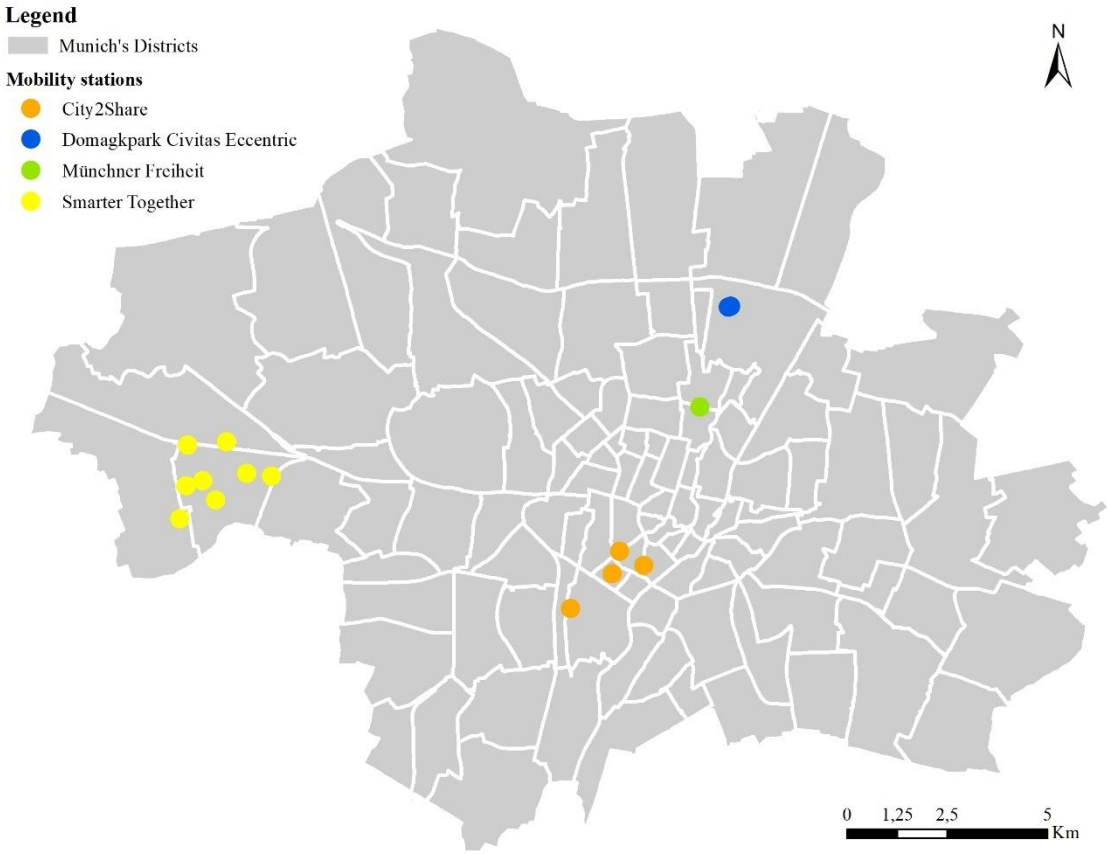

Figure 16. Location of the existing mobility stations in Munich
Source: own illustration; districts retrieved from OpenStreetMap (2020).

3.2.1.4. Smarter Together in Munich

In Munich, the *Smarter Together* was implemented in the districts Neuaubing-Westkreuz and Freiham. The EU-program funded 6.85 million euros for the project in the city, which was complemented by the local government's financial resources and private investors. It was an estimated investment of 20 million euros within the framework of this project until 2021. Collaborating with the project, there are municipal supply and service companies, such as the *Stadtwerke München (SWM)*, *Münchner Gesellschaft für Stadterneuerung (MGS)*, and the *MVG*; academic partners, such as the *Technical University of Munich (TUM)* and the *University of St.Gallen*; research institutions such as the *Fraunhofer Association*; and private companies, such as *STATTAUTO*, *Securitas*, and *Siemens*. (Landeshauptstadt München, 2019, p. 8)

There are approximately 23,000 residents in the project area, which "is part of what is geographically the largest but also the most thinly populated urban district of Munich" as well as the "largest redevelopment area in Germany". Freiham is estimated to have 28,000 residents by 2041. (Landeshauptstadt München, 2019, p. 11)

According to Neumann *et al.* (2016, p. 969), the main priority of the project "is on modernizing housing estates with varied structures of ownership, formulating user-centric mobility concepts, and developing innovative business models." Moreover, it aims at producing green electricity and, therefore, a project for the eco-friendly power supply was implemented in the Freiham district.

Regarding the involvement of a big player as *Siemens* in the project and, likewise, considering the existing criticism on the concept of smart cities concerning corporate-driven strategies, Mendes *et al.* (2019, p. 218) point out that the company was involved in the project from the beginning. The company "exerted a major influence on the entire process." However, the city administration and the company had different perspectives and goals, and the city officials in Munich were conscious and concerned about the fact that corporate-driven strategies would lead to a dependence on the technological solution provided by the company. Surprisingly, *Siemens* was the one that decided to resign from the partnership with the City, after realizing the incompatibility of interests (while Siemens wanted to develop an intelligent platform to automate urban infrastructure, the municipality wanted to use such a platform to guide urban planning) and, therefore, entrusted the responsibility to their subsidiary *VMZ*. This convergence, according to the author, "created the conditions for mutual enrolment to occur, that is, for the two actors involved (the city administration and *VMZ*) to become the ally they need to achieve their goals." (Mendes *et al.*, 2019, p. 221)

Another cooperation that Mendes *et al.* (2019) evaluate is the one between the city administration and *MGS*, which was also, according to the authors, a relationship surrounded by "many equivocations". Since even before the *Smarter Together*, in 2012, *MGS* was responsible for developing an urban renewal program called *Soziale Stadt* in Neuaubing Westkreuz. Nevertheless, *MGS* was only involved in the last phase of the preparation of the proposal. Thus, when the company was included, the actions for the smart city project were already defined and only a few questions remained to be discussed. The company was invited to be a project partner and be responsible for the tasks of energy renewal and community engagement. However, there were rising concerns as the objectives of the *Smarter Together* project diverged from the objectives of the *Soziale Stadt* program. Among the concerns were planned mobility solutions and mobility stations. According to the authors,

> Mobility stations would also create conflicts with resident parking habits, destroy scarce public space, while not taking into account actual resident mobility needs and the district's historical infrastructure. Secondly, the planned smart delivery boxes would primarily serve big online traders and supermarket chains, undermining the Soziale Stadt goal of regenerating and preserving small businesses in the district's centres. Beyond this, the smart infrastructure would minimize personal contact and eventually cause an increase in traffic in residential streets. (Mendes *et al.*, 2019, p. 222)

Fortunately, as explained by the authors (p. 223), *MGS* representatives stated that the *MVG* did its best to consider the objectives set by the *Soziale Stadt* program, and the cooperation was successful. The fact that the municipality owns both companies

contributed to this positive result. Nevertheless, there was a concern to maintain the distinction between the projects:

> (…) members of MGS carefully avoid infusing the Soziale Stadt project and activities with the smart city discourse of Smarter Together. (…) Smarter Together projects might be mentioned, but not with the keyword 'smart city' or in terms of an EU funded lighthouse project. (Mendes *et al.*, 2019, p. 222)

3.2.1.5. The mobility stations within the *Smarter Together* in Munich

As previously mentioned, there are currently eight mobility stations in the neighborhoods Neuaubing-Westkreuz and Freiham. Four of them were implemented in July 2018, and the other half in December 2018 and January 2019, all in the scope of the *Smarter Together*. The budget needed for the project was approximately €120,000-180,000 for each mobility station, which varies according to the components and equipment at each station. Regarding the timeframe, the implementation lasted approximately 6 months after the planning documents were concluded. (Smarter Together, 2019a, p. 6, 2019b, p. 43)

The primary operator of the mobility stations in Munich is *MVG*, the public transport company operating in the city. All stations have the similar infrastructure and provide the following services: *MVG Rad* bike sharing (Figure 17), *MVG eRad* pedelecs[3] (Figure 18), *MVG e-trikes* cargo tricycle sharing (Figure 19), *SWM* charging stations for electric vehicles, and *STATTAUTO* station-based car sharing (Figure 20). Furthermore, all of the eight mobility stations provide public wireless internet and all of them have a digital information board, which provides information on the mobility options available. Besides, two of the stations (Westkreuz and Freienfelsstraße) offer parcel lockers, which are named as *Quartierbox* and are operated by *SWM* and *MVG* in cooperation with *Getnow* (Figure 21). The *MVG e-trike* system and the *Quartierbox are* novelties implemented in the *Smarter Together* and, so far, are present exclusively in the project area.

The *Quartierboxes* are available for 24 hours every day. Currently, it is possible to use them in different ways: one is by placing an order through the *Getnow* delivery company's website or application. Another way is to use the boxes to store personal items or leave deliveries for neighbors to pick up. In this sense, local businesses can also take the initiative to leave their products in the boxes to be picked up by customers at any time. Both refrigerated and room temperature compartments are offered.

As can be seen in the figures below, the mobility stations implemented in the scope of the *Smarter Together* are very similar to the other ones in different neighborhoods in Munich, which demonstrates the intention to create a single and broad network for the whole city. However, it is essential to highlight that cars and bicycles use the corporate-design from the *Smarter Together* program.

[3] A *pedelec* is a type of low-powered electric bicycle which assists the cyclist when cycling, still requiring the cyclist to pedal for the engine to run. The systems offered by *MVG eRad* and *Sycube*, respectively in Munich and Vienna, are both *pedelecs*. They are referred simply as e-bike sharing throughout this work.

Figure 17. Mobility station at Mainaustraße, Munich
Source: own photograph, 2020.

Figure 18. *MVG eRad* bike sharing, Munich
Source: own photograph, 2020**.**

Figure 19. *MVG eTrike* stations, Munich
Source: own photograph, 2020.

Figure 20. Car sharing vehicle with the *Smarter Together* corporate design, Munich
Source: own photograph, 2020.

Figure 21. Parcel locker *Quartierbox, Munich*
Source: own photograph, 2020.

Figure 22. Mobility station Leienfelstraße, Munich
Source: own photograph, 2020.

Regarding the location of the mobility stations at the macro level, mobility stations were set up nearby all the existing five suburban railway (S-bahn) stations located in the project area: Freiham, München-Neuaubing, Westkreuz, Aubing, and Leienfelstraße. The other three mobility stations were placed spread in the district, aiming at creating a network. The majority of the mobility stations are located in public spaces. However, one station

is situated on private ground, though it is still accessible and available for everyone: the station Freienfelsstraße.

Figure 23 presents the locations of the mobility stations implemented in the scope of the *Smarter Together* in Munich. A list of all sites is shown below:

- **Aubing:** Colmdorfstraße 34;
- **Freienfelsstraße:** Wiesentfelser Straße 16;
- **Freiham:** Hans-Stützle-Straße 2;
- **Leienfelsstraße:** Ilse-Fehling-Straße 37;
- **Mainaustraße:** Mainaustraße 73;
- **Neuaubing:** Bodenseestraße 238;
- **Westkreuz:** Friedrichshafener Straße 11;
- **Wiesentfelser Straße:** Wiesentfelser Straße 53.

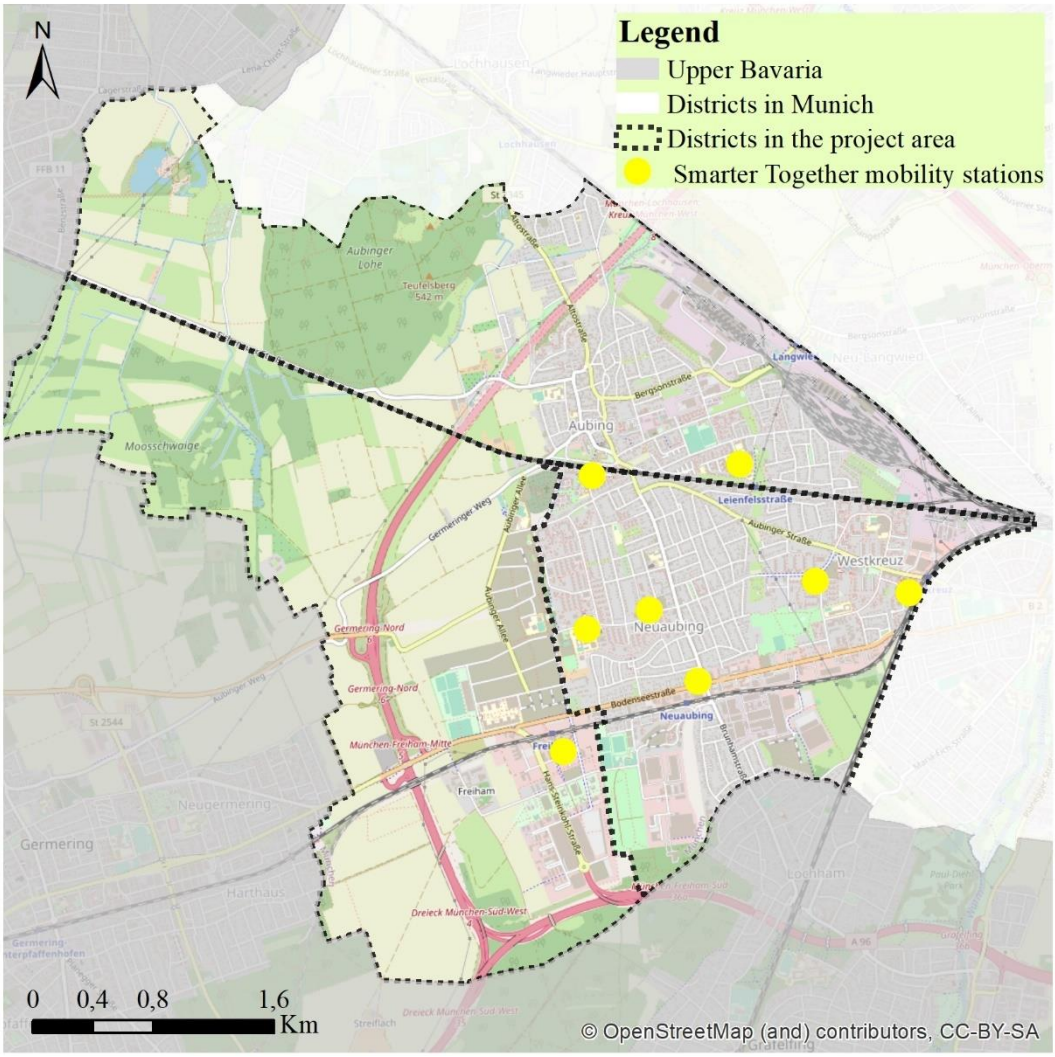

Figure 23. Location of the mobility stations within the *Smarter Together* in Munich
Source: own illustration; districts and Upper Bavaria limits retrieved from OpenStreetMap (2020), base map from OpenStreetMap.

3.2.2. Vienna

Most of the content of this chapter was published as a scientific paper in the congress proceedings of the *Congreso Campus FIT 2020*. This paper was written as part of this Master's thesis during an exchange semester in which the author resided in the City of Vienna and it is partially reproduced here for the reader's convenience. To read the full paper, see Silva and Uhlmann (2020).

Vienna is Austria's capital and most populous city, with about 1,897,491 inhabitants. It has an average population density of 46 people per hectare. (Magistrat der Stadt Wien, 2019a)

3.2.2.1. Urban mobility in Vienna

In 2018, the modal split would show that the share of public transport was 38%, whereas by car only 29%. Concerning the non-motorized modes, the modal split share of walking was 26% and by cycling 7%. Regarding the year of 1993, the modal split share of public transport has risen by nine percentage points and the share of cycling has increased by four percentage points. In comparison with other major cities in Germany and Austria, the modal split share of public transport is significantly higher. (Magistrat der Stadt Wien, 2019a; Ahrens, 2015, p. 86; BMVIT, 2016, p. 101)

The numbers above demonstrate the results of several policies that have prioritized public transport and cycling during the last years in the City of Vienna. Offering an annual public transport pass for €365, the number of passes issued in 2018 was 822,174, which represents 43% of the city population. The bike sharing system *Citybike Wien* has over 120 stations and offers free rides (for the first-hour ride) with only a single subscription fee of €1. (Magistrat der Stadt Wien, 2019a; Citybike Wien, n.d.)

Nonetheless, the municipality wishes to improve even more this scenario, by targeting that by 2025, "the citizens of Vienna shall use public transport, cycle or walk to cover 80% of the trips they need to make, whilst the share of car transport should decrease to 20%." (Magistrat der Stadt Wien, 2015, p. 16)

3.2.2.2. Smart mobility approaches in Vienna

The initiative *Smart City Wien* was first announced in March 2011. Since June 2014, after some forums and a multi-stakeholder process, the *Smart City Wien Framework Strategy* has been adopted aiming at providing the best quality of life for all inhabitants while minimizing the consumption of resources and through innovation. (Magistrat der Stadt Wien, n.d.)

Fernandez-Anez *et al.* (2018, p. 14) developed a Conceptual Model and analyzed the discourses of relevant stakeholders about the Smart City Wien. As stated by the author, "technology, though important, does not play a key role in the Vienna Smart City, and this tendency should hence be maintained." However, the author also highlights the need to promote social inclusion and encourage human and social capital, as the citizen-centric

vision seems to be not getting much attention. Social polarization, according to the author, is a trend according to surveys he conducts, though there are only a few projects that address this issue:

> This contradiction must be resolved by increasing the number of projects to tackle social inclusion. There are very few projects aimed at fostering human and social capital despite its importance to stakeholders. Promoting human and social capital is therefore an essential element for achieving social inclusion. (Fernandez-Anez *et al.*, 2018, p. 15)

Regarding the *Smart City Wien Framework Strategy*, it has influenced the long-term strategy of the City of Vienna defined in the Urban Mobility Plan, a thematic concept of the Urban Development Plan STEP 2025. The main goal is to shift the largest possible share of automobiles to public transport and non-motorized modes. To achieve this goal, the Urban Mobility Plan proposes concrete targets as well as fields of actions, which are: Sharing instead of owning; Together in the region; Transport infrastructure: the backbone of the city; Mobility needs innovation; Efficient mobility through mobility management; Transport organization: a smarter way to of managing mobility; Business in motion; Governance: responsibilities and resources; and, Public Space: sharing streets equitably. For each of these fields of action, several near-term steps and measures are proposed. (Magistrat der Stadt Wien, 2015)

In line with the Urban Mobility Plan, several smart mobility initiatives are currently being conducted in Vienna:

- *Wien Mobil*: Mobility as a Service (MaaS) app, offering real-time information and ticketing possibilities to support multimodal and intermodal mobility. Through this app, Wiener Linien is aiming today at being an integrated mobility service provider, offering car sharing, bike sharing, and e-scooter sharing through the Wien Mobil app, a system that also supports public transport.
- *WienBot*: a platform/app that enables a person to ask for advice and to get tips, directions, and information through artificial intelligence. Currently available both in German and English.
- *Grätzlrad Wien*: a public cargo bike sharing system.
- Many e-scooter providers: *Bird*, *Lime*, *Circ*, *Tier*, *Arolla*, *Hive*, *Kiwi*, among others. Some of the companies work in partnership with *Wiener Linien*, offering 20 min ride for free for those that own the annual public transport ticket. Recently, some spaces specifically designed for e-scooter parking have been implemented in place of some car parking spots throughout the city.
- Bike sharing systems: *Citybike Wien*, a dock station system offering conventional bicycles; *Sim Bike*, a dock station system offering electric bicycles; and, *Donkey Bike*, a free-floating or dockless system, offering conventional bicycles.
- Around 150 charging stations for electric cars provided by *Wien Energie*.
- E-car sharing providers: a station-based system, named as *Stadtauto*, and a few free-flowing systems, such as *ShareNow*, *Eloop,* and *UFODRIVE*.

Nowadays mobility providers are not charged from the municipality, on the other hand, those that are in partnership with *Wiener Linien* need to provide data, which can be valuable for transport planning. Despite all the several smart mobility possibilities being

offered, public transport is the backbone of the city and the new services are complementary. This explains the importance of the public sector keeping the lead over infrastructure, coordinating the strategies, and maintaining public transport at the forefront.

3.2.2.3. *Smarter Together* in Vienna

In Vienna, the *Smarter Together* project was implemented in the 11th District of Vienna, which is also known as Simmering. The program funded approximately 7 million euros for the project in the city and this triggered a total investment of over 80 million euros. There are approximately 21,000 residents in the project area. Besides the mobility station, several other projects were implemented in the area, such as housing refurbishment and school constructions, all of them targeting smart city strategies. Several partners are involved in the project, among which: *TUM*, *University of St.Gallen*, *BWSG*, *Fraunhofer*, *Austrian Post*, *Sycube*, *Siemens*, and *Toshiba*. (Magistrat der Stadt Wien, 2019b)

The 11th district is in a peripheral location and it is "characterized by its working-class history, a diverse building stock with a high share of municipal and subsidized housing." (Magistrat der Stadt Wien, 2019b, p. 11) The population density is 44.3 inhabitants/ hectare, which is below the average for Vienna. Concerning the motorization rate, there are 363.1 automobiles/1,000 inhabitants. This rate is also below the average for the City of Vienna, in which there are 373.8 automobiles/1,000 inhabitants. (Magistrat der Stadt Wien, 2019d, p. 302)

According to Neumann *et al.* (2016, p. 970) the neighborhood "is quite representative for Vienna":

> It´s traditionally a worker's district with large housing estates from 1940- 1980 but also some industry and some housing from the 1920ies. It is located in the South-East of Vienna and would have received only little attention without "Smarter Together", since it is between two large development areas. (Neumann *et al.* (2016, p. 970)

In Vienna, *Smarter Together* has gained much importance and involved approximately 70 professionals in a multidisciplinary approach. Among the projects in the area, there is the refurbishment of social housing and a public secondary school, which aims at reducing energy demand. Furthermore, the district heating system will be renovated and use local renewable energy sources. (Neumann *et al.* (2016, p. 970-971)

Regarding urban mobility, according to Smarter Together (n.d.), besides the mobility station, the project also implemented several e-mobility services in different locations, such as:

- *BWSG:* Electric car sharing at Hauffgasse 37-47.
- *Siemens*: Industrial logistics including electric charging stations for employees, electric forklifts, an e-car for internal delivery, and a new bulk handling system.
- *Austrian Post:* E-logistics with 2 electric vans and parcel locker.

3.2.2.4. *Wien Mobil Station*: the public mobility stations in Vienna

There are currently three mobility stations composing the *Wien Mobil Station* system. In September 2018, the first public station was implemented at Simmeringer Platz as a result of the EU-funded project *Smarter together*. Later, in 2019, two other stations were implemented: one at Rochusmarkt and another in Richard-Wagner-Platz. (Smarter Together, 2019c) The stations are located in different neighborhoods and the infrastructure and the services available vary (Figure 24).

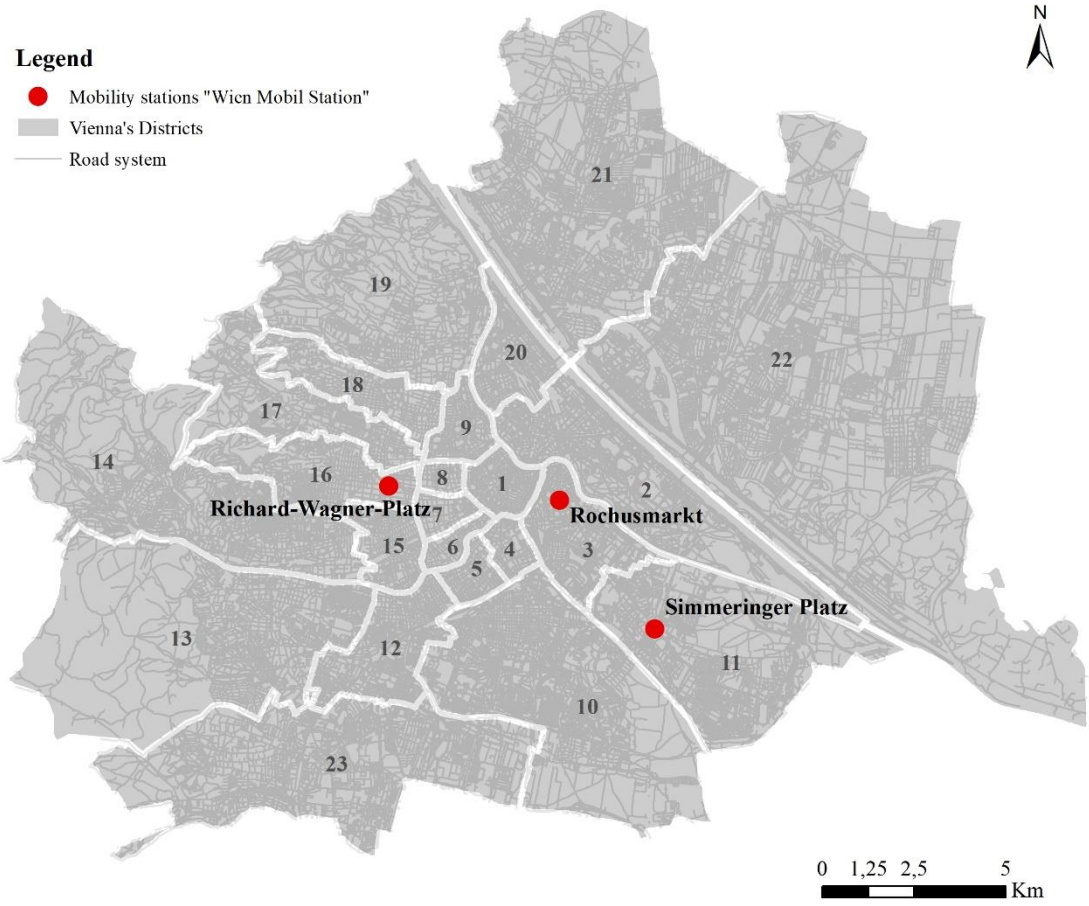

Figure 24. Location of the existing public mobility stations in Vienna
Source: own illustration, 2020; districts and streets retrieved from, respectively, Open Data Österreich (2019) and OpenStreetMap (2020).

According to Neumayer (2019), a geoprocessing analysis was developed with nine criteria for the implementation of the mobility stations in Vienna. The criteria are:

- Type of stop: places having a subway stop are graded higher than sites with tramway or buses stops, respectively;
- Connection to cycle traffic: the existence of a bikeway or a segregated cycle trail is graded higher than a cycle lane or a shared path, respectively;
- Existence of a charging station for electric cars;
- Existence of a *Stadtauto* station;

- Existence of *Citybike Wien* or *Sim Bike* station;
- Existence of a taxi stop;
- Population coverage: places adjacent to building blocks or counting areas ("Zählsprengel", the smallest region in official Austrian statistics) with more than 1,999 residents are graded higher than places adjacent to building blocks or counting areas with fewer residents;
- Public transport user/day: locations with more than 5,000 users/ day are graded higher than places where the public transport is less used;
- Existence of an urban development or industry/commerce area with over than 10.000m².

Unfortunately, the above criteria have not determined the locations of the existing public mobility stations. The interviewees, in general, reported the difficulty faced by *Wiener Linien* in obtaining authorization to use the public spaces for implementing the mobility stations. Thus, the availability of space has been the main criterion for the installation of the public mobility stations in Vienna so far.

Below there is a description of the two public mobility stations implemented in September 2019 in Vienna. The first one, located at Simmeringer Platz, will be presented on detail in subchapter 3.2.2.5, as it is was developed in the scope of the *Smarter Together* and, therefore, is one of the main focus of this work. Moreover, it has some specific characteristics which differ from the others.

The *Wien Mobil Station Richard-Wagner-Platz* is located in the 16th District, also known as Ottakring. It is positioned in the corner of a big square with the same name, which is on Thaliastraße Street, the busiest and most commercially important street in the neighborhood. It offers a good connection to the tram line and is approximately 1 km away from the closest subway station. The configuration of the station is different from the other mobility station, because the services offered are not concentrated in a single location, but rather are spread in the corner of the square. This is partly explained because the strategy adopted for this mobility station was to use the existing infrastructure, such as the bike sharing system *Citybike Wien* (see Figure 25) and the existing charging stations for electric cars from *Wien Energie*. The e-car sharing system is the one from *Stadtauto* (Figure 26*)*. Moreover, there is an information board (Figure 29), a shared cargo van, bike racks, and space for parking e-scooters. The integration of the bike sharing *Citybike Wien* with the *Wien Mobil Station* was an initiative from *Wiener Linien* that resulted in an agreement between both.

Figure 25. *Citybike Wien* and space for e-scooters at Richard-Wagner-Platz, Vienna
Source: own photograph, 2019.

Figure 26. *Stadtauto* car sharing at Richard-Wagner-Platz, Vienna
Source: own photograph, 2019.

The *Wien Mobil Station Rochusmarkt* is located in the 3rd district, also known as Landstraße. The mobility station is surrounded by retail stores, a big market square, and some residential buildings. It is close to the subway station Rochusmarkt (line U3) and tram connections. The configuration of this station is similar to the one in Richard Wagner Platz. However, the bike sharing station *CitybikeWien* is not completely connected to the mobility station because it is located across the street and a few meters further, but it is included on the mobility station map and it's reachable by foot. As stated by Franz (2020), the station is less attractive because it is dislocated and nobody sees that its many parts belong together. Besides bike sharing, it has the same mobility offers as the station in Richard-Wagner-Platz: car sharing, charging station (Figure 27), space for e-scooters (Figure 28), bike racks, and information board (Figure 30), however, it does not offer cargo vans. It also has a bench, which the station in Richard-Wagner-Platz does not.

Figure 27. Bench and charging stations at Rochusmarkt, Vienna
Source: own photograph, 2019.

Figure 28. space for e-scooters and bike racks at Rochusmarkt, Vienna
Source: own photograph, 2019.

Figure 29. Information board at Richard-Wagner-Platz, Vienna
Source: own photograph, 2019.

Figure 30. Information board at Rochusmarkt, Vienna
Source: own photograph, 2019.

3.2.2.5. The mobility station at Simmeringer Platz

As previously mentioned, among the three existing public mobility stations in Vienna, only one was implemented in the scope of the *Smarter Together* and inside the project area, which is the 11th district (Figure 31). This single station was implemented in September 2018 as the first public mobility station in Vienna. The preparation and planning phases lasted from one to two years, while the installation took two months. Regarding the budget, around €550,000 and €600,000 were needed for this mobility station, including conceptualization, design, planning, and implementation. (Smarter Together, 2019b, p. 16, 2019d, p. 24),

Wiener Linien is the main operator of the mobility station and it is responsible for planning and managing, as well as general maintenance (e.g. winter maintenance), the operation of the digital information board, and the maintenance of the public bicycle pump. *Wiener Linien* is also responsible for dealing with approvals, constructions, and electric connections. The company works in cooperation with several services provides. The mobility station at Simmeringer Platz is co-operated with four different sub-operators, which are responsible for the operation and their specific infrastructure. The sub-operators are *Stadtauto*, the e-car sharing provider; *Sim Bike*, the e-bike sharing provider; *Safety Dock*, the operator of the lockable bicycle boxes; and, *Wien Energie*, the provider of the charging stations for electric vehicles. Unfortunately, there is no interoperability between services and it is not possible to register for all of them at once, meaning that each service requires it is own app. (Magistrat der Stadt Wien, 2019a, p. 31; Smarter Together, 2019d, p. 25; Neumayer, 2019)

Currently, the mobility station at Simmering offers six station-based e-bike sharing (Figure 32), one station-based e-cargo bike sharing, three lockable bike boxes with electricity (Figure 33), electric car charging station with two parking spots, one station-

based car sharing (Figure 34), a digital information board, an air pump, and a public bench.

Parcel lockers were originally planned for this mobility station, however, for strategic reasons and with a view to neutrality concerning different postal services it was decided to take them out of the scope of the project. (Smarter Together, 2019d, p. 26)

Figure 31. Mobility station at Simmeringer Platz, Vienna
Source: own photograph, 2019.

Figure 32. *Sycube* e-bike sharing, Vienna
Source: own photograph, 2019.

Figure 33. *Safety Dock* bike boxes, Vienna
Source: own photograph, 2019.

Figure 34. *Stadtauto* car sharing, Vienna
Source: own photograph, 2019.

The mobility station Simmeringer Platz is located near the last subway station of the line U3, also named as Simmering, and has tram connections. The neighborhood was defined by the project *Smarter Together* and the decision on where to place the station on a microlevel was done considering space available nearby public transport connections. (Neumayer, 2019)

Figure 35 presents the location of the *Wien Mobil Station Simmeringer Platz*.

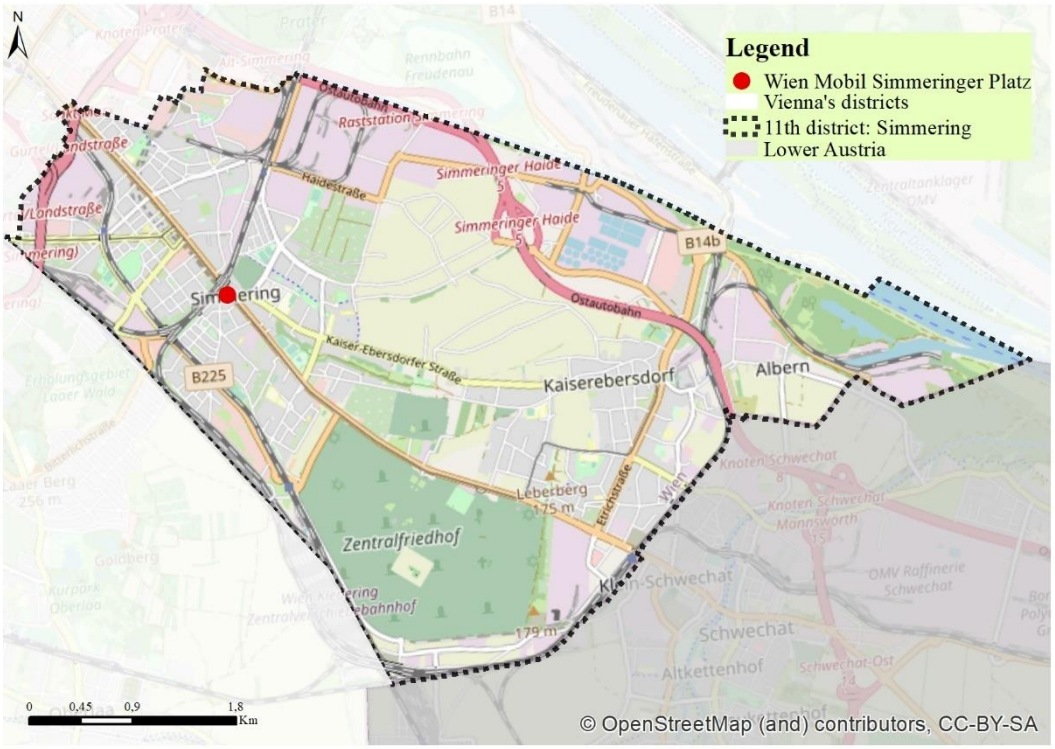

Figure 35. Location of the *Wien Mobil Station Simmeringer Platz* in Vienna
Source: own illustration; districts and Lower Austria limits retrieved from OpenStreetMap (2020), base map from OpenStreetMap.

4. METHODOLOGY

The development of this thesis can be divided into two distinct stages: 1) during the first, the author resided in Vienna, conducted exploratory research, still unsure about the outcomes; 2) in the second stage, living in Germany, the author applied the knowledge acquired during the exploratory research in Vienna to the context of Munich focused on obtaining the information that would help to find out about the lessons learned from the project. The first stage was developed between October 2019 and January 2020, while the second was conducted between May and August 2020. As a mixed-method research, several activities were conducted during these periods. While the literature review was mainly theoretical and academic, the interviews, surveys, and site-visits were instead part of an empirical investigation on the topic. The methods carried out during the development of this study were:

- Literature review;
- On-site observation;
- Collection and analysis of secondary data;
- Explorative expert interviews; and,
- Online surveys.

4.1. On-site observation

The author tried to apply ethnographic methods, by positioning herself in the mobility stations to observe the behaviors of users. Unfortunately, not many users were seen (as presented in Silva and Uhlmann, 2020), and thus the method was not very satisfactory for this purpose. However, on-site observation contributed to a better understanding of the interaction of passers-by with the infrastructure, utilization rates, as well as other characteristics of the mobility stations, such as visibility and accessibility. Moreover, besides visiting the stations, this method enabled a better understanding of the neighborhood's characteristics, such as land use, type of occupation, social activities occurring in public space, among others.

In Vienna, the mobility station at Simmeringer Platz was visited on October 10th and December 11th, 2019, and January 8th, 2020. Those were weekdays and the observation was done approximately for 2 hours during the afternoon on all occasions.

In Munich, all the existing eight mobility stations were visited during June 20th and 22nd, 2020, a Saturday and a Monday, respectively. The observation was done for approximately 30 minutes in each station, except for the mobility station named as Westkreuz, in which the author remained for around 2 hours. A walking tour was carried out between a mobility station and another, enabling a better understanding of the district and its characteristics.

4.2. Collection and analysis of secondary data

Through the *Smart Data Wien* virtual platform, it was possible to obtain raw and complete secondary data from the *Sycube* bike sharing system. This company collaborated with the development both by offering an interview and by authorizing the use of the data. The data considered are from bike sharing trips that started at the mobility station located at the *Wien Mobil Simmeringer Platz*, for the period between September 2019 and June 2020. Some data was disregarded as possibly representing errors in the system: records lasting less than 5 minutes (73 entries) and records lasting more than 20 hours (6 entries). A total of 286 entries were considered. The analysis of these data is presented in chapter 5.2.2.

Moreover, existing reports were taken into account, such as 1) a report developed by the Austrian Institute of Technology (AIT) which presented the results of surveys conducted with residents in Simmering concerning their mobility patterns; 2) several reports developed by GB* concerning the community engagements activities conducted in Simmering; 3) all deliverables from the *Smarter Together* available online.

In Munich, unfortunately, despite several attempts, it was not possible to obtain raw data regarding the utilization of any of the services offered at the mobility stations, as they were treated as internal and confidential data by both *MVG Rad* and *SWM*.

4.3. Explorative expert interviews

Several interviews with experts were conducted to obtain an overview of the project in both cities, as well as opinions on planning, implementation, and operational phases.

4.3.1. In-person interviews

Between October 2019 and January 2020, seven in-person interviews were conducted. Among the interviewees there were: responsible professionals working for the operating companies (*MO.Point*, *CityBike Wien*, *Sycube*, and *Wiener Linien*, in Vienna, and *Tim*, in Graz), as well as an expert involved in the community engagement activities of the *Smarter Together* in Vienna and working for the *GB**, and an expert acting in the consulting company *Urban Innovation*, in Vienna). In this stage, the author also tried several times to contact the car sharing provider in Vienna (*Stadtauto*), but did not succeed.

4.3.2. Interviews per e-mail and videoconference

Due to the limitations during the coronavirus pandemic, between May and August 2020, interviews were conducted per e-mail. Three interviews were conducted with responsible professionals working for the planning and operating companies involved in the project (*MGS*, *SWM*, and *MVG Rad*).

Moreover, an interview was conducted as a videoconference, preceded by the sending of questions by e-mail and proceeded by a face-to-face meeting a little later. The interviewee is an academic that focuses on the study of mobility stations in Munich and Germany, and who had recently published a dissertation on the subject (cited numerous times as a source for this thesis).

4.4. Online surveys

There have been some attempts to conduct face-to-face surveys with users and passers-by in the Simmering project area in Vienna. However, due to factors such as the low utilization rate of the system and the winter weather, the idea was not successful. In the second phase of the research, between May and August 2020, this possibility did not even come into question given the recommendations of social distancing during the coronavirus pandemic. This scenario resulted in the decision to carry out surveys through online platforms.

The survey was designed in German and launched on the online platform *Google Forms*, as well as, in the case of Munich, in *SurveyMonkey*. *Google Forms* was first chosen by the author because it is a free platform that does not limit the number of questions and makes it possible to carry out filters that direct users to questions that are intended for their profile, based on a previous question. *SurveyMonkey*, on the other hand, offers a limited free version, which offers a maximum of ten questions and does not allow the use of additional features. However, when the author had already created the survey and disseminated it among some groups, the *MGS* team requested that the survey should be done on a different platform, stating that *Google Forms* would be questionable for data protection reasons. To obtain a greater number of responses, the survey was then created in *SurveyMonkey*, and the anonymous mode was enabled (in which the user IP is not collected). The survey published through *SurveyMonkey* consists in a shorter and simpler version considering the limitations of the free version offered by the platform.

The longest version of the survey in Google Forms (for users of the mobility stations) consisted of 17 questions. The shortest survey route (for non-users that were not aware of the mobility station) consisted of only 8 questions. In *SurveyMonkey* the survey was limited to 10 questions and only one single form was presented to all.

The surveys were launched on week 25 and closed on week 30 (in the year 2020), approximately one month later. The target group was addressed via different platforms: publication on the Facebook page *Kulturstreetwork Neuaubing Westkreuz*, and publication on the Facebook groups *Simmering! Gemeinsam sind wir stark!*, *Wir Lieben Simmering & ganz Wien*, and, *westkreuz, unsere heimat*. Besides, in Vienna, there was the collaboration of the *GB** team for the dissemination of the survey among the residents of the region. In Munich, the *MGS* team collaborated by disseminating the *SurveyMonkey* form. Interestingly, some people who had access to the survey forms also contacted the author by e-mail or Facebook, requesting more information about the project and/or expressing some opinions.

A total of 17 valid responses were obtained for the survey form concerning Simmering, in Vienna. The sum of responses received regarding Neuaubing-Westkeuz, in Munich, was 28 (10 via *Google Forms* and 18 via *SurveyMonkey*).

Figure 36 presents the structure of the survey in *Google Forms*. Figure 37 shows the structure of the survey in *SurveyMonkey*. The analysis of the collected data is presented in chapter 5.3.

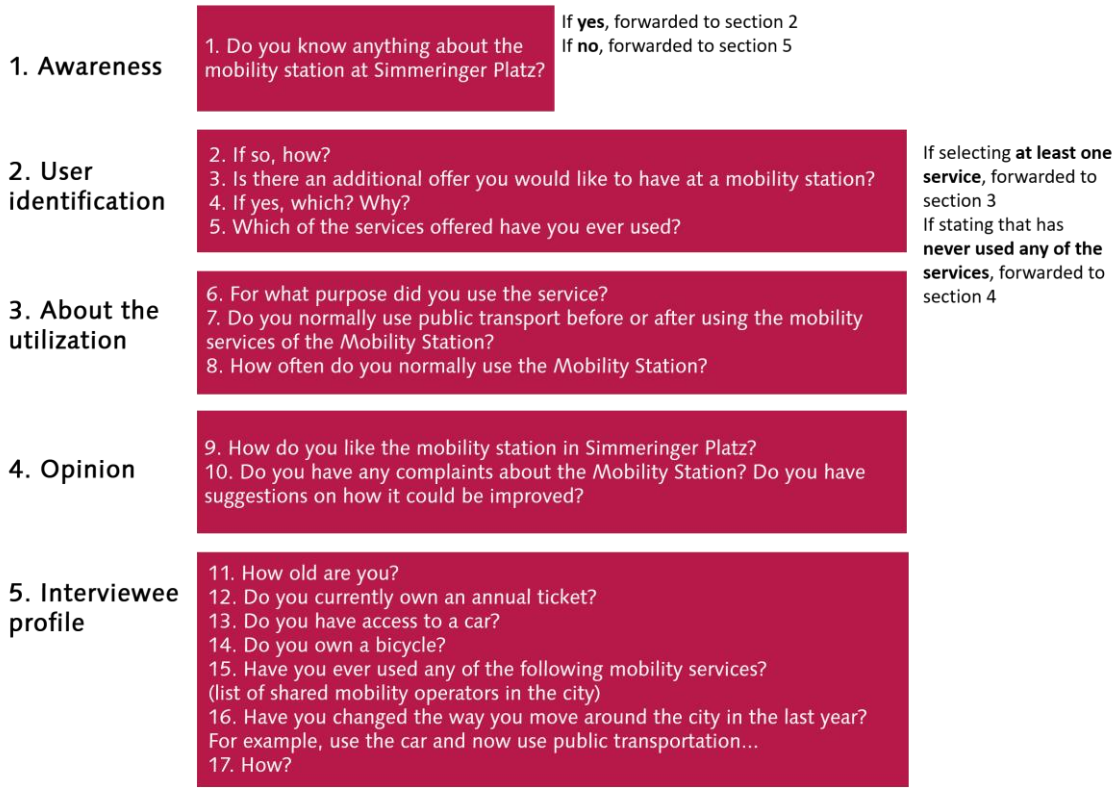

Figure 36. Structure of the survey on *Google Forms*
Source: own illustration, 2020.

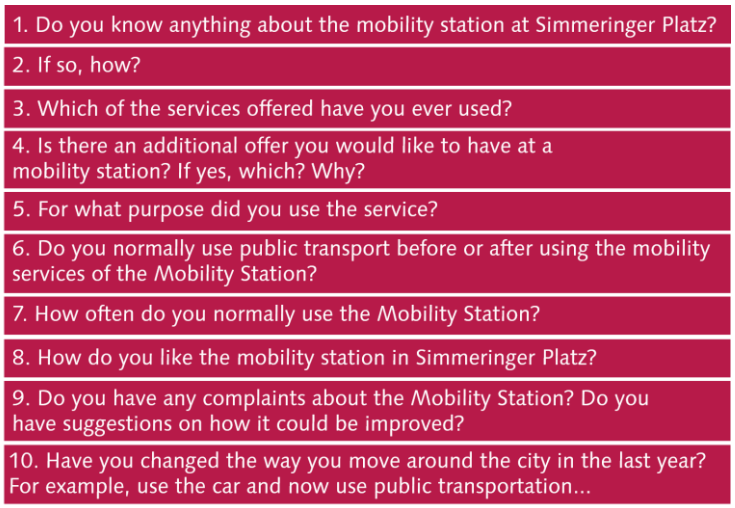

Figure 37. Structure of the survey on *Survey Monkey*
Source: own illustration, 2020.

5. RESULTS AND ANALYSIS

The objective of this master thesis is to present the main characteristics of the mobility stations implemented in the scope of the *Smarter Together* project in Vienna and Munich, sharing what can be learned from their experiences. Besides presenting positive and negative aspects of the experiences in both cities, it aims to present a comparative study that suggests possible reasons for greater use in a certain context and indicates better approaches for other cities wishing to develop similar systems in the future. The expected contributions with this thesis are therefore to identify important aspects to be taken into account in the planning, implementation, and operation stages of mobility stations while providing an understanding of the concept of smart cities beyond the simple adoption of technology.

This chapter presents the results obtained through the different methods used during the elaboration of this master thesis.

5.1. Residents' mobility patterns and community engagement activities

Aiming at presenting the residents' profile and information on their mobility patterns and interests, data obtained through community engagement activities, which took place during the planning and implementation phases of the project, are presented. Therefore, this part consists of mainly secondary and previously processed data. The goal is to provide a better understanding of the context of project implementation.

5.1.1. Munich

In Munich, five workshops with citizens were held regarding urban mobility in the scope of the *Smarter Together*. In those events, participants had the opportunity to give their opinions on the mobility stations and to decide on the e-vehicles to be provided at the district. (Smarter Together, 2019a, p.11)

The co-design process was developed by the *Munich Centre for Technology in Society (MCTS)* at *TUM*, in cooperation with *MGS*. The community engagement activities were held in a strategic location that combines event and exhibition spaces, as well as a civic center. It was open for public consultation three days a week and, in total, received approximately 4,000 visitors. (Landeshauptstadt München, 2019, p. 13-14)

Moreover, a district laboratory named as *Stadtteillabor* as set up by *MGS* in the project area (Smarter Together (2017, p. 14)

Several community engagement activities were conducted between May and July 2016, such as meetings with stakeholders, information events for residents aiming at creating awareness about the project, and collective researches aiming at collecting knowledge, discussing, and providing a concrete recommendation for the project. The

recommendations resulting from the events were summarized by the *TUM* team and presented to the public to create transparency and to document feedback. (Smarter Together, 2017, p. 15-17)

Among the requests made by the participants there are:

> (…) improvements to the cycling infrastructure in the project area, the adaptation of stations at bus and commuter rail stops, and the need for rapid usage assessment in order to respond to growing demand by expanding the services on offer. The desire for a variety of vehicles for hire was also expressed, as was the request for mobility stations to feature pump stations for bicycles and, if possible, drinking water fountains. The consensus was that easy hiring processes and comprehensive information for local residents are vital if widespread use is to be made of these services. (Landeshauptstadt München, 2019, p. 19)

The mobility stations planned for the project area in the scope of the *Smarter Together* were positively assessed by most of the participants as an additional offering to supplement existing mobility offers. However, many residents were concerned about parking spaces. Another factor that has raised people's concerns was the importance of offering ways for people who do not have bank accounts, such as young people or refugees, to still register as users of the mobility systems offered. Furthermore, participants shared the concern that mobility services would only be used occasionally. (Smarter Together, 2017, p. 17)

Some of the resulting recommendations for the mobility stations are highlighted below:

- Bicycles for children;
- Cargo bicycles for different uses (e.g. transporting children and shopping);
- Flexible bicycle trailers that can be dismantled for use with one’s bicycle;
- No additional pressure on the parking situation in the area;
- Inclusive access for people who don’t hold bank accounts (e.g. pre-paid card)
- Integrate the possibility of borrowing accessories (e.g. child seats, etc.)
- Interim stops not counted towards bike rental period
- Bikes can be deposited anywhere
- Parcel locker to enable the exchange of things and the storage of accessories, such as bike helmets and child seats, located in the same location as the cargo bikes.

(Smarter Together, 2017, p. 18-19)

It is noted that, when planning and implementing the mobility stations, there was a concern to meet some of the recommendations indicated by the community engagement actions, but unfortunately, not all were met.

More information on the community engagement activities held in Neuaubing-Westkreuz can be found on the *Smarter Together* deliverable named Smart City Catalyst (see Smarter Together, 2017).

5.1.2. Vienna

Before the mobility station at Simmeringer Platz was implemented, interviews were conducted with residents aiming at better understanding their profile. Those surveys were first carried out online by AIT, however, it demonstrated the need for face-to-face surveying, which was then implemented by the GB* 3/11 in some events and the mall located in the neighborhood. A flyer to announce the online survey was also developed and sent to local households in the project area. (Smarter Together, 2019f, p. 37)

> This activism provided not only an interesting number of responses, it also by fact reached out to populations that would otherwise never been reached such as pensioners and migrant populations with low educational level or with even lower level of language knowledge in German. (Smarter Together, 2019f, p. 33)

According to the report developed by AIT (2016, pp. 5-6), the survey was carried out between August and December 2016. Only 241 questionnaires were fully completed and therefore considered in the evaluation. Among the participants, 81% live in a household with at least one bicycle, among which 4% have at least one e-bike available. 41% of them stated that they would like to cycle more often if they were able to choose. In this sense, "infrastructure improvement is therefore needed since the surrounding structure does not encourage them to do so." Concerning public transport, 88% of them have a public transport stop in 5-7 minutes walking distance from their residence and 77% own a season ticket for public transport (annual passes or student tickets). The automobile, on the other hand, was not the main mean of transport of the participants, as only 59% of the participants live in a household with one or more vehicles, whereas 75% own a driving license. As for smart mobility, not so many participants stated that would like to travel more frequently with an electric car or with electric bike in the future (29% and 20%, respectively). Only 9% of respondents stated that they already use car sharing.

As shown above, most of the interviewees have never used a shared mobility alternative and only a few stated that they would like to do it. Therefore, it is possible to assume that the population in the district cannot be considered as "early adopters" and that they need more input to be interested in smart mobility services. Areas where residents show no or low interest in shared mobility alternatives require greater effort in advertising and educational campaigns. The *Smarter Together* team was aware of that and, therefore, several community engagement activities took place in the scope of the project.

> Since in particular the topic of the Mobility Point is very difficult for non-professionals to understand, it was necessary to convey the implementation project as clearly as possible. (Smarter Together, 2019f, p. 50)

> Unlike e.g. refurbishment projects, where the residents are directly affected by the measures, especially in case of mobility schemes, it is a challenge to activate citizens. (Smarter Together, 2019f, p. 52)

Therefore, besides the survey described above, the planning and implementation phases included community engagement activities with residents, which allowed them to share opinions, as well as to test the e-bike sharing system.

The central communication platform for community engagement during the implementation of the *Smarter Together* project in Vienna was *SIMmobil*, a mobile information booth. This infrastructure had an appealing design and, as it was a "booth on wheels", it could be placed where the residents already were, allowing a greater number of people to be involved in the actions carried out by the project. It was organized by GB* 3/11 and it was open at six different locations in around 90 days. Approximately 3,000 talks with visitors were registered. (Smarter Together, 2019e, p. 26)

> (…) the idea of being locally present at different sites with different contents appeared to be strategically the right one as it provides additional communication possibilities in regards to static offices of the different stakeholders in the project area.
>
> (…) the outdoor solution in particular helped to activate citizens and enhance awareness for smart mobility and the impact of the individual mobility behavior. (Smarter Together, 2019f, p. 52)

Several activities were conducted in the neighborhood between 2016 and 2018. The main ones used the *SIMmobil*, while a few others were complementary public events. During the co-design and co-creation phases, in 2016, the following inputs were collected: Location next to subway station Simmering; e-bike station; info point; WLAN and charging for devices; Integrated Mobility Cards as access medium to all services; roofed benches; greening, trees; kiosk; ATM; fitness devices; e-scooter, longboard sharing, e-skateboards. In July 2016 there was an event, which had a contribution from a total of 105 visitors. This event took place in front of the public library and lasted 15 days, for four hours per day. In the location, e-bikes were available for testing, however, only a few people among all visitors tried it. Experts from the partner *Sycube* were at the location, providing instructions, and answering specific questions about the system. This activity resulted in some conclusions regarding the electric bike sharing system that the residents would like to have such as having a basket and good and reliable brakes and electric support. Moreover, it should be suitable for men or woman and handlebars and saddles should be easily adjustable. Later, in October 2016 another action was held for nine days. It consisted of a special workshop for children, providing bike repair for free. In 2017, a workshop called Geh-café was held with a guided tour focused on mobility. In 2018, an event in front of the subway station was held, providing information about the mobility station. Finally, during the first weeks after the mobility station was implemented, in September 2018, there were people at the mobility station informing about it and helping people on how to use it. (Magistrat der Stadt Wien, 2019b; Smarter Together, 2019e; Smarter Together, 2019f; Breitfuss, 2019)

More information on the community engagement activities held on Simmering can be found on the *Smarter Together* deliverables named Urban Living Lab and Co-Design Processes (see Smarter Together, 2019e, 2019f).

Although the community engagement actions implemented in the scope of the *Smarter Together* in Vienna seemed to have contributed to the involvement of part of the neighborhood's population in the project and could contribute with suggestions, which were partially adopted, the actions were most informative. When the actions took place most of the decisions had already been made, for example, the mobility station had already been in the scope of the project since its inception, so residents were not given

the opportunity to say whether or not they would like to have this infrastructure in the neighborhood. Besides, in many events the location and the different mobility offers to be placed at the mobility station had also already been decided. This situation was previously discussed in chapter 3.1, which mentioned certain community engagement strategies as mere tools to "confirm previously made assumptions", as presented by Mendes *et al.* (2019, p. 20).

Another important aspect to be mentioned is that after the implementation of the mobility station no further activities for purposes of education or marketing were conducted in the neighborhood. Advertising actions must take place continuously instead of being restricted to the implementation phase. It is important to promote the system and make residents feel familiar with the tools and services offered. As the excerpt from the deliverable named Urban Living Lab (Smarter Together, 2019d) presented below demonstrates, this information is already known by the project. However, for some reason, it remains ignored.

> Success and failure of services like mobility points are closely intertwined with digital-analog-digital communication manners of users. First experiences of operating the WienMobil Station Simmeringer Platz show that, although easily accessible information about service offers are available and communicated via apps, Internet and traditional communication streams, users are reserved in order to use the actual service. Merely digital availability is no sustainable solution for offering mobility services. Human to human communication and interaction is key when talking about acceptance of new mobility services. (Smarter Together, 2019d, p. 28)

5.2. Usage patterns of the mobility stations

The usage patterns of the mobility stations implemented in the scope of the *Smarter Together* are presented to allow an understanding of how, why, and when the mobility services offered are used. Besides, this analysis identifies possible underutilization or overutilization. The results take into account the secondary data obtained, as well as the expert interviews.

5.2.1. Munich

As data concerning the mobility services offered at the mobility stations in the *Smarter Together* in Munich was unavailable, this analysis took into account only the content of the expert interviews.

Regarding *MVG Rad* and *MVG eRad* systems in the context of the whole city of Munich, Götz (2020) states that the systems are mainly used by students and locals. There is an intrinsic relationship between the utilization rates and weather, with higher utilization during summer and a decrease in the utilization during winter. Moreover, he highlighted that the decisive factor is not the cold, but rather the precipitation, as both rain and snow cause the number of rentals to drop significantly.

When talking specifically about the stations implemented within the *Smarter Together* project, Götz (2020) affirms that the utilization rates of the station in the project area are lower than the rates of the other stations in Munich. He points out the distance from the city center as one of the reasons for this scenario. Moreover, Götz stated that the stations are used more evenly on weekends, while during the week the usage is more volatile. He mentioned the work hours as peak hours for weekdays, in the morning or after work, while on weekends the utilization is spread over the whole day.

Nowadays the *MVG Rad* system offers a fleet of 4,000 bikes in approximately 300 stations, while 34 e-bikes are available under the *MVG eRad*, which are located in the eight *Smarter Together* mobility stations and in the four *City2Share* mobility stations (MVG, s.d.). The *eTrike* has a fleet of 20 electric cargo bikes (Götz, 2020). However, during the on-site observation, considering all *Smarter Together* stations, only a small number of e-bikes were seen, while no *eTrikes* were seen at all. According to Götz (2020), this can either mean that the system is highly used or that the bicycles were in maintenance. Either way, this demonstrates a lack of reliability and the need of offering a higher number of electric bikes and cargo bikes to meet the demand.

Regarding the integration with public transport, Braun (2020) affirms that figures indicate that inhabitants use the bikes for the first and last mile to and from the suburban railway stations.

According to Filimon and Mandel (2020), the parcel lockers (*Quartierbox*) are not as much used as originally expected and it seems that it is not attracting much interest.

5.2.2. Vienna

According to an interview conducted with Neumayer (2020), the most used service offered at the mobility station at Simmeringer Platz differ on weekdays and weekends. During the weekend the most used service is pointed as being the e-bike sharing, while on weekdays the lockable bike boxes are mentioned as the most used service.

Considering that shared e-bikes are one of the most used mobility offers at the station, it is relevant to analyze your data, which were obtained through the *Smart Data Wien* virtual platform and complemented with data obtained directly with *AIT*.

Figure 38 shows the total number of trips recorded monthly on the *Sycube* e-bike sharing system originating from Simmeringer Platz. There was a huge drop in utilization during the winter months (from October 2019 to March 2020), among which the month of December 2019 stands out with no record of utilization at all. However, even when the system was most used, in May 2020, when the utilization reached the mark of 80 bike rides, it can still be said that it was low, with an average of only 2.6 trips per day. Among the reasons for the increase in demand from April onwards are the weather (start of spring), but also the recommendations of social isolation resulting from the coronavirus pandemic. According to Einwöreger (2020), during critical periods, more people have used available shared mobility offers instead of public transport.

For comparison purposes, the numbers presented by Dechant (2020) concerning the utilization rates of Citybike Wien bike sharing in Richard-Wagner-Platz and Salmgasse

in 2019 were, respectively, 10,890 and 5,431 riders/ year, representing an average of 907 and 452 trips per month. The utilization rate of the *Citybike Wien* during the winter represents around 20% of the usage of June and the number of bikes provided during winter is around 8% less than during summer. Moreover, weekends are highly influenced by the weather, whereas weekdays have more stable utilization rates.

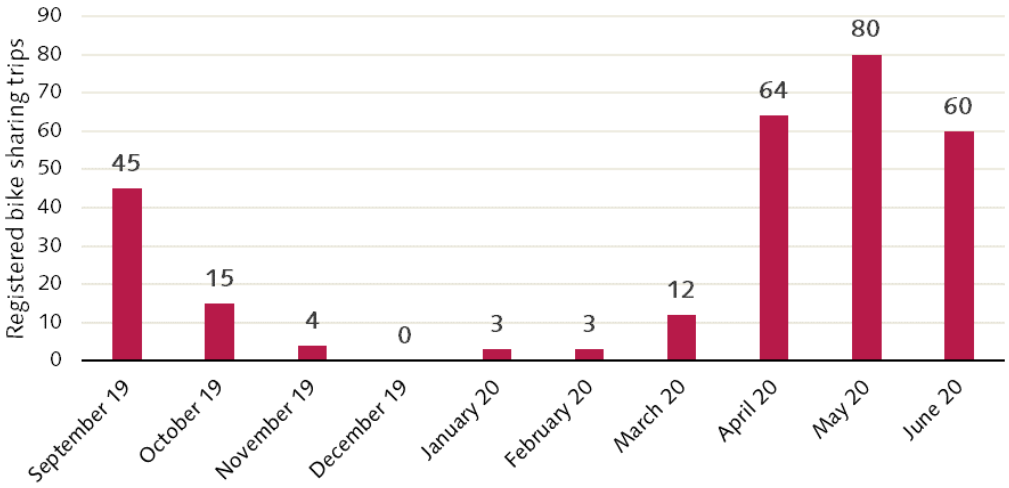

Figure 38. Monthly number of shared bike trips (Simmeringer Platz, Vienna)
Source: own illustration, 2020, based on Smart Data Wien, n.d.

Regarding the purpose of the trips, according to Neumayer (2020), the main trips are for leisure. Considering the information provided by Dechant (2020) on the influence of climate on use on weekdays and weekends, it can be assumed that systems mainly used for leisure purposes, as the *Sim Bike*, are even higher impacted by the weather than systems used for work and study purposes.

Figure 39 presents the average duration of the trips recorded in the analyzed period. It also confirms the fact that the majority of trips are for leisure purposes, considering that 68% of the trips last more than 1 hour, and only 17% of the trips last less than 30 minutes. For comparison purposes, according to Dechant (2020), the most common ride duration in *Citybike Wien* is 9 minutes.

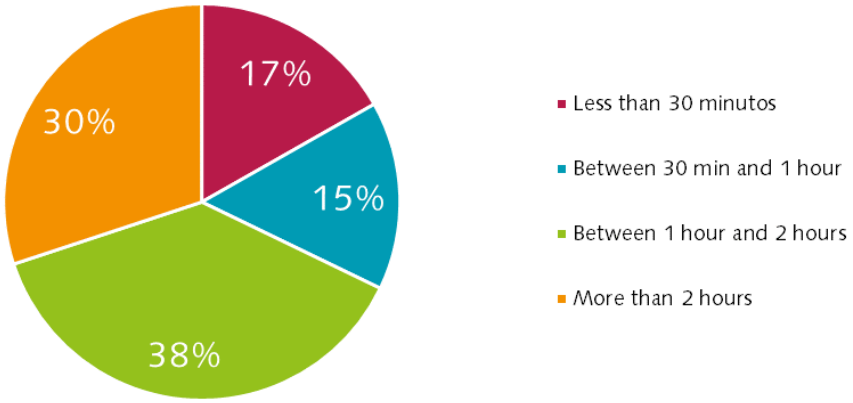

Figure 39. Duration of shared bike trips (Simmeringer Platz, Vienna)
Source: own illustration, 2020, based on Smart Data Wien, n.d.

Figure 40 shows the distribution of trips per day of the week. It shows that there is a relative balance between uses during the different days of the week, with a significant drop on Wednesday and Thursday. As expected, Saturday is the day when the system is most used. Interestingly, Monday is the second day with the highest utilization rate, followed by Friday and Tuesday.

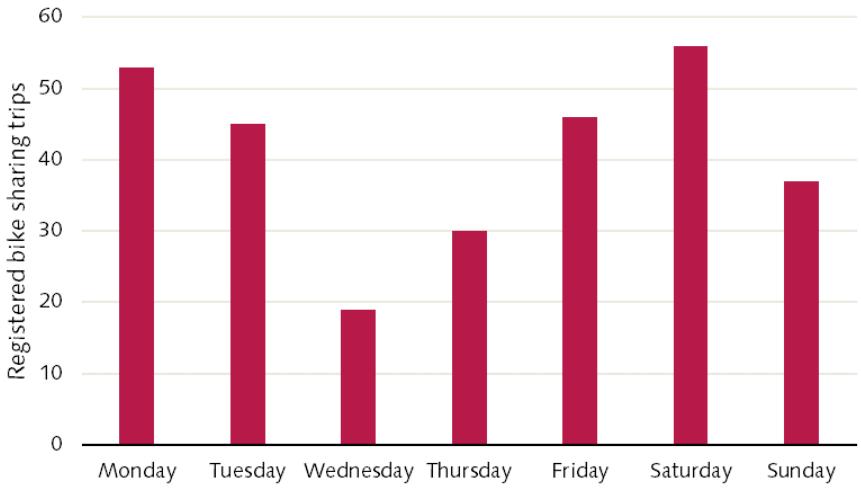

Figure 40. Shared bike trips per day of the week (Simmeringer Platz, Vienna)
Source: own illustration, 2020, based on Smart Data Wien, n.d.

Figure 40 presents the distribution of trips by the time of the day. It indicates a peak hour at 3 pm, with significant uses also in the period between 1 pm and 5 pm. Interestingly, one trip was recorded starting very early, at 4 am, while three were recorded starting very late, at 10 pm.

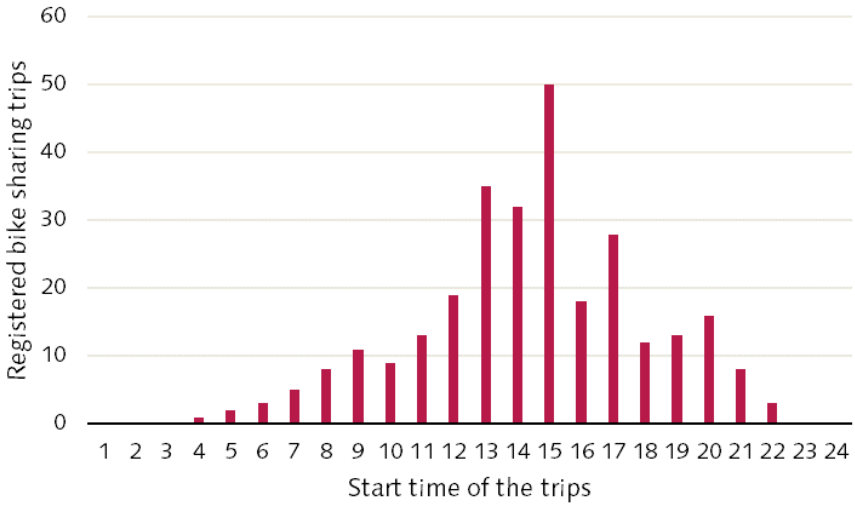

Figure 41. Shared bike trips by the time of day (Simmeringer Platz, Vienna)
Source: own illustration, 2020, based on Smart Data Wien, n.d.

The e-bike sharing system from *Sim Bike* offers only another e-bike station, located in the cemetery Zentralfriedhof, which is approximately 3.5 km from Simmeringer Platz. According to Einwöreger (2019), there is almost no integration between the two existing stations, as the distance between the stations is quite big. The distance between stations, as well as the number and the density of stations, are, according to Castro Fernández (2011, p. 50), some of the driving forces in bike sharing systems. As explained by Dechant (2020), when *Citybike Wien* was first implemented, in a period in which no similar system existed worldwide, it was assumed that 800 m was a reasonable distance between stations. More recently, however, cities like Paris, Lyon and Barcelona implemented bike sharing systems with a distance of only 300 m between stations. (Castro Fernández, 2011, p. 212-213)

Figure 42 presents an analysis of the final destination of the trips that started in Simmeringer Platz. It shows that the majority of trips (94%) ended at the origin, meaning the users returned to their starting point at the end of the journey. This indicates that the system is rarely being used for intermodality.

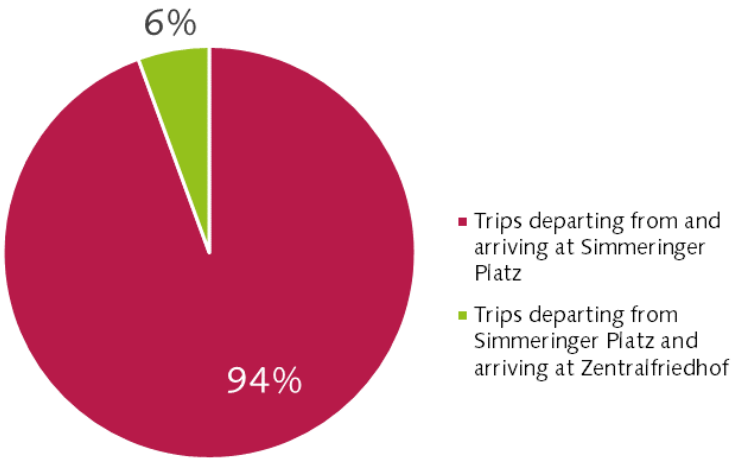

Figure 42. Integration between Simmeringer Platz and Zentralfriedhof, Vienna
Source: own illustration, 2020, based on Smart Data Wien, n.d.

5.3. Acceptance, perception, and awareness of the mobility stations

This chapter aims to provide an overview of residents' perceptions on the implementation of mobility stations within *Smarter Together*: whether they know they exist, have used them, like them, have criticism or suggestions. The results take into consideration the interviews with experts and, mainly, the answers obtained from the surveys. Only a small slice of reality is portrayed and, therefore, broad communication with the community is still needed to understand their perceptions, criticisms, and desires.

5.3.1. Munich

Filimon and Mandel (2020) affirmed that they have "the impression that the stations are very well received by the residents" and that "visitors are mostly positive towards the mobility stations and see it as a great opportunity for the district, even if some of them don't use it". There is an *MGS* office right in front of the mobility station Westkreuz and, in this context, they stated that no complaints were brought to their attention so far. Moreover, their visitors, mostly older than 50, are often interested in the mobility stations and ask questions about them.

> Sometimes we get the impression that the rental system seems to be too complicated for some of the older visitors. At the same time some of our 50+ visitors are considering to use it the mobility stations in the future. A few of them even downloaded the application already and have specific questions. (Filimon and Mandel, 2020)

Götz (2020) said that although there were some criticisms at the beginning of the project when the stations were implemented, the problems pointed out back then have now already been solved.

> Of course, there were critical voices at the beginning whether the project would be crowned with success. Some residents also complained about the brightness of the display on the stele. But all these problems were quickly resolved so that the project could start smoothly.
> (Götz, 2020)

In Munich, among the 28 people who responded to the online survey, 75% were aware of the mobility stations in Neuaubing-Westkreuz. Among the respondents who indicated they already knew about them, the majority said they got to know them while passing through them on the streets (52%). Respondents that affirmed that they heard about the mobility stations by word of mouth (24%) represented the same amount as those that got informed through the media (24%).

Only 52% of the respondents affirmed to have used at least one of the services offered at the mobility stations. Considering the respondents that have ever used the mobility stations, the most used services were: bike sharing (46%), digital information boards (27%), charging stations (13%), parcel lockers (7%) and cargo bike sharing (7%). None of the respondents affirmed to have used car sharing. Concerning the main purpose for using the services offered at the mobility stations, among the respondents that selected one out of the options given, work (25%) and leisure (25%) were the main answers obtained, followed by shopping (13%) and education (6%). However, 31% marked the purpose of their trips as "Other".

Unfortunately, respondents are not frequent users of the mobility stations, since 82% among those that have ever used it said they had done it only a few times or only once, while the remaining 14% said they had used the station only a few times a month. No respondents said they used it many times a week, or even once or twice a week.

Regarding the integration with public transport, 53% affirmed that they have used public transport before or after they used the services offered at the mobility stations.

Most of the respondents affirmed that there is no additional mobility offer that they would like to have at the mobility stations. However, the answers and clarifications from respondents who said that they would like to have an additional offer were translated into English by the author and are presented below. Although most did not understand the question (which aimed to know if users wanted to be offered with other types of services, such as e-scooters, free-floating car sharing, or bike racks), it still possible to identify some general complaints about the mobility stations through the comments.

> Wi-Fi network

> More charging stations with free parking

> The mobility station S4-Bahn Aubing should work reliably and preferably every 10 minutes!

Rental without app, real flat rate for residents of the district, bikes with the possibility to take children with you as well as bikes in different sizes (the existing ones are too big for many women)

Better signposting as part of the networking with other transport services, e.g. signs at S-Bahn stations

The respondents were also asked if they had any complaints about the mobility stations and if they had any suggestions on how they could be improved. Again, the answers were translated into English by the author and are presented below:

The e-trikes were out of order for a while

Wi-Fi network would be nice

Poor network reception made borrowing/returning difficult. I would like to have the possibility to borrow via a phone number (like DB Call a Bike) instead of via app.

Load wheels are not yet available everywhere

Completely unsuitable for families because no children can be taken along, unsuitable for older people because the lending is only possible via apps

Unfortunately, the mobility station on Ilse-Fehling-Straße was often not functional. I was able to rent a bike via app, but then I could not get away from the mobility station. I rented a bike there 3 times and 3 times it did not work. Since then I do not use the station any more.

Finally, respondents were asked to rate mobility stations on a scale of 1 to 5, with 1 being the best grade and 5 the worst grade[4]. The majority of respondents (44%) rated the mobility stations with a score of 2, meaning that they are quite satisfied with the infrastructure. The average score obtained by the mobility stations deployed in Neuaubing-Westkreuz considering all respondents was 3.5.

In Munich, considering that most respondents used the *SurveyMonkey* form, which did not include questions about the respondent's profile, it was considered best not to present this information. The responses collected by *Google Forms* represent a small portion of the total responses and would not represent the reality of the sample.

[4] In *SurveyMonkey* this rating was starred, with 1 star being the worst score and 5 stars being the best score. For analysis, SurveyMonkey's results have been inverted to make it possible to compare them with *Google Forms* results.

5.3.2. Vienna

In Vienna, among the 17 people who responded to the online survey, only 47% were aware of the mobility station in Simmeringer Platz. Among the respondents who indicated they already knew about it, the majority said they got to know about it while passing through it on the street (87,5%).

62,5% of the respondents affirmed to have used at least one of the services offered at the mobility station. Considering the respondents that have used the mobility station, the services most used services were: bike sharing (50%), car sharing (25%), digital information boards (12,5%), charging stations (12,5%), lockable bike boxes (12,5%) and cargo bike sharing (12,5%). Concerning the main purpose of using the services offered, leisure was pointed out as the main motivation to use the mobility station by most respondents (62,5%).

Unfortunately, respondents are not frequent users of the mobility station, since 75% among those that have ever used it said they had done it only a few times or only once, while the remaining 25% said they had used it only a few times a month. No respondents said they used it many times a week, or even once or twice a week.

Regarding the integration with public transport, 50% affirmed that they have used public transport before or after they used the services offered at the mobility station.

Most of the respondents affirmed that there is no additional mobility offer that they would like to have at the mobility stations (75%). However, the answers and clarifications from respondents who said that they would like to have an additional offer at the mobility station were translated into English by the author and are presented below.

Covered bicycle stand

Cargo bike (unfortunately no longer offered)

At this point it is important to clarify that the project indeed offered an electric cargo bike, operated by *Sycube*, however, repetitive attempts of theft and cases of vandalism, led to the need for continuous maintenance of the bicycle, making it unavailable for many months. According to Einwöreger (2020), the cargo bike is to be repositioned at a monitored location at Franz Haas Platz, which is located about 1 km from Simmeringer Platz. This issue will be discussed and presented in more detail in chapter 7.2.3 (Reliability).

The respondents were also asked if they had any complaints about the mobility station in Simmeringer Platz and suggestions on how they could be improved. Again, the answers were translated into English by the author and are presented below:

Get rid of it and make it a green area

Too few bikes, no further stations in the district, there is no network effect, too little

Awareness

Get rid of it and plant a tree

There were indeed two answers expressing a lot of dissatisfaction and suggesting similar actions (turning the area green and planting a tree). In this sense, it is important to clarify that possibly the answers came from the same person since the survey was anonymous and did not collect any data from the respondents. However, those answers were collected on different days, therefore there was not enough evidence to consider them as invalid.

Finally, respondents were asked to rate mobility stations on a scale of 1 to 5, with 1 being the best grade and 5 the worst grade. 50% of respondents rated the mobility stations with a score of 1, meaning that they are a lot satisfied with the infrastructure. However, two respondents (25%), which were the same that commented about "getting rid" of the station as presented above, rated with a score of 5. The average score obtained by the mobility station implemented in Simmeringer Platz considering all respondents was 2.25.

In Vienna, the profile of respondents was of adult or elderly people, with an age range between 21 and 70 years, with the majority of respondents (59%) aged 40 or older. Most respondents (65%) said they own an annual public transportation pass. Besides, most have access to a car (82%) and own a bicycle (94%). It is possible to say that the majority of respondents are familiar with shared mobility systems since 70% said they have already used *Citybike Wien*, while 60% and 50% said they have used *Drive Now* and *Car2go*[5] car sharing, respectively.

[5] It is important to clarify that currently *Car2go* and the former *DriveNow* integrate *ShareNow* as a single free-floating car sharing system.

6. OVERVIEW

To simplify the understanding of all aspects discussed above regarding the mobility stations and the shared mobility systems in Vienna and Munich, Table 1 presents an overview of the aspects previously presented.

Table 1. Overview of the mobility stations implemented in the scope of the *Smarter Together* in Vienna and Munich

	Munich	Vienna
General aspects at the city level		
Population	1,559,354	1,897,491
Urban density (people/hectare)	50	46
Number of mobility stations	15	3
Infrastructure at the mobility stations within the *Smarter Together*		
Number of mobility stations	8	1
Bike sharing	Yes, *MVG Rad*, *MVG eRad* and *MVG eTrike* – same operator as in the whole city	Yes, *Sycube* e-bike sharing – different operator than in other areas of the city
Station-based car sharing	Yes, *STATTAUTO*	Yes, *Stadtauto*
Free-floating car sharing	No	No
Charging stations	Yes, *SWM*	Yes, *Wien Energie*
Parcel lockers	Yes, *SWM +MVG*[6]	No
Lockable bicycle boxes	No	Yes, *Wiener Linien*
Public bicycle pump	Yes	Yes
Corporate-design	*Smarter Together* design	A specific design developed for the *Wien Mobil* project
Usage patterns		
Parcel lockers	Not as much used as planned	Not applicable
Bike sharing	Not as much used as the stations located in central areas	Underutilized, especially during winter; trips with long duration; peak day: Saturday; peak hour at 3 pm. Still, mentioned as the most used service on weekends.
Lockable bicycle boxes	Not applicable	Mentioned as the most used service on weekdays.
Acceptance, perception, and awareness		
Awareness of survey respondents	75%	45%
Evaluation by survey respondents (1 to 5, 1 being the best and 5 the worst)	3.5	2.25

Source: own table, 2020

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[6] Parcel lockers are available in two out of the eight stations.

7. DISCUSSION

This worked aims at sharing what can be learned from the experiences held in Munich and Vienna regarding the implementation of mobility stations in the scope of the *Smarter Together* project. In this chapter the many aspects previously presented will be discussed.

7.1. Location choices

As previously presented, the project areas defined by the *Smarter Together* both in Munich and in Vienna are on the outskirts of the municipalities. This demonstrates an intention to cover peripheral areas and to better distribute the supply of urban infrastructure in the municipalities. Furthermore, from the urban mobility perspective, the implementation of mobility stations in areas that do not offer as good public transport connections as the central areas is an outstanding initiative as an alternative for the first and last mile. However, despite the undeniable benefits associated with this good intention, the location choice imposed many challenges on the projects.

After analyzing the experiences held in both cities, it was possible to realize that, although they faced similar challenges concerning the locations, they have decided to approach them differently. While Munich integrated the project area to the existing mobility offers of the city, expanding the existing network, Vienna decided to implement a new bike sharing system in the project area. Both decisions were challenging and both would require a greater investment, either by expanding an existing network or by creating a new and dense network for the project area and its surroundings.

The issue that should be highlighted here is that when deciding to create a new system, Vienna should also have been concerned with strengthening it, giving the necessary conditions for it to grow and consolidate in the project area. On the contrary, only one mobility station was deployed, as well as only a second bike sharing station, 3.5 km away. Besides, considering that after one year two new mobility stations were implemented in the municipality, but in other neighborhoods and following a different logic (taking advantage of the existing infrastructure and mobility offers), it seems that the municipality gave up the initial idea and, in a way, abandoned Simmering and the *Smarter Together* project, at least from the mobility stations perspective.

According to interviews conducted in the scope of this thesis, although *Citybike Wien* is a consolidated bike sharing system in Vienna, with an increasing number of members and users, it could not be implemented at the mobility station at Simmeringer Platz because the existing network currently does not reach the area and creating more stations would be out of the scope of the project. (Neumayer, 2019) There are no plans and no budget at the moment for expanding the *Citybike Wien* system. (Dechant, 2020)

The fact that there is only one station in the project area and the only other station in the system is relatively distant are the main negative points of the mobility station in Vienna. There is no network and, therefore, the users have no real alternatives for first or last-mile transportation, which, after all, are the main objectives that one has in mind when

installing mobility stations in the periphery of the city. A single station, as the one being offered, provides no network and it results in a system used mostly for leisure and very specific purposes. Moreover, it does not make the system attractive as an intermodal mobility provider.

It is important to clarify and point out, however, that originally two mobility stations were planned for the project area in Vienna, one being the existing station at Simmeringer Platz and the other being a station at Hauffgasse. The sites were chosen considering the proximity to public transport, the public space available, and even the integration of shared mobility services. However, the Hauffgasse station was canceled at the beginning of 2017 due to technical factors, since a pipeline was identified at the site. At that time, the team even evaluated another location on the same street, but it was assessed that it would not offer adequate visibility, neither the proper connection with public transportation. (Smarter Together, 2019d, p. 13-16) It is indeed strange that in such a large project area, with active commercial areas and another subway station (Enkplatz), no other possible location could have been found for the deployment of at least one other mobility station. If the lack of suitable locations was the main reason for the decision to implement a single mobility station, it is essential to highlight the importance of a political will to allocate certain public spaces to serve the purpose of the mobility station.

In Munich, *MVG Rad* currently offers almost 300 bike sharing stations and the company is working on a concept to build more stations in the outskirts of the city, to enable a better transition between Munich and the surrounding cities, which are also provided with the service. (Götz, 2020) Although the project area did not offer any bike sharing station previous from the implementation of the project, the decision was to provide the neighborhood with a network of mobility stations, all offering bike sharing: a total of eight stations, four implemented in 2018, and other four in 2019.

> To expand the bike-sharing system to the project area Neuaubing-Westkreuz/ Freiham, bicycle stands and bikes which are compatible with the existing bike-sharing system have been commissioned and IT implementation processes have been carried out. (…) After all requirements were defined and described, a call for tender has been executed. The compatibility of e-bikes to the already existing bike-sharing system was one of the main requirements. (Smarter Together, 2019a, p. 13-14)

This was a completely different approach than in Vienna and much more inclusive. Although Götz (2020) mentioned the location in the peripheral area as one of the reasons for the lower utilization rate in comparison to Munich's central areas, it is still positive that the residents are now provided with the same system offered in the whole city. Moreover, the number and distribution of stations enable real intermodality and multimodality, as well as serves for first and last-mile transportation.

Furthermore, the project areas were not only challenging from the mobility services network perspective but also due to the estimated low demand and consequent lack of interest from possible operators, as can be seen, is this excerpt from the deliverable about the mobility stations Simmeringer Platz.

> (…) Wiener Linien from scratch would like to encourage partners to integrate into and participate at mobility points in future times. (…) This asset for partners also reflects

> the challenging location of this first mobility point in the specific, local socio-economic fabric of district Simmering. (Smarter Together, 2019d, p. 26)

In the case of Munich, the interview with Götz (2020) also demonstrated that the location of the mobility stations in peripherical neighborhoods is also a challenge for the operators there. However, in Munich, the companies operating almost all services in the mobility stations are owned by the municipality (which is the case for *MVG* and *SWM*), which directly affects decision making and facilitates the implementation and operation of projects despite low revenue forecasts.

Finally, another aspect to be addressed is the location on the micro-level. It concerns the decision on where to place the mobility stations within the neighborhoods, preferably surrounding public transport. According to Franz (2020), the most important aspects to be considered when planning mobility stations in the public space is to make them visible, reachable, and connected to public transport.

Indeed, the mobility station at Simmeringer Platz, in Vienna, is installed nearby a major public transport hub, however, the chosen location does not offer visibility and possibly many public transport users have not even noticed it. Einwöreger (2019), explained that there was a lot of discussion about the location of the station at Simmeringer Platz and that he believes that the current location is not the best and it would have been better if the mobility station had been placed in front of the subway station instead of on the side and across the street – where it currently is. It is also important to highlight that, as presented in chapter 3.2.2.4, *Wiener Linien* has developed a geoprocessing methodology to define the most suitable sites for the deployment of mobility stations. However, according to an interview with Neumayer (2020), this methodology was not used to define the location of any of the existing mobility stations. On the other hand, space availability was a decisive factor in the choice of deployment sites.

In Munich, five stations are located in the vicinity of mass public transport stations and three are close to residential areas. In a way, the distribution of the stations on the macro scale of the neighborhood is good, as it allows first and last-mile trips from the residence to the public transport system. However, when considering the micro-scale location and the visibility of the mobility stations, as in Vienna, in most cases the mobility stations are not directly in front of the main entrance of suburban railway stations. The mobility stations have been placed in somewhat hidden places, and there are no signs or information panels in the suburban railway stations that indicate the existence of them.

> Of central importance has been the accessibility and visibility of the mobility station. In this context, transport planning and safety had to be considered, as mobility stations are typically located on public property. The implementation of further framework conditions and regulations, such as fire protection, was essential. Besides, Mobility stations should use as few car parking spaces and green spaces as possible to avoid conflict of interest. (Smarter Together, 2019a, p. 9)

In Munich, according to the interview conducted with Braun (2020), the main criteria for defining the location of the mobility stations deployed in the project area were the location concerning the public transport network, the availability, and accessibility of space, the

visibility in public space, as well as specific criteria such as access to electricity and fire regulations.

The availability of space, therefore, seems to have been a factor of decisive importance in the cities, both in Vienna and Munich. Unfortunately, the stations are not located in the best location, but in the best place that could be found available. From a planning perspective, the methodologies adopted in both cities indeed considered the technical knowledge on the subject. However, decisions involving urban public space are complex and involve many issues and many conflicts of interest. In this context, the importance of the political will to deploy mobility stations in the most appropriate locations is emphasized here. Of course, when this is not possible, there is a need for indicative signage, as well as wide communication and dissemination regarding the infrastructure, which has not happened in either of the two cases evaluated in this work.

7.2. The role of the operators

The mobility station operators, as well as the operators of the mobility services offered, play an important role in the project. In addition to many responsibilities, operators are those who deal with daily problems while seeking to minimize damage. In the case of Munich and Vienna, the main operators are *MVG* and *Wiener Linien* respectively, both city-owned public transport operators. In the case of Munich, the services offered are mostly sub-operated by *MVG* itself or by *SWM*[7], the only exception being the *STATTAUTO* car sharing system. In the case of Vienna, the only sub operator owned by the city is *Wien Energie*, since *Stadtauto*, *Sim Bike,* and *Safety Dock* are private companies. This, therefore, is perhaps the main difference between the mobility stations in Munich and Vienna regarding operation. This chapter will discuss issues concerning the interoperability between the sub-operators, as well as the affordability of the services offered and the reliability of the operation.

7.2.1. Integration

Luginger (2016) analyzed different case studies of mobility stations and developed an evaluation method based on a classification scheme, considering what she named as tiers of integration. The author identified eight tiers of integration: physical, marketing, information, registration, trip planning, booking, access, and billing integration. Hereby those tiers of integration will also be considered as aspects to be assessed on the mobility stations implemented under the *Smarter Together* in Vienna and Munich. As the discussion of **physical integration** overlaps with the discussion on the location of stations presented previously (see subchapter 7.1), it will not be presented again. In order to fully understand the concept of all tiers of integration, see Luginger (2016, p. 51).

First of all, **marketing integration** relates to using a brand identity for the systems as well as an integrated marketing strategy (e.g. financial benefits to attract users). According to Luginger (2016, p. 97), “the development of an own branding and a

[7] MVG is a subsidiary of SWM.

corresponding corporate design play a key role for the implementation of multimodal mobility services". Indeed, the public mobility stations in Vienna have a branding, the *Wien Mobil*, and a unique design in red color, which is the same used by *Wiener Linien*. The mobility offers, on the other hand, are offered mostly with the provider's colors and branding. In Munich, on the other hand, although the mobility stations implemented in the project area are part of a bigger concept implemented in the whole city, under different names, it was decided to use the corporate design of *Smarter Together* in all mobility stations and mobility offers in the project area. In both cases, corporate design plays a big role in the awareness of the mobility stations, as most of the people got informed about the service while passing by the station, as shown in the results of the online survey, and considering experiences in other cities, obtained through literature review. The mobility stations implemented in the scope of the project are easily recognizable in the public space and this is achieved through good corporate design, as well as the big information digital boards installed in both cities.

As for financial benefits and discounts as an integrated marketing strategy, in both municipalities, a few discounts in shared mobility systems are offered to annual public transportation cardholders. In the case of Munich, discounts are offered to *MVG Rad* users and *STATTAUTO* users, whereas in Vienna there is a partnership with *Stadtauto* that gives some benefits for the use of car sharing. It should be noted that these benefits are offered for the shared mobility systems as a whole and have no direct relationship with the deployment of mobility stations. Furthermore, in Vienna, some benefits were granted to users in the testing phase of the systems, such as the free use of shared electric bicycles and lockable bike boxes. Certainly, all these strategies stimulate the use of shared mobility systems. However, they could still be better developed by both municipalities, by including all the other services offered at the mobility stations.

Secondly, offering all relevant information about the service in one single platform is essential and is referred to as **information integration**. Among the information that should be presented to users, there should be information on the mobility offers, pricing, customer benefits, registration, and instruction on how to use the offer. Both Munich and Vienna offer information digital boards with material about the services offered at the mobility stations, as well as about the municipal transport system, in general. In both cities, the digital boards have two sides: in one, a touchscreen interactive map is available, while in the other information on the mobility offers are presented, however not detailed. In Vienna, the board informs three steps to use the mobility stations and its services and the main step is to register directly with the partner. Moreover, it states that registration information can be found on the provider terminals or the *Wien Mobil* website. There are indeed providers terminals for the lockable bike boxes and the bike sharing system, however, no information regarding car sharing or the charging station can be found at the station. In Munich, the scenario is similar. The digital information board informs on how to register and on how to use the *MVG Rad* and *MVG eRad*, however, there is no information on prices and customer benefits. Information on the *eTrikes* and the parcel lockers can be found nearby those offers. As in Vienna, there is no information on car sharing and neither on charging stations. In both cities, there is also no website or virtual platform that provides all information about all providers, instead, there are platforms that redirect users to the websites of mobility providers.

Trip planning is also considered a tier of integration by Luginger (2016). It refers to offering one single platform that presents the location information of all services. Both in Munich and Vienna this is possible, through the platforms *MVG More* and *Wien Mobil*, respectively.

Other important aspects are **registration** and **booking**. According to Luginger (2016, p. 99), "the provision of an integrated registration process may reduce entry barriers for potential users". As previously explained, the public mobility stations in Vienna are operated by *Wiener Linien* and different sub-operators. To use a certain system, the user needs to register for each specific mobility offer. Franz (2020) sees the lack of interoperability as a negative aspect in the *Wien Mobil Station*. There is, however, the app *Wien Mobil*, which may provide such possibilities in the future. Nowadays it only offers a section from which it is possible to be redirected to the provider's website. In Munich, the scenario is similar. There is the app *MVG More*, which provides the possibility to reserve and book bikes. However, although car sharing stations are shown in the app, to register for the system or to book a car, the app redirects the user to the provider's app. E-charging stations are also shown, but to charge a vehicle or to order a charging card the users are redirected to the *SWM* website. Strangely and unfortunately, *eTrikes* are not yet integrated in the *MVG More* application, so there is no information about their availability or even redirections. In a way, the scenarios in both cities are quite similar for registration and booking, since redirecting is the main way to enable registration to take place in an integrated manner. Although this is still not perfect, "the provision of good redirections to the partner's applications is a cost-efficient alternative to direct integration of access into the smartphone application." (Luginger, 2016, p. 101)

Finally, **access** and **billing** are the other two tiers of integration considered by Luginger (2016). Access integration refers to the use of two or more modes of transport through the same card or smartphone application, while billing refers to giving the possibility that users receive a single bill charging for all services used during an intermodal trip. None of the systems evaluated in this study, neither in Vienna nor in Munich, already offer these possibilities to their users.

As shown in Table 2, the current scenario of the integration strategies in both cities is quite similar. In both cases, there is a need for further information integration so that potential users can easily access instructions and prices for all modes of transport on a single platform. This is probably the easiest issue to resolve in the short term and also the one that most affects system use since when information cannot be easily found and is not clear enough, potential users can give up using the system and continue using the modes of transport with which they are already accustomed. While important to promote integration between the systems offered, other issues such as registration, access, and billing are somewhat more complex to resolve.

Table 2. Overview of the integration strategy in Munich and Vienna

		Munich	Vienna
Mkt.	Brand identity	✓	✓
	Tariff offers	✓	✓
	Information	✗	✗
	Trip Planning	✓	✓
	Registration	Redirection to partner's website	Redirection to partner's website
	Booking		
	Access	✗	✗
	Billing	✗	✗

Source: own table, 2020.

7.2.2. Affordability

Services offered at the mobility stations should be affordable to everyone, enabling that all people have the opportunity to try different mobility possibilities. Considering that the concept of affordability is intrinsically related to the local reality, in this work, the affordability of the mobility services offered at the mobility stations in Vienna and Munich under the *Smarter Together* will be assessed through a comparison with other similar systems offered in the municipalities. This analysis, in addition to assessing affordability, ultimately indicates the attractiveness of the services offered.

Franz (2020) affirms that the main competitor for the shared mobility systems in Vienna is public transport because it is currently good and affordable enough that public transport users might see no reason to use other options. Although the analysis does not consider a comparison between cities, but rather a comparison between the systems offered in each city between themselves, it is important to clarify that the assessment made concerning public transport can be mainly relevant for Vienna, given that currently, public transport fares in Vienna are cheaper than in Munich. For example, in Munich, the unitary, daily, and annual passes are respectively 38%, 34%, and 43% percent more expensive than in Vienna. Although no direct relationship between the acceptance of shared mobility offers and the price of the public transport system is found in the literature, it was deemed important to mention it here as well, as this topic was pointed out in the interviews. Moreover, it is certain that, by having different mobility alternatives, users tend to choose the one that is most convenient for them, and the financial aspect is certainly a topic that is taken into consideration by some. Of course, the affordability of the public transport system in Vienna, as well as the good infrastructure, are positive aspects of the urban mobility in the city, which must be acknowledged. One of the concrete targets of the Urban Mobility Plan Vienna is to keep public transport as the backbone of the city. In this context, the shared mobility alternatives and the mobility stations are possibilities to improve the way people currently use public transport, complementing it and discouraging users from switching from public transport to private cars in the future. While this is an important and necessary strategy, it is challenging and its results are often not immediately visible.

Concerning the bike sharing systems in Vienna, it is first of all important to note that *Citybike Wien* is a conventional bike sharing system while *Sim Bike* offers electric shared

bikes, which would justify charging higher rates. However, from the user's perspective, it would be worth further researching whether they actually would be willing to pay a higher fee for this service. Franz (2020) said there was no real need for electric bicycles in the city, given the short distances between public transportation stations. On the other hand, he said that the deployment of electric bicycles in cities is a trend nowadays. This demonstrates the influence and global impact of certain policies, which often may not reflect local demands. In any case, another factor that makes it hard to compare *Citybike Wien* with *Sim Bike* is that the number of stations in each system and the consequent possibility of intermodality offered by each is incomparable. While Citybike Wien has more than 200 stations, Sim Bike has only 2. Finally, when specifically dealing with the issue of affordability, although offering greater possibilities to its users, *Citybike Wien* today charges a one-time registration fee of only 1 euro, while Sim Bike charges a fee of 10 euro. Certainly, this can limit users who wish to use the system for the first time and who are not yet sure whether they wish to become frequent users. Besides, *City Bike Wien* is free during the first hour of travel, while Sim Bike charges a fee of 2 euros every hour. (Citybike Wien, n.d., Sim Bike[8]) Given all this, and knowing that the comparison cannot be made in a simplistic way considering only the amounts charged, one can see that, in general, it is possible to say that the Sim Bike system is not as attractive from a financial point of view as the *Citybike Wien* system, which can be one of the factors that justify the difference in demand between the systems, as pointed out in chapter 5.2.2.

As for car sharing in Vienna, the comparison between the systems operated by *Stadtauto* and *ShareNow* is also made with caveats, considering that they are systems with distinct services, as one is a station-based system while the other is a free-floating system. Therefore, they are systems used in different ways, with different usage profiles. In any case, the price analysis of the systems did not reveal any significant discrepancy between them. Both charge a registration fee and charge similar prices per minute. *Stadtauto* also has an advantage over the competitor, which is the partnership made with *Wiener Linien*, which offers a two-month free trial for holders of annual public transportation cards, including 2 hours of travel free of charge and offering lower rates for other trips. Franz (2020) explained that *Stadtauto* was selected to operate in the mobility stations because it already had a contract with the City of Vienna, a decision made when this was the only company accepting a short-term contract (3 years).

According to Braun (2020), the services offered at the mobility stations in Munich are attractive. She compares the prices between bike sharing and e-scooters and affirms that bike sharing is much cheaper.

In Munich, the *MVG Rad* system is the main bike sharing system available in the city. When comparing its affordability with the other systems available in the city, it must also be taken into account that the system is hybrid and is available on a massive scale in the territory of the municipality, especially in central areas. However, it is a cheaper system than *Call a Bike*, when the price per minute is considered. The daily rate, however, is 33% lower in the *Call a Bike* system. Daily rent is not used on typical days by frequent users, though.

[8] Prices charged for the use of the *Sim Bike* system were collected at the mobility station Simmeringer Platz during on-site visits in 2020.

As for the *STATTAUTO* car sharing system offered in Munich's mobility stations, the final price of the service to users is higher than the prices charged by *ShareNow* in the city. The main reasons are the registration fee and the monthly fee, which are not charged by *ShareNow*. However, as stated above, these are different systems and are mostly used for different purposes. Also, for frequent users, the registration fee and monthly fee are not as significant in the long run.

Finally, the services offered at the mobility stations in both Vienna and Munich are charged at prices similar to those on the market, the only exception being the *Sim Bike* bike sharing system. In this case, it is important to emphasize that the *Citybike Wien* has been operating with municipal subsidies for more than 15 years and, therefore, it is understandable that there are so many differences between the systems. Considering that both operators, *Gewista* and *Sycube*, are partners of the city, it is essential to future think about ways to make the systems complementary with, somehow, standardized tariffs.

It should also be noted that the analysis presented here regarding affordability was quite superficial and did not take into account the operating costs and the subsidies of the systems, neither the financial conditions of the potential users and their budget for mobility purposes.

7.2.3. Reliability

The issue of reliability is presented here, as lack of reliability was observed in some of the services offered, both in Munich and in Vienna. In the case of Vienna, the main mobility service that had its reliability questioned were the bike sharing system and electric cargo bike. In Munich, the *eTrikes* electric cargo bikes also raised a question about reliability. Not offering the bicycles regularly makes the system not reliable. Someone wanting to use the systems daily to go to work or school would never choose to use them, as the bikes might not be available when they most need it.

The bike sharing system at Simmeringer Platz, in Vienna, has dealt with several cases of vandalism, resulting in the need of maintenance and bicycle repair, which resulted in the scenario in which there was only one bike available at the station during the whole month of January 2020, instead of the original six. Previously, the cargo bike was stolen and it took the operator company *Sycube* a few months to replace it. Vandalism occurs frequently, almost every week. One of the reasons might be that the e-bikes attract criminals for its components, such as board computers and batteries. It was not possible to identify the criminals as they have damaged or stolen the bikes without registering in the system and no video surveillance is allowed on the streets of Vienna. Most probably is that vandalism occurs during the night, as the station is quite bright, open, and visible during the day. (Einwöreger, 2019) When the cargo bike was finally replaced, someone tried to steal it again. For this reason, in 2020, the cargo bike was removed from the mobility station and will be relocated to a better-monitored place. This new location is Franz Haas Platz, approximately 1 km away from Simmeringer Platz. (Einwöreger, 2020) Although this situation reflects external factors such as vandalism and lack of video surveillance in the area, it calls into question the reliability of the system. The systems were continuously improved to prevent theft and vandalism of bicycles, but nevertheless,

the situations persisted. The solution of changing the location of the station mitigates the problem but does not solve it, as it generates other issues such as the absence of physical integration between the shared mobility services, which is one of the main objectives to be achieved when deploying a mobility station. Moreover, the fact that the system has only six shared electric bicycles and only one cargo bike corroborates this problem. In an ideal scenario, there would be a larger number of bicycles so that they could be replaced during maintenance periods, not affecting the users of the system. An important observation is that, indeed, more e-bikes were planned at the beginning of the project, but the negotiation involving different authorities has made it hard to implement them:

> The selection and scope of services available represent a compromise of hard negotiations with several already mentioned partner authorities. Availability of space, concessions towards new mobility services (…) and matters of architecture and urban design limited original plans of scope of services at the mobility point. Higher numbers of E-Bikes and bicycle storage boxes were pursued in the beginning of the project. (Smarter Together, 2019d, p. 26)

As for Munich, there is also a relatively small fleet of *MVG Rad* electric bicycles and *eTrike* electric cargo bicycles, as noted during the field observation and pointed out by Götz (2020). The bicycles are quickly rented during summer, and, therefore, many times no available bicycles are found.

In both cases, the issue of reliability could be resolved by increasing the fleet, both to meet demand and to ensure that bicycles can be replaced during maintenance periods. In the case of Vienna, in addition to the increase in the fleet, it would be important to think of ways to improve surveillance in the area, avoiding vandalism.

7.3. The role of the *Smarter Together*

The *Smarter Together* is an EU innovation project which presents itself as a smart city project that considers people's needs and combines top-down and bottom-up approaches. It seems to be a project that, aware of the existing criticisms in the literature about the application of ICT in the urban environment, aims at approaching the smart city concept in a human-centered way and therefore focuses on the challenges of co-creation and co-designing.

> The SMARTER TOGETHER participation strategy is fundamentally anchored in the inclusive project vision of SMARTER TOGETHER focusing the citizen’s perspective and partnership of stakeholders. (Smarter Together, 2019f, p. 51)

The co-creation pursued by the *Smarter Together* concerns both the community, through a long-term collaboration, and stakeholders, who should be reliable and involved partners in all stages of the project. Besides, the project is presented as an initiative to foster dialogue between different cities in Europe, aiming at the exchange of experiences and collaborative learning about innovative and sustainable urban solutions. The project has involved the local population through community engagement actions and documented all this experience, fostering other cities with lessons learned in this field. Besides, several methodologies were developed for stakeholder dialogue and the replication of tested

solutions. The objective of the project is to generate and share knowledge about the methods, solutions, and processes tested in its scope. In this context, it is noted that it was a successful project and has much to contribute to the study of more sustainable and innovative infrastructures.

As a project developed from an EU innovation fund, *Smarter Together* fulfills its role by creating financial incentives for new investments in the next generation of technologies needed for low-carbon transition, boosting growth and competitiveness, and supporting innovative low-carbon technologies.

Nevertheless, the aims of the project seem to lack one important aspect: providing improvements in the districts selected. This is not an issue presented in the reports, on the website, nor in the interviews conducted with the experts. The selected districts seem to be mere urban labs, i.e., places to test and think about innovations. The project itself is not concerned about the outcomes and the legacy to be left in the neighborhoods in which the infrastructures were tested. In this sense, it is therefore up to the municipalities benefiting from the funding to concern themselves with such issues and to ensure that this legacy is not left aside after 2020. Certainly, one issue that *Smarter Together* raises is that EU innovation funds could, in addition to fostering the development of low-carbon technologies, carry out long-term monitoring of investments made and play a greater role in changing social and behavioral aspects.

7.4. Smart cities as agents of inequality

Usually, as shown by the literature review, smart city projects are implemented in urban areas already gentrified, intensifying this issue, and benefiting only a portion of the population, usually the one with more financial resources. The fact that the *Smarter Together* project has selected only peripheral neighborhoods demonstrates the interest in having a more inclusive project, which does not aim to favor the central areas, as is usually the case. Despite the good intention, it was possible to perceive, through the analyses presented here, that there were difficulties in finding operators interested in providing services in the areas, which are not considered attractive from the market point of view. As some mobility offers are operated by private partners, there is a tendency for corporate-oriented strategies to be followed, making the interests of users and the city no longer the priority of projects, and making the municipality dependent on certain infrastructures only offered by such private partners.

Moreover, as mentioned in chapter 2.1, Basis (2017) was concerned about the segregation promoted by the adoption of technology and the concept of smart cities. In this sense, it is notable that the e-bike sharing station implemented in Simmering (*Sim Bike*), in Vienna, partially promoted this scenario, as people living in the neighborhood are provided with an infrastructure that is exclusively located there and in the cemetery, not giving them the possibility to integrate with the existing system (*Citybike Wien*) and, therefore, emphasizing and reinforcing the neighborhood segregation. In this sense, it would be important to expand the *Sim Bike* system and integrate it in some way with the *Citybike Wien*, associating the image of both as the systems that integrate the public bike sharing service of the City of Vienna. This could be done through a partnership between

the operators, which would include integrated advertising campaigns, single registration, single billing system, similar rates, among others.

Given this scenario, what is apparent is that, in general, the project sought to provide peripheral areas with innovative infrastructure, but ended up finding several challenges. The project involved the local population through various community engagement actions, which is positive. Besides, the project reports recorded efforts to implement the systems with a wider range of mobility offerings, larger fleets, and more mobility stations. However, the efforts made with technical knowledge were not sufficient given the challenge imposed by the location choice, in peripheral neighborhoods, which goes against the interests of the market.

Nevertheless, it is essential to clarify that the low demand makes it hard to implement certain transport offers without subsidies, and in this sense, it is understood that it would have been interesting, to have previously evaluated the profile of the neighborhoods and the real needs of their residents. The results presented here show that not only the selected neighborhoods did not have the most appropriate characteristics, but also that mobility stations were not among the main local demands.

Furthermore, the simple implementation of mobility stations is unable to transform cities and neighborhoods into smart. Several authors have criticized the concept of smart mobility because it is often seen just as propaganda. The main beneficiaries of the mobility stations set up in the districts Simmering, in Vienna, and Neuaubing-Westkreuz, in Munich, are not the residents, but the city, due to the advertising around the buzzword smart city (as well as smart mobility and MaaS), which is certainly a trend worldwide.

The analyses carried out on the scope of this work do not allow us to state whether or not mobility stations have intensified inequalities in the municipalities where they have been implemented. It is certain, however, that it was a project that brought some opportunities to the neighborhoods. In the long term, the mobility stations set up under *Smarter Together* may have positive impacts on the neighborhoods and the municipalities. To this end, the improvement of infrastructure must be included in public policies, expanding the network, and providing conditions for mobility stations to solidify and integrate with the mobility infrastructure as a whole. The stations deployed within the scope of *Smarter Together* should therefore not be treated merely as a pilot project to be replicated in other areas of the city, but rather as the beginning of a long-term project aimed at benefiting the neighborhoods Simmering, in Vienna, and Neuaubing-Westkreuz, in Munich.

7.5. Sustainable urban mobility as a future goal

Considering *Smarter Together* as a project that aims to reduce CO2 emissions by providing infrastructure that promotes sustainable mobility, the implementation of mobility stations are indeed important initiatives that should be continued. Public mobility stations have the potential to encourage intermodality and multimodality and, for this reason, it is outstanding the initiative to deploy these stations in a context where a lower share of the automobile in the modal split is sought. The fact that the public mobility stations are not being used as much as planned should, in no way, be understood as a failure of the system, but rather as an opportunity to promote improvements.

Often, the demand for active mobility infrastructures, such as bike paths and shared bicycles, only arises as the infrastructure is provided. Since these are modal choices that still require paradigm shifts and changes in travel behavior, it is essential to encourage them by providing the necessary infrastructure to make people feel safe and comfortable to start the change process. In this sense, in the case of the mobility stations deployed in Simmering and Neuaubing-Westkreuz, although nowadays the demand for the mobility offers is quite low given what it could potentially be, it is still valid that the infrastructure has been provided, as a way to stimulate changes in travel behavior, which may only be seen in the future.

As for shared cars, because they are relatively recent mobility services that have emerged worldwide only since the late 2000s, their use is not yet part of the daily lives of most of the population. Actions to popularize the use of shared cars and to make more people reconsider car ownership as a consumption pattern is essential and a positive aspect to highlight in the mobility stations implemented under *Smarter Together*.

Moreover, the parcel lockers, which are located in two mobility stations in Munich, are an excellent way of improving urban logistics, in a scenario in which e-commerce is increasingly expanding. While reducing the number of delivery vehicles in the neighborhoods and lowering the delivery costs for companies, the parcel lockers also offer comfort and convenience to their users.

Considering that *Smarter Together* aimed to test innovative and sustainable solutions, as well as to develop methods and processes that could be transferable to all cities, it is considered that despite the numerous challenges faced and problems identified, the project contributes enormously to the study of sustainable mobility solutions, bringing lessons learned to cities in Europe and around the world regarding the deployment of mobility stations.

8. LESSONS LEARNED

Some lessons learned, as well as recommendations for policymakers and operators when planning future mobility stations, are presented below based on the experiences of deploying mobility stations in Munich and Vienna, which are the main case studies assessed in the scope of this master thesis.

1. **Understand the needs of potential users:** The mobility station projects implemented in the districts Simmering and Neuaubing-Westkreuz had broad social participation, through the realization of several community engagement events. However, citizens were involved in stages in which much of the project had already been decided. In this sense, it is important to involve potential users from the beginning of the project, trying to understand their real needs, so that attractive solutions can be proposed, aiming at better use of the project resources.

2. **Involve all stakeholders from the beginning**: Likewise, stakeholders should be involved in the project as early as possible. It is clear that in many cases the definition of stakeholders takes time, as it is the result of calls, bids, and tenders. However, especially when stakeholders are municipal bodies that will participate in some stage of the project, they should be involved as early as possible, to enable them to be truly engaged in the actions to be developed and to ensure a greater possibility of gaining political strength to implement the project, minimizing the possibility of conflicts of interest, which are common in the urban space dispute.

3. **Take into account the existing systems in the city:** The experiences evaluated demonstrated quite different approaches to deal with the issue of deploying mobility stations in areas previously lacking infrastructure. Although both municipalities were facing a very similar scenario, each decided to act differently. Of course, there were justifications for such decisions, such as that the existing system did not cover the region where the mobility station was installed, requiring the deployment of many other stations to operate. In any case, it is undeniable that the decision to implement a new system represents a greater challenge since it requires a high investment in advertising, as well as in a network of stations.

4. **Create dense networks of stations:** Another distinction between the projects is that, while Munich has deployed eight mobility stations in the project area, Vienna has opted for only one. Considering that the main objective of the mobility stations is to allow intermodality and multimodality, it is essential to provide the project area with a dense network of stations.

5. **Consider visibility and accessibility when planning:** Although in both case studies there was a concern to deploy mobility stations surrounding public transport stations, it was observed that both in Munich and Vienna, despite some effort, no appropriate visibility and accessibility is offered at the mobility stations, which are often located in areas somewhat hidden from the main entrances to metro or suburban rail stations. It is understood that the dispute for urban space is

a reality and it is not always possible to negotiate with stakeholders for the infrastructure to be implemented in the places identified as most suitable from a technical point of view. However, some mitigating measures can be adopted, such as indicative signs in public transport stations.

6. **Provide reliable, affordable, and interesting services:** The services offered at the mobility stations need to be available when users want to use them, they need to offer competitive prices in comparison to the other transport alternatives in the city, and they need to be comfortable and safe. Electric and sustainable mobility is still a new and unknown topic for many people, and therefore reliability, affordability, and attractiveness are the characteristics that will indeed motivate people to change the way they currently move around the city. To promote paradigm shifts it is necessary to offer not only good but the best possible services.

7. **Disseminate the services of mobility stations and promote awareness:** Finally, among the lessons learned is that both projects demonstrated that most people first learned about mobility stations when passing by them while walking on the streets. This result reflects two main things: the first is positive and demonstrates that the corporate design of the stations and the information panels are appealing and visible, the second, on the other hand, is that there were not many advertising campaigns to disseminate the services offered at the mobility stations. In this sense, the importance of continuously promoting the mobility stations and their services is stressed, ensuring that a greater number of people can be informed about the new mobility possibilities. Besides, the projects also demonstrated that, since this is a complex issue and still unknown to a large portion of the population, educational actions are needed to encourage and assist people to use the services.

9. CONCLUSIONS

Smarter Together is a project with a cutting-edge scope and it contributed greatly to research and innovation, by creating living laboratories to experiment with the application of technology in the urban environment. The mobility stations in Vienna and Munich offer an innovative infrastructure and serve the purpose of the project, contributing to research on the field, as their implementation has been thoroughly documented through the many deliverables developed under the scope of the project. The analysis of the project allows many lessons to be learned, bringing many insights for the deployment of other mobility stations in the future, whether in follower cities or any other city in Europe or worldwide.

However, from the perspective of the mobility stations assessment, many caveats were made, indicating that although the project relied on a skilled technical team that was already aware of the numerous challenges (location, station network, integration, publicity, community engagement), many issues remained unresolved, resulting in systems that are not as popular and not as used as they could be. This is particularly true for Vienna, where it was possible to diagnose the underutilization of the system by evaluating the data from the bike sharing system, by observation on-site, and by interviews with experts. In the case of Munich, underutilization was not so evident, but the challenges faced are, however, quite similar.

The main differences identified between the systems implemented in the scope of *Smarter Together* in the cities evaluated in this study are mainly 1) Vienna's decision to implement a new bike sharing system in the project area while Munich chose to understand the network of the existing and already consolidated system in the city, and 2) the limitation imposed by the project in Vienna by the implementation of a single mobility station in the study area, while in Munich a larger investment was made in the system, with a total of eight mobility stations being implemented in the study area.

It is important to note that Munich has already been gaining experience and making partnerships for the deployment of mobility stations since 2014 when the Münchner Freiheit mobility station was deployed. Vienna, on the other hand, had its first public mobility station implemented with incentives from the *Smarter Together* project in 2018. It is therefore understandable that the city still has a long way to go, either through a better understanding of the citizens' needs or by building a strong network of partners.

Another issue raised during this work concerns the fact that the added benefits to the districts where the infrastructure was tested were not among the priorities of the *Smarter Together* project. It raised some questions about what would be the main beneficiaries of the project, as well as its main objectives, which often seemed to be related to the diffusion of buzzwords such as smart cities, sustainable cities, eco-cities, low carbon cities, and so on. The *Smarter Together* project confirmed what the literature on the subject states: that for quality systems to be offered, many other relevant factors must accompany the decision to deploy ICT systems in urban spaces, which are rather human-centered. The project has shown, however, that it is not easy to put technical and academic

knowledge into practice and that often conflicts of interest and political will are the main determinants in the success of a project.

Concerning the limitations of this work, there are many, among which some should be highlighted: 1) Researching in Munich was more limited than in Vienna, as it was not possible to interview many experts, and, moreover, the e-mail interviews did not give much opportunity for spontaneous answers on topics such as challenges and underutilization; 2) it was not possible to obtain data about the systems in Munich as they were considered confidential, therefore it is infeasible to make statements about the utilization rates of systems implemented in the study area; 3) although the online survey obtained a favorable number of responses, still it corresponds to an insufficient sample to draw the opinion of the residents of the neighborhood, moreover, a face-to-face survey would allow a better approach and greater possibility of acquiring additional information, perhaps not perceived by the author; 4) it was not possible to conduct interviews with representatives of car sharing operators in both Vienna and Munich, and no data on the system was collected, which resulted in a overlooked assessment; 5) the methods used to trace the affordability of the systems is subjective and does not consider neither the operating costs and subsidies of the systems, nor the costs of living and purchasing power in the cities and districts analyzed; 6) urban density and land use are aspects that directly influence the success of a mobility station system like the ones assessed in this work, however such urban aspects were not analyzed in depth; 7) it is also possible that the urban design of the mobility stations influences the use of the systems and the way the population perceives the stations, however, this was not deeply addressed. Moreover, it is important to emphasize that this work addressed exclusively the theme of mobility stations and did not evaluate the other actions implemented in the scope of *Smarter Together.*

For future research on the topic of the mobility stations implemented in the studied cities, it is recommended to further investigate the relationship between urban density and utilization rates, as well as the influence of urban design on the perception and acceptance or users and potential users. Besides, the parcel lockers deployed as multifunctional neighborhood sharing boxes are indeed innovative. Therefore, a specific study on their use would be appropriate to expand the literature on the subject, which is still incipient.

So, finally, what lessons can be learned from the experiences held in the scope of the *Smarter Together* in Vienna and Munich? Many lessons were shared throughout this work, but the main lesson is that investment in research and innovation is important, however, to promote changes in travel behaviors, paradigm shifts, and social changes, careful attention should be paid to the potential users and their needs (and, more than that, it is important to truly commit with the issues they point out). Moreover, no change can be made without the political will to face possible conflicts of interest that will arise in these processes. Finally, the *Smarter Together* has proved to be an excellent project for its purpose, but it leaves many issues under the responsibility of the municipalities. The main one will be to deal with the project legacy, by improving the systems and investing in the districts where it was implemented. Therefore, future actions will determine whether this was indeed a good project, or just a project full of good intentions and a disappointing outcome. There is still time to learn from mistakes and act to solve problems and promote improvements.

REFERENCES

Abdoullaev, A. (2011). Smart World: A Development Model for Intelligent Cities. 11th IEEE International Conference on Computer and Information Technology (CIT-2011) and 11th IEEE International Conference on Scalable Computing and Communications (ScalCom-2011).

Ahrens, G. (2015). Sonderauswertung zum Forschungsprojekt "Mobilität in Städten – SrV 2013" - Städtevergleich. Technische Universität Dresden, Verkehrs- und Infrastrukturplanung, Dresden.

Alarcos, Á. (2017). Evaluation of the Mobility Station in Domagkpark. Development and Test of a Methodology for the Impact and Process Evaluation of Sustainable Mobility Measures in the Framework of the ECCENTRIC Project. Master Thesis, Technische Universität München, Munich.

Albino, V., Berardi, U., & Dangelico, R.M. (2015). Smart Cities: Definitions, Dimensions, Performance, and Initiatives, Journal of Urban Technology, 22:1, 3-21.

Apex Insight (2019). Global Parcel Shops and Locker Networks: Market Insight Report Retrieved on July 13, 2020, from https://apex-insight.com/product/global-parcel-shops-and-locker-networks-market-insight-report/

Austrian Institute of Technology (2016). Smarter Together: Endauswertung der Kernbefragung, Wien | Simmering. AIT, Vienna.

Bassi, A. (2017). Looking at Smart Cities with an Historical Perspective.

Bauchinger, L., Reichenberger, A., Oedl-Wieser, T., & Dax, T. (2020) Multimodale Verkehrslösungen als Chance für nachhaltige städtisch-ländliche Beziehungen.

Benevolo, C., Dameri, R. P., & D'Auria, B. (2016). Smart Mobility in Smart City: Action Taxonomy, ICT Intensity and Public Benefits, Springer International Publishing Switzerland 2016, T. Torre et al. (eds.), Empowering Organizations, Lecture Notes in Information, Systems and Organization 11.

Braun, K. (2020, Jun 2). Interview per e-mail.

Breitfuss, A. (2019, Nov 28). Personal interview.

British Standards Institution (2014). PAS180, Smart Cities: Vocabulary, BSI Standards Publication.

Browne, M., Allen, J., & Leonardi, J. (2011). Evaluating the use of an urban consolidation centre and electric vehicles in central London. International Association of Traffic and Safety Sciences Research. 35. 1-6.

Bundesministerium für Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie. (2016). Österreich unterwegs 2013/2014. Ergebnisbericht zur österreichweiten Mobilitätserhebung „Österreich unterwegs 2013/2014“. BMVIT - Bundesministerium für Verkehr, Innovation und Technologie, Vienna.

Castro Fernández, A. (2011). The contribution of bike-sharing to sustainable mobility in Europe. Doctoral Thesis, Technische Universität Wien.

City2Share (n.d.). City2Share: sozial. urban. mobil. Model Quarters for Sustainable Urban Electromobility in Munich & Hamburg. Retrieved on July 19, 2020 from http://www.city2share.de/

Citybike Wien (n.d.). Citybike Wien. Retrieved February 20, 2020, from https://www.citybikewien.at/en/

Cohen, A., & Shaheen, S. (2016). Planning for shared mobility. 2016. 1-106.

Crainic, T. G. (2008). City Logistics. In INFORMS TutORials in Operations Research. Published online: 14 Oct 2014; 181-212.

Dechant, H.E. (2020, Jan 10). Personal interview.

Deutsch, Y., & Golany, B. (2018). A parcel locker network as a solution to the logistics last mile problem, International Journal of Production Research, 56:1-2, 251-261.

Efthymiou, D., Antoniou, C., Waddell, P. (2013). Factors affecting the adoption of vehicle sharing systems by young drivers. Transp. Policy 29, 64–73.

Einwögerer, T. (2019, Dec 27). Personal interview.

Einwögerer, T. (2020, May 27). E-mail.

European Environmental Agency. (2016). Towards clean and smart mobility. EEA Signals 2016, Copenhagen.

European Platform on Mobility Management. (2008). TEMS - The EPOMM Modal Split Tool: München. Retrieved on July 15, 2020 from http://www.epomm.eu/tems/result_city.phtml?city=309&map=1

Fabián, P., & Krištofová, L. (2015). Transport Research and Innovation in The EU Horizon 2020 Programme.

Filimon, M.; & Mandel, F. (2020, Jun 10). Interview per e-mail.

Franz, G. (2020, Jan 23). Personal interview.

Fulton, L., Mason, J., & Meroux, D. (2017). Three Revolutions in Urban Transportation. Institute for Transportation and Development Policy, Davis, CA, 2017.

Giuffrida, M., Mangiaracina, R., Perego, A., & Tumino, A. (2016). Home delivery vs parcel lockers: an economic and environmental assessment.

Götz, J. (2020, Jun 29). Interview per e-mail.

Harrison, K. (2017). Who Is the Assumed User in the Smart City?.

Heller, E. (2016). Evaluation of Mobility Stations in Offenburg. Assessment of perception and acceptance of an integrated multimodal mobility service and potential changes in mobility behavior. Master Thesis, Technische Universität München, Munich, Germany.

Hofer, C. (2020, Jan 14). Personal interview.

Interreg North-West Europe. (n.d.) eHUBS - Smart Shared Green Mobility Hubs. Retrieved on July 19, 2020, from https://www.nweurope.eu/projects/project-search/ehubs-smart-shared-green-mobility-hubs/

Jong, W. M., Joss, S., Schraven, D., Zhan, C., & Weijnen, M. (2015). Sustainable–Smart–Resilient–Low Carbon–Eco–Knowledge Cities; Making sense of a multitude of concepts promoting sustainable urbanization. Journal of Cleaner Production. 109. 25-38.

Kirchberger, C. (2020, Jan 27). Personal interview.

Landeshauptstadt München (2019). EU-Project Smarter Together Munich: Documentation of Activities and Achievements. Department of Labor and Economic Development, Munich.

Laporte, G. & Meunier, F. & Calvo, R. (2015). Shared mobility systems.

Luginger, L. (2016). Success Factors of Integrated Multimodal Mobility Services. M.Sc. Environmental Engineering Master´s Thesis. Technische Universität München, Munich.

Magistrat der Stadt Wien (2015). STEP2025, Thematic Concept: Urban Mobility Plan Vienna. Vienna City Administration, Municipal Department 18, Urban Development and Planning, Vienna.

Magistrat der Stadt Wien (2019a). Vienna in Figures 2019. Stadt Wien Wirtschaft, Arbeit und Statistik, Vienna.

Magistrat der Stadt Wien (2019b). Simmering: Smart Urban Renewal, Implementation Report of Smarter Together Vienna 2016 — 2019. Stadterneuerung und Prüfstelle für Wohnhäuser, Vienna.

Magistrat der Stadt Wien (n.d.). Smart City Wien: Start of Initiative. Retrieved February 20, 2020, from https://smartcity.wien.gv.at/site/en/the-initiative/start-of-initiative/

Meijkamp, R. (1998). Changing consumer behaviour through eco-efficient services: an empirical study of car sharing in the Netherlands. Bus. Strat. Env., 7: 234-244.

Mendes, C., Farías, I.; & Varga, H. (2019). Zur Ko-Gestaltung "smarter Lösungen", Munich Center for Technology in Society. Retrieved on July 20, 2020 from https://mediatum.ub.tum.de/node?id=1520952

Midgley, P. (2011): Bicycle-Sharing Schemes: Enhancing sustainable Mobility in Urban Areas, New York: United Nations, Department of Economic and Social Affairs, Commission on Sustainable Development, Background Paper No. 8.

Miramontes, M. (2018): Assessment of mobility stations. Success factors and contributions to sustainable urban mobility. Munich, Germany.

Morganti, E., Seidel, S., Blanquart, C., Dablanc, L., & Lenz, B. (2014). The Impact of E-commerce on Final Deliveries: Alternative Parcel Delivery Services in France and Germany. Transportation Research Procedia.

München Stadtportal (2020). München in Zahlen - Interessante Fakten über die Stadt. Retrieved on July 13, 2020 from https://www.muenchen.de/sehenswuerdigkeiten/muenchen-in-zahlen.html

Murgante, B., & Borruso, G. (2015). Smart Cities in a smart World. In S. T. Rassia and P. M. Pardalos, eds. Future City Architecture for Optimal Living. Springer Optimization and Its Applications. Cham: Springer International Publishing.

MVG. (s.d.) MVG Rad. Retrieved on July 30, 2020, from https://www.mvg.de/services/mobile-services/mvg-rad.html

Neumann, H. M., Gaiddon, B., Girardi-Hoog, J., Thielen, K., Wendt, W., & Vignali, E. (2016). Three cities - Lyon, Munich, Vienna - will be SMARTER TOGETHER.

Neumayer, V. (2019, Nov 8). Personal interview.

Novikova, O. (2017) The Sharing Economy and the Future of Personal Mobility: New Models Based on Car Sharing. Technology Innovation Management Review, 7(8): 27–31.

Okuda, T., Hirasawa, S., Matsukuma, N., Fukumoto, T., & Shimura, A. (2012) Smart Mobility for Smart Cities, Hitachi Review Vol. 61, No. 3

Open Data Österreich (2019). Retrieved on June 6, 2019, from https://www.data.gv.at/

OpenStreetMap (2020). Retrieved on January 10, 2019, and July 19, 2020, from https://www.openstreetmap.org/

Papa, E., & Lauwers, D. (2015). Smart mobility: opportunity or threat to innovate places and cities. 20th International Conference on Urban Planning and regional Development in the Information Society, Proceedings, pp. 543–550.

Pfertner, M. (2017) Evaluation of Mobility Stations in Würzburg. perceptions, awareness, and effects on travel behaviour, car ownership, and CO2 emissions. Master Thesis, Technische Universität München, Munich, Germany.

Prettenthaler, F. E., & Steininger, K. (1999). From ownership to service use lifestyle: the potential of car sharing, Ecological Economics, 28, issue 3, p. 443-453.

Silva, B., Khan, M., & Han, K. (2018). Towards sustainable smart cities: A review of trends, architectures, components, and open challenges in smart cities. Sustainable Cities and Society.

Silva, L. M. C., & Uhlmann, J. (2020). Contributing Factors for the Underutilization of Mobility Stations: The Case of the "Wien Mobil Station" in Vienna. In: Actas del Congreso Campus FIT 2020. Universitat Politècnica de València: Departamento de Ingeniería e Infraestructura de los Transportes, p. 163-179.

Smart Data Wien (n.d.). Sycybe Bike Sharing. Retrieved on February 23, 2020, from https://smartdata.wien/iot/network/ODM=

Smarter Together (2017). Smart City Catalyst. Deliverable 4.2.1. Retrieved on August 10, 2019, from https://www.smarter-together.eu/file-download/download/public/437

Smarter Together (2019a). Mobility Stations. Deliverable 4.5.1. Retrieved on May 14, 2020, from https://www.smarter-together.eu/deliverables/mobility-stations

Smarter Together (2019b). Smart City Toolbox. Deliverable 8.3.2. Retrieved on August 12, 2020, from https://www.smarter-together.eu/file-download/download/public/1621

Smarter Together (2019c). Zwei neue WienMobil Stationen eröffnet. Retrieved on October 4, 2019, from https://www.smartertogether.at/zwei-neue-wienmobil-stationen-eroeffnet/

Smarter Together (2019d). Mobility Point Simmeringer Platz. Deliverable 5.5.2. Retrieved on June 14, 2019, from https://www.smarter-together.eu/file-download/download/public/1245

Smarter Together (2019e). Urban Living Lab. Activities in Vienna from 02/2016 until 12/2018. Deliverable 5.2.1. Retrieved on August 8, 2019, from https://www.smarter-together.eu/file-download/download/public/1011

Smarter Together (2019f). Co-Design Processes. Activities in Vienna from 02/2016 to 12/2017. Deliverable 5.2.2. Retrieved on August 8, 2019, from https://www.smarter-together.eu/file-download/download/public/1015

Smarter Together (n.d.). Smarter Together. Retrieved on July 19, 2020, from https://www.smarter-together.eu/

Tim (2020). Tim Österreich. Retrieved on July 10, 2020, from https://www.tim-oesterreich.at/

Tim. (2019). gewechselt. geschont. gespart. Was tim geschafft hat. Ein Bericht. Holding Graz: Graz, Austria.

Wendt, W., & Dübner, S. (2017). Co-Creation for Smart City Solutions – a Peer-to-Peer Process. REAL CORP 2017 – PANTA RHEI – A World in Constant Motion. Proceedings of 22nd International Conference on Urban Planning, Regional Development and Information Society. pp. 99-108.

Wilke, A., & Lieswyn, J. (2018). Dockless bikeshare – friend or foe?.

Wiltschko, G. (2019, Nov 6). Personal interview.

Statutory Declaration

I hereby affirm that the Master thesis at hand is my own written work and that I have used no other sources and aids other than those indicated. All passages, which are quoted from publications or paraphrased from these sources, are indicated as such, i.e. cited, attributed.

This thesis was not submitted in the same or in a substantially similar version, not even partially, to another examination board, and was not published elsewhere.

Weimar, 24.08.2020 ..... Place, Date

Raiza Maciel Costa da Silva ..... Signature