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The Role and Design of Open Territorialized Mobility Platforms for Sustainable Mobility

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9.1 Urban Mobility in Europe

People mainly travel within urban areas to go to work and school rather than for pleasure (Kanger et al., 2020; Ruggieri et al., 2020). Mobility of people is at the heart of our society and economic activities. Globally, passenger travel activity increased by 74% between 2000 and 2015 and it is estimated that it will double in cities by 2050, with several negative consequences, such as congestion, air pollution, noise, and accidents (Nemoto et al., 2021).

Urban mobility platforms often include multiple services and modes of transport (by rail, road, and sea) (Mounce & Nelson, 2019). To

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describe the mobility situation of a city, region, or urban area, we talk about "modal split", which is the percentage of trips that occur regularly in an area by transport system. Sustainability in transport can be achieved with sustainable modes of transport, and private car use does not usually enhance sustainability, whereas public transport and non-motorized modes, such as walking and cycling, do (Black, 2010). It is therefore important to understand what drives people towards and away from specific modal splits and the trend of those who move by choosing among the various transportation systems available, including public and private transportation, scheduled services such as buses and streetcars, dial-a-ride services such as cabs, car sharing, micro-mobility devices such as bicycles and scooters, and walking, in order to enhance transport sustainability (Santos et al., 2013).

The study of travellers' choices and definition of some emerging trends aim to improve the design and sustainability of urban transport to meet current and future passenger needs. What means of transportation do Europeans prefer to use? Table 9.1 shows the travel preferences of European citizens by percentage according to the type of transportation used, considering that most daily travel takes place for work purposes. The data presented are extracted from the EPOMM[1] dataset and the Audimob-ISFORT[2] (for Italian cities) datasets on the modal split of all trips in cities above 400,000 inhabitants. Of these, we present data for 32 European cities that are among the most representative of different geographic areas and among those with the highest population density, which are more exposed to traffic issues and are challenged by the need for more efficient public transportation systems.

Among the 32 cities selected, the percentage of trips made on foot is equal to or greater than 30% in only 13; among them, only Naples, Paris, Seville, and Valencia are small centres, less than 200 km^2, and therefore

[1] EPOMM is the European platform on Mobility Management (MM), formed by a network of governments in European countries, represented by the ministries that are responsible for MM in their countries. EPOMM is an international non-profit organization based in Brussels. One of the most popular tools is TEMS (The EPOMM Modal Split), a database of the modal splits of more than 380 European cities of varying sizes (largely consisting of centres with above 100,000 inhabitants).

[2] Italian High Institute for Transportation Education and Research, available at https://www.isfort.it/ricerca/audimob/.

Table 9.1 Data about modal trips in the main European cities

City	Country	Population	Area (km²)	On foot (%)	By bicycle (%)	Private transport (%)	Public transport (%)
Amsterdam	Holland	747,093	219	20	22	38	20
Athens	Greece	3,627,500	3808	8	2	53	37
Barcelona	Spain	4,600,000	7733	46	1	35	18
Berlin	Germany	3,506,239	892	30	13	31	26
Brussels	Belgium	1,136,920	161	3	2	47	48
Bucharest	Romania	1,940,000	228	22	1	24	53
Budapest	Hungary	1,700,000	525	32	1	2 k	47
Copenhagen	Denmark	548,443	88	25	31	29	15
Genoa	Italy	583,601	243	21	0	48	31
Hamburg	Germany	1,735,663	755	28	12	42	18
Helsinki	Finland	613,100	715	32	11	23	34
Lisbon	Portugal	2,800,000	2802	16	1	48	35
London	England	7,556,900	1572	20	3	40	37
Lyon	France	1,243,000	1746	32	2	51	15
Madrid	Spain	3,260,000	606	29	0	29	42
Marseille	France	1,177,000	672	34	1	54	11
Milan	Italy	1,352,000	182	22	4	47	27
Munich	Germany	1,326,807	310	28	14	37	21
Naples	Italy	3,085,000	119	30	1	18	51
Oslo	Norway	573,185	454	34	5	36	25
Paris	France	2,211,297	105	47	3	17	33
Riga	Latvia	699,000	307	19	2	45	34
Rome	Italy	2,628,080	1285	16	0	27	57
Seville	Spain	1,450,000	141	31	2	53	14
Sofia	Bulgaria	1,600,000	1344	14	3	51	32
Stockholm	Sweden	1,889,945	6519	17	1	47	35
Tallinn	Estonia	414,752	159	30	4	26	40
Turin	Italy	886,837	130	7	1	64	28
Valencia	Spain	1,540,000	135	41	2	40	17
Vienna	Austria	1,721,573	415	28	6	29	37
Vilnius	Lithuania	554,192	401	36	1	38	25
Warsaw	Poland	1,702,000	517	21	1	24	54

Source: EPOMM-TEMS and Audimob-ISFORT

more easily traversable, while the other nine have a medium or large territorial extension. Interestingly, the citizens of Barcelona, the city with the largest land area considered in the analysis, move much more on foot (46%) than by private or public transportation. As far as bicycle travel is concerned, excluding Copenhagen and Amsterdam, there are even fewer centres with a value that can be considered significant; in fact, most are at a level below 10%.

Public transport accounts for more than 30% of trips in 56% of cities analysed, while in Marseille and Seville it does not reach 15%. The proportion of trips made by public transportation exceeds 50% in three cities: Rome (57%), Warsaw (54%), and Bucharest (53%).

Private vehicles, including cars and motorcycles, are the most frequently used and least environmentally sustainable form of modal split; the Italian city of Turin ranks first in terms of private vehicle use, with this journey type exceeding 50% of trips there and also in five other European centres.

Considering as an indicator of sustainable mobility the combination of public-transport–cycling-walking, we observe that this exceeds 70% of trips in the cities of Paris (83%), Budapest (80%), Helsinki (77%), Bucharest and Warsaw (76%), Tallinn (74%), and Copenhagen, Madrid, and Vienna (71%) (see Fig. 9.1). Among the largest cities, Helsinki has the best distribution of modal shares: low car use (23%) is matched by a 32% share of walking trips (well above the European average) and a 34%

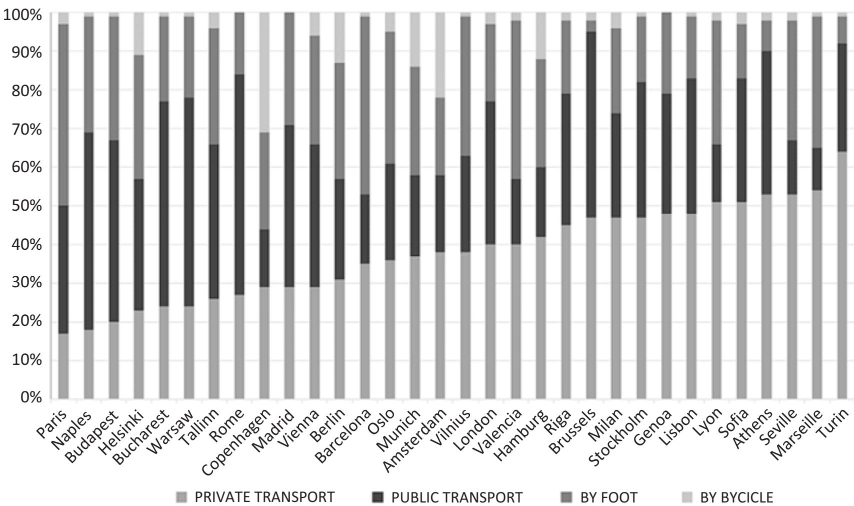

Fig. 9.1 Percentage of modal trips in the main European cities. Source: Own elaboration of EPOMM-TEMS and Audimob-ISFORT data

share of public transport; finally, it ranks among the top cities for cycling, which accounts for 11% of trips. London, historically known for its efficient public transport system, records a very low share for bicycle use (3%) and a high average for private transport (40%). On the contrary, Copenhagen has excellent values of bicycle and pedestrian mobility, at 31% and 25% respectively, higher than those of private cars and public transport, at 29% and 15% respectively. But in this case, we observe a smaller territorial extension of the city (only 88 km^2), where it is easier to move on foot or by bicycle.

Nevertheless, the environmental sustainability of public transport is also tightly related to the technology used for the motorization of transport means, such as buses and boats. In the European cities under analysis, a proportion of the vehicles still run using internal combustion engines (ICEs). The countries with the lowest number of registered gasoline vehicles are Austria, France, and Portugal (Eurostat, 2021). The environmental impact of public vehicles also depends on their age: currently in Europe most public vehicles are between 10 and 20 years old, while only 15% are less than two years old (Eurostat, 2021).

For these reasons, the next section introduces the concept of open territorialized mobility platforms and focuses on green technologies that public service providers in the main European cities are using, focusing on electric buses. Finally, Sect. 9.4 focuses on the Venice case to start discussing how historical European cities are greening their fleets and the dialogue that exists between the space of a city and the new electrified technologies.

9.2 Open Territorialized Mobility Platforms

There is increasing talk about environmentally sustainable mobility, which also involves the public transportation sector. Mobility can be environmentally sustainable when it reduces impactful effects such as air pollution, noise pollution, and emissions, and this requires traditional means of transportation to be converted to hybrid, electric, or hydrogen vehicles (Holden et al., 2020).

Recently, the passenger transportation industry has undergone changes as a result of the emergence of open online public and private platforms that serve specific urban areas by providing multiple mobility services, such as shared mobility services or more traditional public travel services, and that provide information about how to reach point-to-point specific destinations by mixing public or shared transport services (Alochet, 2020). Multiple applications exist that share information about roads and public transportation, warn of accidents, delays, and congestion, and improve integrated mobility payment systems (Di & Ban, 2019). The purpose of these platforms is to facilitate mobility by giving people greater control over their trips through real-time access information. These platforms rely on service innovation and digitalization and deploy the new paradigm of mobility as a "service" through which the user enjoys a comprehensive mobility offering from a single app (Cabigiosu, 2019). In this way, the user is free to access on his or her own initiative, when and where he or she prefers, the desired mix of mobility services.

A term that is still little known is "open territorialized mobility platforms". These are platforms which can specialize in either a specific mobility service or a mix of services, managed by public or private service providers that operate in an extended region, province, or urban area (Alochet et al., 2021). KINTO is an example of a private mobility service provider which has an open platform that offers shared mobility services. Today, both private and public service providers rely on online platforms and apps to inform clients and sell their services.

Public mobility service providers manage platforms that provide a mix of transport services that cover urban or metropolitan areas and promote sustainable and shared mobility, in turn reducing traffic and pollution. These platforms have been growing rapidly in the past few years and have been introducing green technologies to reduce their environmental impact. However, a lack of clarity remains regarding how public mobility service providers select green technologies and particularly regarding the challenges they face when they decide to substitute traditional combustion engine vehicles with electric vehicles. Such uncertainty poses challenges for urban planners and policy makers to evaluate the strength and weaknesses of these emerging mobility services and to propose effective measures to support green transitions.

In the last years, city administrations have been promoting urban transport electrification due to its environmental benefits. For this reason, this chapter focuses on whether and how different public service providers in European capitals are greening their open mobility platforms, with a focus on bus electrification, because buses are diffused in all city centres and electric vehicles represent the most diffused green technology for buses to date (Ruggieri et al., 2020; Glotz-Richter & Koch, 2016; Cabigiosu, 2022).

Previous studies on the introduction of electrified motorization within platforms operated by public service providers within a specific urban area have emphasized both the environmental benefits of these vehicles and also some challenges related to the use of electric vehicles on a large scale (Mathes et al., 2022), such as price/performance improvements, upfront investments, government policies, and clients' motivations (Dijk et al., 2013; Smith et al., 2010; Stephan et al., 2017; Bohnsack et al., 2014).

Local logics and the complex nature of pre-existing mobility systems vary markedly from one place to another, as shown in Table 9.1 and Fig. 9.1. Thus, places both determine the magnitude and origins of sustainability problems and are characterized by different mixes of transport modes and technologies. Potential solutions should address the environmental and mobility needs of the citizens of a specific city, and we still need studies that explore how open territorialized mobility platforms in different urban areas have been introducing electric vehicles, the challenges they are facing, and the specific electric vehicle technologies selected (Scarinci et al., 2019; Ruggieri et al., 2020). In particular, we need to explore the variables that guide this process, which is both diffused and transversal to different cities and also tailor-made to each city's needs.

The next sections aim to first provide an overview of urban green mobility in Europe, then describe how public service providers in the main European urban areas are greening their vehicles, and finally focus on electric vehicles and on the challenges related to their introduction in historical cities.

9.3 Electrification of Mobility Platforms Managed by Local Public Transport Operators in Europe

Hybrid, plug-in hybrid, and full electric vehicles are all types of electric vehicles (Glotz-Richter & Koch, 2016; Mathes et al., 2022). While electric vehicles have higher environmental performance, we know that they also pose some challenges. First, plug-in and full electric vehicles require a dedicated charging infrastructure whose characteristics depend on the battery technology: slow plug-in chargers are usually installed at depots to recharge batteries that have a high autonomy and require a higher charging time, fast plug-in chargers are also installed at stops to recharge low autonomy batteries, and overhead contact lines or inductive (wireless) chargers are used to recharge vehicles during driving. Second, the power grid should provide enough energy to avoid problems in the provision of other public services and in the energy supply to private homes (Rodrigues & Seixas, 2022). Third, electric fleets are more expensive than ICE fleets due to the cost of electric batteries (Kumar & Alok, 2020). Fourth, electric fleets need dedicated control and security systems (Zhu et al., 2018).

Table 9.2 illustrates how the main public transport operators in major European capitals are approaching the green transition and compares the diverse technological choices. We collected the data by browsing the websites of public transport operators in major European capitals. Table 9.2 shows the findings related to those capitals that are implementing, or have in place, relevant sustainable mobility projects.

Table 9.2 shows a strong presence of electric buses on European roads, although in different years, almost all capitals have been purchasing or replacing bus fleets that have been operating on fossil fuels for years. All the analysed cities, except for Lisbon, have electric buses running, of which the first to start was Barcelona in 2012. This may be due to European sustainability plans that “obligate” the conversion of fleet power to electricity by 2035; cities therefore prefer to invest the money granted by states in electric-powered infrastructure. Interestingly, 10 to 15 cities with full electric buses mix full electric motorization with other sustainable motorization types such as biogas or hybrid buses.

Table 9.2 Sustainable public transport technologies in Europe by city

Cities	*Public transport service provider*	Biogas/biomethane bus	Ethanol/rape methyl ester/hydrogenated vegetable oil buses	Hydrogen bus	Bus with induction charging	Electric buses	Hybrid buses	Self-driving electric mini steamers	Self-driving electric mini buses	On-demand hybrid/electric cabs and buses	Solar-powered ferries	Electric ferries	Electric streetcars	Wind-powered trains	Hydrogen trains	Electric trains	Hybrid steamers
Amsterdam	GVB Holding – https://over.gvb.nl/					2018		2016				2020	2020	2017			
Barcelona	TMB – Transports Metropolitans de Barcelona – https://www.tmb.cat/	2012		2021 (test)		2012	2012										
Berlin	BVG – Berliner Verkehrsbetriebe – https://www.bvg.de/de				2015	2019					2021 (test)	x			2021 (test)		
Brussels	STIB – Société des Transports Intercommunaux Bruxellois – https://www.stib-mivb.be/					2016	2019										
Hamburg	VHH – Verkehrsbetriebe Hamburg-Holstein– https://vhhbus.de/					2019	2014										
Helsinki	HSL e Nobina – https://www.hsl.fi					2021			2021								

(*continued*)

Table 9.2 (continued)

Cities	Public transport service provider	Biogas/biomethane bus	Ethanol/rape methyl ester/hydrogenated vegetable oil buses	Hydrogen bus	Bus with induction charging	Electric buses	Hybrid buses	Self-driving electric mini steamers	Self-driving electric mini buses	On-demand hybrid/electric cabs and buses	Solar-powered ferries	Electric ferries	Electric streetcars	Wind-powered trains	Hydrogen trains	Electric trains	Hybrid steamers
Lisbon	Carris – Companhia de Carris de Ferro de Lisboa – https://www.carris.pt/												2021				
London	TfL – Transport for London – https://tfl.gov.uk	2015	2013	2013	2021 (test)	2015				2015							
Madrid	EMT – Empresa Municipal de Transportes de Madrid – https://www.emtmadrid.es	2017				2017	2017			2016							
Milan	ATM – Milanese Transportation Company – https://www.atm.it					2017				2019							
Munich	CAM – Compagnie des Autobus de Monaco – https://www.cam.mc/					2019											
Oslo	Ruter As – https://ruter.no	2018				2018						2015	2021				

Paris	Île-de-France Mobilités e RATP – https://www.ratp.fr	2015		2017		2020	
Stockholm	SL – Storstockholms Lokaltrafik – https://sl.se/sl	2017	x	2015	2015		x
Vienna	Wiener Linien e ÖBB – https://www.wienerlinien.at/			2013			
Zurich	VBZ – Verkehrs betriebe Zürich – https://www.stadt-zuerich.ch/vbz/de/			2020			

Source: Own elaboration

Cities such as Copenhagen, Lisbon, Valencia, and Zurich are focusing their efforts on encouraging the use of micro-mobility devices such as scooters and bicycles, aiming to discourage private car use as much as possible. Copenhagen, famous for being a bicycle-rich city, has developed a bike-sharing project called Bycyklen in cooperation with the public transport operator. Citizens of Copenhagen get around a lot by bike and on foot, while the most frequently used buses are the "harbour buses"; these are boats, not environmentally friendly for now, but an excellent alternative to urban road traffic. Lisbon, famous for its hilly forms, is traversed by electric funicular lines and since 2021 also by *eléctricos*, new-generation electric streetcars (the first dating back to 1901). Valencia, traversed largely by bicycles and scooters, aims to give back space to its citizens through a reduction in the circulating car fleet by offering them the opportunity to walk in quality public spaces and creating light infrastructure for cycling for short trips and lots of public transport for longer-distance travel. In 2018, a "bicycle ring road" sprang up around the Old Town; 5 km was carved out by taking a lane away from cars, but this also allowed for wider sidewalks and improved public transportation stops. Finally, Zurich lags behind in the adoption of environmentally friendly transportation such as electric buses (the first vehicles appeared in 2020), but only because it has invested in micro-mobility since 44% of the population travels by bicycle.

Compared to the city of Barcelona, which began its conversion to more sustainable mobility in 2012, Madrid adopted public transportation such as electric and biogas buses later, in 2017. Nevertheless, its strong point is digitization. The company Geotab, in collaboration with the Spanish public transport operator, chose to install monitoring devices on electric buses to collect data to better understand the fleet's activities, including the distance travelled, the daily mileage of the vehicles, the daily electricity consumption, the average energy consumption of each vehicle, and the vehicle's charge value. The data also offered a better understanding of how to adjust charging sessions to avoid creating overloads when charging during peak hours. Digitization and continuously developing technologies allow operators to have more control over their vehicles and create very important future investment forecasts.

Looking at self-driving vehicles, one realizes that the road to adoption in Europe is still long. Only Helsinki and Paris have begun to run driverless electric minibuses on their streets, while in 2016 Amsterdam began to let small "waterbuses" navigate its canals, guiding them by remote control.

As for solar energy and hydrogen, the city of Berlin has been implementing pilot tests since 2021, but due to the high costs of design and testing itself, the results for the adoption of such technology will be seen only in the future. On the other hand, a country that has already been harnessing the power of wind for four years thanks to windmills on its territory is the Netherlands, which, with its wind-powered trains, is the most advanced European country.

As we can see in Table 9.2, capitals have mixed and implemented diverse sustainable mobility projects. The main reasons why we observe diverse mixes of sustainable mobility services in different cities are complex and multifaceted and still need dedicated studies. For example, mobility projects developed in cities in northern Europe are not adaptable to cities in southern Europe and vice versa, due to a number of factors such as weather conditions, traffic, road gradients, different needs of citizens, and the maturity level of the technologies themselves. Mobility systems should be custom designed for the mobility needs and condition of the individual city, and this explodes the complexity and cost of design. The next section deals with this topic, focusing on challenges related to electrified mobility in historical city centres.

9.4 Electrified Mobility in Historical Cities: Challenges and Opportunities

Table 9.2 shows that public transport operators are mixing different green technologies, but since 2013 they have all been mainly introducing electric buses. Electric buses can be hybrid, plug-in, or full electric; full electric buses have batteries that display different durations and recharging times and require dedicated recharging infrastructures.

While we observe from Table 9.2 an increasing relevance of electric public mobility, we still know little about why and how operators select different battery electric vehicles (BEVs) and about the challenges related to the introduction of electric vehicles in the historical city centres that characterize European urban areas. To start exploring this research question, we present the case of AVM (Azienda Veneziana della Mobilità—Venetian Mobility Company), which manages the public territorialized mobility platform of Venice. AVM was founded in 1996 and delivers the mobility services of the metro area of Venice, serving in 2022 a population of 639,000 people moving by bus, vaporetto, ferryboat, funicular railway, tram, and bicycle. AVM represents an interesting case both because it must manage the complexity of integrating land and sea services and because Venice is an ancient city and mobility service solutions have to be integrated in this landscape. Furthermore, Venice is one of the main touristic cities worldwide and the mobility services provided should be projected to support the stress deriving from frequent demand peaks. Overall, Venice constitutes an interesting setting to explore the challenges related to the introduction of electric vehicles in the historical city centres that characterize European urban areas.

Our data sources consisted of primary and secondary data. Primary data were semi-structured interviews (DiCicco-Bloom & Crabtree, 2006), all conducted between 2021 and 2022 with AVM and Venice municipality managers who have different roles but are all the most knowledgeable informants about the Venetian electrification projects. We also collected internal documents, presentations, and reports. Our secondary sources were press articles presenting and discussing these and other electrification projects of public transport, which allowed us to triangulate the information collected during our interviews.

We identified three electrification projects. The first was the electrification of the bus fleet on Venice Lido Island, the second consisted in the electrification of the vaporetti fleet, and the third was the introduction of electric and hydrogen buses in Mestre, which is part of the Venice municipality but is built completely on the land and has a small historical city centre.

The Venice Lido is a small island of about 73 km^2 between the Venice Lagoon and the Adriatic Sea with 20,000 inhabitants. The Lido hosts a small city centre and popular beaches. AVM started the electric bus project in this area in 2018 because it is a circumscribed area where Venice municipality was investing in greening the island and it was economically feasible to substitute all existing buses with electric buses. Furthermore, traffic is not intense, and the bus line is a simple vertical line with only 20 stops. The project was completed at the end of 2021 and involved the introduction of 30 full electric buses. The batteries installed on the vehicles have a limited range of about 60 km in summer and 50 km in winter, the length of the longest line.

In 2015, AVM also started a project of re-motorization of 35 vaporetti currently in service to be transformed into plug-in hybrids, the refurbishment of 12 new boats equipped with a stage 5 endothermic engine, and purchase of 62 new plug-in hybrid boats (vaporetti and others). Re-motorization of some boats, rather than buying them new, was considered the best solution in terms of time, cost, and service level and was concluded by the end of 2021. At the end of 2022, AVM was finalizing the call for hybrid vaporetti construction.

At the beginning of 2022, Venice also received extra funds from the Italian government related to the pandemic crisis that must be used for electric or hydrogen buses. In Mestre, AVM decided to introduce 33 electric buses with a slow recharge system but a high autonomy of about 400 km as well as 90 hydrogen buses. At the end of 2022, 20 electric buses were introduced and the remainder should be introduced by 2026.

Our interviews were specifically aimed at understanding which challenges public service providers face when introducing electric vehicles and why we observe a mix of different technologies, for example hybrid and full electric vehicles. While pros and cons were raised, the first surprising insight was that electric buses require more space than hybrid vehicles for multiple reasons: the battery autonomy of a full electric bus is positively correlated to its recharge time and to the availability of numerous recharging points. In the Lido and Mestre, AVM selected the required electric technology by balancing the bus autonomy required with the space available to build rechargers. In the specific case of the Lido of Venice, which is an island with relevant space constraints, AVM did not have the space for all the slow-charging columns required to recharge its 30 new full electric buses. AVM therefore chose low-capacity batteries with fast-charging stations that can be placed at the bus stops so that buses can be recharged along the way during their daily service. AVM built fast-charging points where the bus recharge time is about 7 minutes as well as some slow-charging columns at the terminal for recharging overnight or for less frequently used vehicles.

On the Lido, however, AVM also had to identify the sites on which to place fast rechargers along the bus routes: many sites are on private property and AVM must obtain permission from the property owners to build the rechargers and from the municipality because the rechargers should respect the existing landscape.

The issues related to space availability to build rechargers for vaporetti are even larger, because vaporetti need more energy and bigger rechargers in an area like Venice, which is part of the UNESCO global cultural property. For these reasons, in the ancient historical city of Venice (about 50,000 inhabitants) AVM decided to use plug-in hybrid vaporetti to avoid landscape constraints and because it was not possible to build rechargers able to supply enough energy for about 100 vaporetti. In fact, in Venice, a relevant aspect to consider is the preservation of the artistic and cultural heritage, and AVM could not build rechargers all around the city.

Another relevant issue in introducing electric vehicles in an area where other public transport services exist is the need to respect pre-existing timetables (where and when the vehicles stop daily). AVM decided to mostly maintain existing routes and timetables to avoid reducing their service level and to ensure coordination with other public mobility services. This implies that the new electric buses and vaporetti should be able to reach comparable performance (mean speed and autonomy) with traditional combustion engine vehicles even if they need longer recharges. This is an additional complexity that service providers must consider when planning their green transition and is a more difficult target to reach in cities where traffic is intense and the autonomy of full electric vehicles is lower.

Finally, routes served by full electric vehicles and rechargers at the bus station are less flexible because they are constrained by the positioning of rechargers. This is an issue in those cities where routes should be modified to serve specific events or new areas or if there is a peak in demand only during certain hours, but recharger capacity limits the number of buses and the number of buses that can serve the same route.

In contrast, in Mestre (with more than 88,000 inhabitants), a city with more space at the depot and more traffic, AVM could introduce buses with high battery autonomy and recharging overnight at the existent depot. They planned to introduce 30 buses and 30 rechargers. Nevertheless, they combined electric and hydrogen vehicles to have buses with higher autonomy comparable to that of ICE buses and shorter charging time and to avoid building a terminal with 123 rechargers, which would have increased the size, cost, and complexity of the recharging infrastructure. Furthermore, Venice municipality is investing in hydrogen technology as a political choice.

Overall, the case of AVM suggests that space and landscape constraints, the existing timetables, the routes' length, and the existing traffic on those routes as well as how many vehicles should be run and recharged along the same route all affect the electric transition of the public transportation service in historical cities and not all electric technologies can be equally viable in the same city.

9.5 Conclusions

This chapter describes and discusses the importance of public transport services in Europe, whose relative share varies widely from one city to another, and how public transport service providers are introducing different mixes of electric vehicles in their service platforms. The chapter shows that, overall, the approaches of European capitals and cities to the green transition of public transport are converging on electric vehicles, but the specific electric technologies adopted and the overall mix of green technologies, which also comprise technologies such as hydrogen or bio fuels, do vary from one city to another. This evidence suggests that different local contexts lead to the adoption of different sustainable technologies to satisfy the mobility needs of their citizens, but we still need studies to explain the drivers of these choices.

Often the debate about sustainable technologies focuses on technological performance, while we still need studies that disentangle their fit with different settings: sustainable mobility systems use new technologies to be applied in a variety of different spaces, including historic cities, that present different constraints, and the same technology may not be applicable in different cities, thus introducing an issue of scalability or replication of the same mobility system solutions in diverse contexts. For example, mobility projects developed in cities in northern Europe may not be adaptable to cities in southern Europe and vice versa, due to a number of factors such as space availability and weather conditions. Mobility systems and green technologies should fit the needs of each city, and this increases problem solving and design complexity, uncertainty, and costs during technological transitions and adoption.

In this vein, this chapter contributes to the debate in the technology and innovation management literature by suggesting that green technological transitions are affected by places and by identifying new avenues for research on specific attributes of places that affect these transitions. The chapter suggests that in the process of public transport electrification, while we are aware that these new technologies pose performance and cost problems, we still need a more explicit spatial perspective on sustainability transitions and to disclose the spatial contingencies of places where transitions take place that affect and shape the transition and increase our ability to understand how to effectively manage it (Coenen et al., 2012; Binz et al., 2014; Kanger et al., 2020; Kumar & Alok, 2020; Thrane et al., 2010). The technological transition to more sustainable innovations should be understood as a process embedded in both contexts and places, to capture the geographical and social dimension of the technological transition and the mix of attributes of well-defined geographically limited areas, such as urban areas, that determine the technology to be adopted and the environmental performance of an electrified mobility system (Bathelt and Glückler, 2014; Soete, 2019): space and landscape constraints, existing timetables, routes' length, traffic intensity, and weather conditions are all examples of variables that may jointly affect the electric transition of public transportation services.

In particular, by relying on the case of Venice, this study shows how places with their local specificities may play a relevant role in sustainable transitions and suggests that while we do have studies that disentangle transitions in multiple countries and industries (Stephan et al., 2017; Silvester et al., 2013), there is still little reflection on the role that specific and transversal attributes of places play in affecting the sustainable transition of public transport at the local level: the same service provider (AVM) selected three different electric technologies for three different areas of the same municipality (Venice). Places affect sustainable mobility system technology, design, and performance, and this chapter opens a call for additional studies that analyse the specific and transversal attributes of places that affect the electrified public transport mobility and for other studies that can similarly be of help in understanding how places affect sustainable transitions.

Different space characteristics may affect the diffusion of a technology as well as how this technology is used and employed in different settings, generating different business cases. We need more business cases that consider the role of places for public transport that will help service providers, policy makers, and stakeholders to envision upfront all variables that should be considered when managing the green transition of an open territorialized mobility platform (Bohnsack et al., 2014; Garud et al., 2010; Sydow et al., 2009; Vergne & Durand, 2010). Coherently, this chapter also calls for more context-specific innovation policies which can guide policy makers in understanding which type of technological innovation can support sustainable mobility in each place, especially in historical city centres that pose specific challenges (Haddad & Benner, 2021). For example, historical cities that have relevant space constraints may face difficulties in relying only on fleets with full electric buses with high autonomy and may need to mix different technologies. Consequently, this chapter also emphasizes the problematic usage or lack of scale in existing transition analyses. Without a concrete analysis of the role of territoriality in the scales of transitions, we might consider innovations as ubiquitous advantageous and overlook specific issues that arise in places within which sustainable mobility transitions are embedded (Coenen et al., 2012).

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