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## Towards a Concept for a Multifunctional Mobility Hub: Combining Multimodal Services, Urban Logistics, and Energy

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## Article

# Towards a Concept for a Multifunctional Mobility Hub: Combining Multimodal Services, Urban Logistics, and Energy

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## Abstract

*Background:* This paper proposes a conceptual framework for a multifunctional mobility hub (MMH) that co-locates shared e-mobility services, urban logistics, and charging/storage infrastructure within a single site. Aimed at high-density European cities, the MMH model addresses current gaps in both research and practice, where multimodal mobility services, logistics, and energy are rarely planned in an integrated manner. *Methods:* A mixed-methods approach was applied, including a systematic literature review (PRISMA), expert interviews, case studies, and a stakeholder workshop, to identify synergies across fleet types and operational domains. *Results:* The analysis reveals key design principles for MMHs, such as interoperable charging, the functional separation of passenger and freight flows, and modular, scalable infrastructure adapted to urban constraints. *Conclusions:* The MMH serves as a preliminary concept for planning next-generation mobility stations. It offers qualitative insights for urban planners, operators, and policymakers into how multifunctional hubs may support lower emissions, more efficient operations, and shared infrastructure use.



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**Keywords:** multifunctional hubs; mobility hubs; micro-depot; charging hub; urban mobility; urban logistics; shared mobility

## 1. Introduction

The European Environment Agency has outlined a vision for sustainable, compact, and mixed-use urban development, in line with the EU's objective of reducing greenhouse gas emissions by 55% by 2030 [1]. However, the transportation sector remains a key challenge, driving the EU to enforce stricter emissions standards, invest in public transport, and expand zero-emission vehicle infrastructure. Achieving these objectives in urban areas requires transformative changes in the composition of fleets towards zero-emission vehicles [2]; a substantial modal shift from private car usage to more sustainable options such as public transport, cycling, and micromobility; and a stronger focus on vehicle sharing [3]. The implementation of these measures necessitates the extensive development of supporting infrastructure.

A significant challenge in this vision is the limited availability of urban spaces, which are predominantly used independently by various fleets, without compactness

or mixture [1]. The shared use of charging infrastructure is essential to enhancing sustainability and lowering costs [4]. In this context, hubs can act as strategic nodes, allowing multiple stakeholders to share resources efficiently while simultaneously charging diverse vehicle fleets such as electric buses, cars, bikes, scooters, and trucks [5,6]. Allowing different users to share vehicle fleets leads to higher overall utilization [7]. This helps to address the common challenge that most vehicles remain unused for large parts of the day. Multifunctional mobility hubs (MMHs) aim to reduce car dependency and improve spatial and resource efficiency by creating functional overlaps [8]. We define MMHs as cooperatively used locations in urban or suburban spaces where renewable energy is generated and stored for various vehicle fleets, both meeting logistical requirements and providing mobility services for private and public customers on the same site. This understanding of MMHs as shared spaces for energy, mobility, and additional services (e.g., logistics) also requires a close reading of the urban context in which they are implemented. When developing a mobility hub, or a network of hubs, the specific characteristics of cities must be carefully considered. Our conceptual development is rooted in the context of a large European metropolis. Many European cities have irregular street networks, high urban densities, mixed-use neighborhoods, and a complex social fabric that varies significantly from one district to another. These factors make standardized hub models difficult to apply without significant adaptation. Rather than proposing an universal model, this paper brings together ideas and requirements identified through literature and expert interviews and integrates them into a conceptual framework for mobility hubs. We are aware that the specific design and implementation of such hubs must always be context-sensitive and developed in close coordination with local stakeholders.

In the last 10 years, mobility hubs of different sizes have been the focus of EU-funded projects. Most projects demonstrate that co-locating multiple shared and public transport modes at convenient hubs makes intermodal travel more seamless and user-friendly. Several initiatives reveal a trend toward multifunctionality that not only connects mobility services but also incorporates urban logistics (e.g., micro-depots) alongside passenger transport [9–11]. At the same time, user-centric design and social inclusion are emphasized in a participatory planning manner [12,13] or in aiming to catering for suburban communities [14]. First results from these international and interdisciplinary projects show that mobility hubs can reduce car usage. They help cut emissions and improve access to the city. When designed as flexible and multifunctional places, they can also include delivery services and community functions. However, the overlap between commercial and private use of vehicles, as well as the shared use of charging infrastructure with interoperable charging technologies and unified billing systems, is not yet addressed in these (foremost practical-oriented) projects.

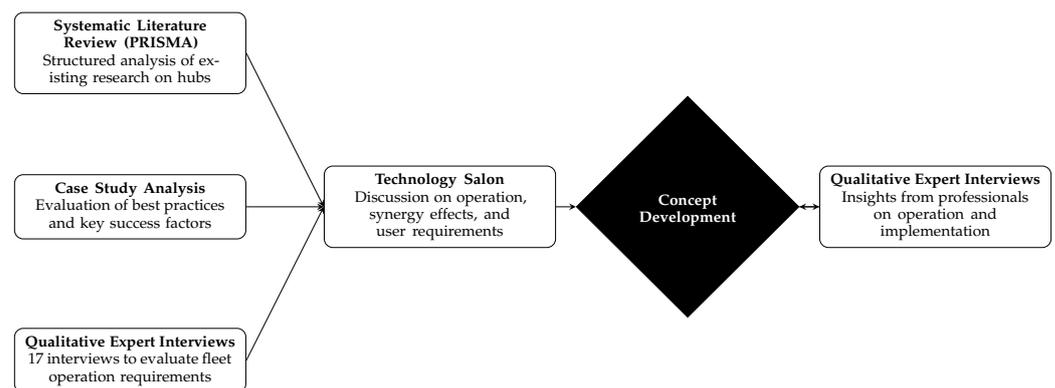
The MMH provides a novel interdisciplinary framework by bridging traditionally separate transport ecosystems (passenger mobility vs. urban freight). Historically, city passenger transport and goods logistics have evolved in silos, but pressing issues like congestion and emissions demand a more unified approach [15]. The MMH concept responds to this gap by conceptualizing hubs that simultaneously cater to people, goods, and—in our case—energy. This represents an emerging research frontier: for instance, recent work explores conditions for adding “logistics functions to mobility hubs” [15], finding that small consumer-goods flows have high potential for integration with passenger hubs. By proposing MMHs, the paper contributes a cross-domain perspective that enriches academic discourse on sustainable urban transport, aligning with calls for a “new generation of mobility hubs” [16] in Europe that go beyond the status quo. It substantiates how co-locating services can optimize systems (e.g., using one hub for both transit riders and parcel pickups,

and combining both with a common energy infrastructure), prompting new research into the design, typologies, and modeling of such integrated hubs.

Although the concept of MMHs appears promising, the current state of research on the topic and its practical realization remains largely unexplored. The few existing publications and real-world examples are primarily confined to defining the concept and providing visual representations. Central questions regarding the practical feasibility of MMHs, the specific requirements of different user groups and fleets, practical design, and the promotion of cooperative use remain largely unanswered. This paper aims to bridge this gap by analyzing the potential of MMHs to transform urban mobility and logistics systems and by proposing features of the governance, functionality, location, size, and design of MMHs. Using a systematic literature review, expert interviews, case study analysis, a collaborative workshop (Technology Salon), and a preliminary conceptual design, this study explores the feasibility, requirements, and benefits of implementing MMHs.

## 2. Methodology

To explore the concept of MMHs, we applied four research methods in five steps. Our approach combined systematic literature and case study analysis, expert interviews, collaborative workshops, and conceptual design, allowing us to address both the current state of knowledge and the practical applications of these hubs. The research design is illustrated in Figure 1.

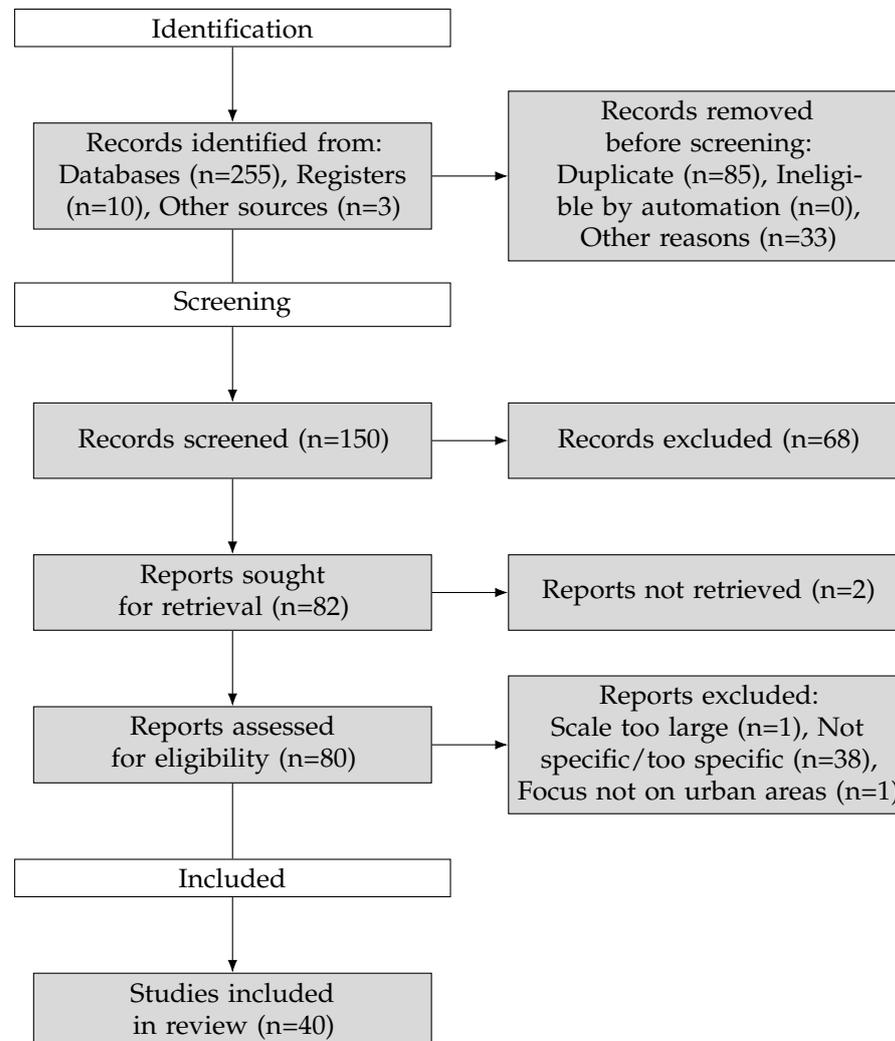


**Figure 1.** Research design: integrating qualitative methods for concept development.

### 2.1. Systematic Literature Review

Firstly, a systematic literature review was conducted with the aim of identifying the current state of scientific knowledge and technological advances related to MMHs. In the systematic review of the literature that spans 2016 to 2024, the focus was on peer-reviewed articles. These were examined in two stages. Firstly, hub typologies were explored, and secondly, the associated functions were analyzed. For this purpose, we applied the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework to ensure a systematic approach [17]. The literature search was carried out on two online databases: Scopus and Web of Science. The search strategy was chosen for both replicability and transparency, allowing for the verification of the findings and facilitating future updates to the systematic review. The process of selecting and analyzing studies involved the identification of 40 relevant sources, which included scientific articles, journal articles, and a few conference proceedings. We obtained a total of 268 studies using the keywords “mobility hubs” in conjunction with “definition,” “function,” “location,” “neighborhood,” “typology,” or “urban” for titles and abstracts, along with the standalone keyword “city hubs.” Duplicate studies were eliminated during the identification stage, leaving 150 studies to be screened. After considering their topics and content, we deemed

82 of these studies irrelevant and excluded them. During the eligibility stage, we evaluated the full text of the articles for relevance. The reports excluded after the assessment totaled 40, with exclusions due to issues such as overly broad or narrow scope and lack of focus on urban areas. This left 40 studies that provided relevant data for the main research objectives of this study. Three reviewers independently screened each record and report retrieved, without the use of any automation or artificial intelligence tools. The methodology applied can be seen in Figure 2. Furthermore, we analyzed case studies to examine how MMH concepts have been implemented in practice so far. The findings are presented in Section 3.1.



**Figure 2.** PRISMA method applied for systematic literature review.

## 2.2. Expert Interviews

In total, 17 semi-structured interviews (30 to 45 min each) were conducted with experts experienced in mobility and multifunctional hubs in Central European metropolises. These experts take on various roles in the mobility business such as logistics companies, CEP service providers, electric micromobility providers, municipal waste disposal companies, and municipal transport companies. This range of knowledge ensures a multifunctional perspective of MMHs. The interviews were structured and coded focusing on the following keywords: possible business models, administrative design and governance, required functionality, location, size and design paradigms, and no-gos. This way the interviews provided insights into stakeholders' operational needs and the expected advantages of future MMHs and their possible operation as well as into initial considerations regarding governance structures without the aim of developing an implementation roadmap.

### 2.3. Technology Salon

To explore the practical and strategic implementation of MMHs, a two-day “Technology Salon” was conducted in Luckenwalde in September 2023. This participatory expert format brought together 16 professionals from city administrations, mobility service providers, logistics companies, energy associations, and research institutions. The event was purposefully held outside the usual work environment to foster open-minded, transdisciplinary dialogue and creative thinking in a focused setting [18]. Using the salon method, the event combined moderated discussions, a philosophical dialogue walk, and small-group design sessions with a Delphi survey. The aim was to identify barriers and co-develop realistic solutions for implementing an MMH. On the basis of a collaboratively refined input paper and the STEEP framework (social, technological, economic, ecological, and political), participants developed visions and design principles for future implementation in urban and peri-urban contexts.

### 2.4. Conception

Following the literature review, expert input, and the technology salon, we initiated the conceptual design phase. This step aimed to synthesize the previously identified technological research and mobility profiles in order to derive a design concept for MMHs. By integrating our findings and visualizing the concept, we developed a preliminary proposal for the hubs, addressing both their structure and their functional integration within urban settings.

## 3. State of the Art in Research and Practice

### 3.1. State of Research

Over the last two decades, mobility hubs of different dimensions have attracted increasing interest in cities around the globe. With the rise of information and communication technologies and the sharing economy during the 2010s, hubs formerly limited to single transport modes, such as bike sharing stations, have expanded in size, modes, and functionality [5,8,19]. What also distinguishes these hubs from traditional passenger transport stations is that they encompass a wider range of transportation options in a compact form [20]. A growing number of cities, especially in the EU and East Asia [21–23], have implemented multimodal and multifunctional services to better accommodate diverse mobility demands. With the growing deployment, the scientific discourse on them has expanded considerably in recent years.

#### 3.1.1. Typologies of Mobility Hubs

The literature on mobility hubs reveals a wide range of perspectives, shaped by diverse contextual influences. According to [23,24], mobility hubs are categorized by their function in the overall transportation system. The following typology is proposed for the systematization of mobility hubs:

(1) Central hubs serve as supraregional connections and combine multimodal transport modes with additional activities such as culture, dining, entertainment, and other such amenities.

(2) Sub-central or suburban hubs connect the urban fringe with the city center. Commonly, this type of hub provides parking space (park and ride), allowing commuters from the hinterland of the metropolises to reach the stations and similar service activities at the central hubs.

(3) Regional hubs are identified as interfaces between urban centers and rural areas [24], serving as connection points between public transport and motorized private transport.

Parking spaces also serve an important function at these locations, but to a lesser extent than the amenities of additional activities.

(4) Decentralized mobility hubs represent the smallest type of multimodal station in urban areas, such as Berlin's Jelbi points, which primarily serve micromobility modes [25].

Furthermore, mobility hubs can be categorized by the quantity and complexity of the transport modes, services, and facilities they provide [26,27]. Simpler hubs might feature shared bicycles or mopeds with minimal infrastructure, while more complex hubs include high-frequency trains and diverse services like package pickups or retail [28]. On this basis, hub types can be systematized as community, neighborhood, suburban, city district, or city edge to city center mobility hubs. Other scholars limit their analysis to three primary types—residential hubs, urban hubs, and regional hubs—classified on the basis of transport-related and urban criteria such as population density and target user groups like residents and commuters [29]. Complementing these functional and user-centered typologies, [29] propose a spatially grounded classification based on the catchment area of shared mobility hubs: neighborhood hubs (serving a range of up to 400 m), district hubs (400–1000 m), and city hubs (more than 1000 m). Also [30] have shown that spatial characteristics such as population density, land-use mix, and proximity to public transport stations influence the uptake of shared mobility services at hubs in mode-specific ways. This spatial perspective offers additional guidance for the planning and allocation of hub types within diverse urban fabrics.

Conversely, some approaches aim to develop mobility hubs irrespective of specific transportation or urban contexts in areas lacking adequate transport services [31,32]. This strategy is intended to provide disadvantaged groups with improved access to mobility resources [33]. Alternative approaches to creating a typology are often highly case-specific, meaning that the resulting classifications are custom-designed for the particular cities where the hubs are located [16]. Recent studies, such as those of [16,19], suggest that specific historical and spatial characteristics of European cities (e.g., organically grown urban structures with narrow streets, central marketplaces, well-defined city centers) should be taken into account when typifying mobility hubs and their locations. In this context, it is essential to link spatial optimization with user-centered design. While ref. [34] emphasize that site selection must account for behavioral responses and externalities across transport modes, ref. [35] highlight the importance of translating user needs, such as safety, accessibility, and lighting, into concrete infrastructure features.

Building on the typology from [23,24], our proposed MMH concept is primarily designed for central urban hubs, where high density, spatial constraints, and a diverse mix of mobility and logistics stakeholders create a strong need for integrated infrastructure solutions. In such settings, MMHs offer the potential to co-locate shared mobility services, last-mile logistics, and energy systems in a compact and efficient way. At the same time, the concept is not limited to central locations. Depending on the local context, it can be adapted to sub-central or decentralized hubs, by combining small-scale parcel micro-depots with e-bike sharing facilities. This flexibility allows the MMH model to respond to varying urban forms and functional demands while maintaining its core principle of multifunctionality.

### 3.1.2. Multifunctionality of Mobility Hubs

Multifunctionality is the capacity to support multiple ecosystem functions or services at a single location that go beyond conventional land uses [36]. Mobility hubs often incorporate shared transport services, public transit connections, and additional amenities like retail or social infrastructure [8,37]. In various definitions, the integration of neighborhood services emerges as a crucial aspect [38]. For example, ref. [29] emphasize the inclusion of additional amenities within their conceptualization, such as retail spaces, workplaces, and

parcel pick-up points like lockers. Similarly, ref. [39] adopts a definition consistent with that of Collaborative Mobility UK (CoMoUK), a UK-based shared mobility organization, which encompasses the idea of “enhanced facilities.” This term refers not only to improvements in transport infrastructure but also to the provision of supplementary services akin to those identified by [29]. According to [40] public value creation is an important factor when planning mobility hubs. Ref. [39] mentions that hubs should convey a “sense of space” and provide attractive pedestrian areas. This is supported by the authors of [41], who state that the challenge is to convert a non-place into a place with added value for passengers. Furthermore, ref. [23] expands the definition by introducing a social dimension, attributing to hubs the potential to enrich public life through the incorporation of enhanced community facilities.

Larger hubs could be designed through zoning [41]: the division into three zones—access, transport/transfer, and commercial/facilities—ensures a clear design language and easier orientation for passengers. Additionally, a supporting infrastructure for shared mobility services should be an integral part of the planning process. Of particular interest in this context is the reservation of designated parking areas for shared transport modes [5,39,42], as well as the integration of hubs into neighborhood parking management [43]—for example, through parking rule sets for free-floating micro-vehicles and designated drop-off locations for on-demand mobility services [5]. Implementing designated areas for bicycle sharing or storage, as suggested by [39], could further encourage the adoption of multi-modal transport among users [44]. However, this also shows that, in addition to considering economic viability for the commercial stakeholders, the administration must be closely involved in the planning of a hub [40].

Although the literature (see also practical examples, Section 3.2) often mentions logistical components such as pick-up stations or the use of e-cargo bikes [45], hubs that mainly incorporate logistical functions are broadly summarized under the terms “city hubs” or “micro-depots,” emphasizing their role in urban logistics [41,46,47]. Within the parcel delivery chain, they serve as central intermediary points in the so-called last-mile logistic process and enable a fine-grained distribution of goods in densely populated urban areas [48]. In line with [49], they are considered mini-warehouses for facilitating deliveries and loads for bike carriers or individual loads. This function is particularly important for meeting the high performance requirements of last-mile logistics [50]. Consolidating goods at such hubs not only reduces the number of trips required but also decreases emissions and traffic congestion through the use of sustainable transport modes like e-cargo bikes [51]. This aligns with findings from [52], who demonstrate that two-echelon distribution systems, where goods are transferred from larger vehicles to smaller last-mile modes, can offer efficient and scalable delivery solutions in urban contexts.

Recent research emphasizes that the multifunctionality of shared mobility hubs increasingly relies on electrified transport modes, shaping both their modal composition and spatial configuration. Refs. [28,53] describe eHUBs as physical locations that integrate multiple electric shared modes, such as shared EVs, e-bikes, and e-cargo bikes, enabling users to flexibly switch between modes for different trip purposes and distances. These electric options are not just substitutes but often complementary, as users may combine them over the course of a week (e.g., EVs for longer shopping trips, e-bikes for leisure) to optimize travel time, cost, and convenience [54]. This electrified mix significantly broadens the functional scope of hubs, making them attractive for diverse user groups and potentially enhancing uptake in suburban areas where public transport is less viable. Accordingly, the location and configuration of hubs must account for the power infrastructure, user charging behavior, and the need for reliable availability of each electric mode.

Our literature review shows that recent studies increasingly focus on hubs that combine shared mobility services with elements of logistics and/or charging infrastructure (see supplementary material). In many cases, these hubs integrate public transport, micromobility (e.g., bikes and e-scooters) and, to a limited extent, delivery services. Several articles also discuss potential hubs that remain at the conceptual or planning stage. These designs aim to improve space efficiency and increase vehicle use by enabling shared infrastructure. However, most concepts do not include a link between renewable energy generation (such as photovoltaics) and local energy storage, which remains a key gap in current planning. Moreover, there is no scientific literature demonstrating that vehicle fleets are shared between commercial users and private individuals. The potential for overlapping use across different user groups and vehicle types is rarely addressed in current research.

### 3.2. State of Practice

This subsection presents various international projects of implemented and planned MMH projects, addressing the three core components: charging hubs, micro-depots, and mobility stations. While the analysis emphasizes best practices for multifunctional hubs, it also considers projects that implement only one of the components as these can function independently. The collected data were translated into structured profiles, capturing fleet composition, energy sources, and site-specific infrastructure. Some projects already combine different hub concepts. The convergence of these concepts is particularly evident as mobility stations increasingly accommodate micro-depot functions, exemplified by Berlin's Merie-Mobil hub [55]. Similarly, selected hubs, like Nuremberg's Audi Charging Hub, provide mobility options during charging [56].

MMHs that combine mobility stations, micro-depots, and charging hubs remain rare. We identified only three examples. The Park Lane Mobility Hub in London offers diverse mobility services, including car sharing, taxi access, and 52 electric vehicle (EV) charging points, alongside a micro-depot supporting last-mile deliveries with cargo bikes and electric vehicles. Its innovative approach has earned it recognition, such as a nomination for the European Parking Award [57]. A second example is Apcoa's planned "Urban Hubs" initiative, which aims to transform existing parking garages into multifunctional hubs for mobility, logistics, and charging. Although implementation is still in the early stages and detailed information is limited, the concept includes shared mobility services, parcel lockers, and plans for future drone integration [58]. A further example is the Zusammenhub in Hamburg, which combines mobility, commerce, and community infrastructure. Located near the Veddel S-Bahn station, it will feature a bus interchange, an electric bus depot for 160 buses, and mobility options such as car sharing, ride pooling, and bike sharing, along with 600 bike parking spaces. The 8000 square meters of commercial and community space will host a supermarket, restaurants, sports facilities, and co-working areas. The project emphasizes sustainable construction, with recycled materials, green roofs, solar panels, and rainwater reuse. The project is currently under development, and a start of service is planned for 2029 [59].

## 4. Results

This section synthesizes the findings into a proposal for MMHs based on the methodological steps and the current state of research and practice. It outlines key design parameters and implementation requirements across three central dimensions: governance, functionality, and location, size, and design. The objective is to provide a practical yet adaptable reference for planning future hubs.

#### 4.1. Governance

*Economically*, MMHs present opportunities for new business models, particularly in sectors related to mobility services, retail, and local entrepreneurship. These hubs can stimulate local economies by attracting investments and creating jobs while also providing additional revenue streams through the leasing of space and advertising opportunities. Research [60] has shown that commercial activities at hub locations can strengthen transit use, especially at suburban hubs but also at inner-city hubs. However, the economic viability of these hubs depends on the development of sustainable financing models and clear operational frameworks.

*Ecologically*, these hubs have the potential to reduce urban traffic congestion and lower GHG emissions by promoting the use of public transport and EVs. Nonetheless, careful consideration must be given to minimizing land use impacts, such as preventing urban sprawl, and avoiding new land sealing by utilizing existing infrastructure like train stations and parking garages. The incorporation of green infrastructure and renewable energy can further mitigate environmental impacts.

*Politically*, the successful implementation of MMHs relies on supportive public policies and a strong political commitment to sustainable urban development. Governments can play a key role by providing incentives for private investments and ensuring that legal frameworks and regulations align with sustainability goals. Collaboration between municipalities, private entities, and the community is essential for fostering a shared vision and ensuring that these hubs meet the diverse needs of urban populations [61]. To operationalize these three aspects, MMHs should be set up in a public–private partnership but designed to operate without long-term reliance on public funding. There is a public demand for MMHs as they help shorten travel distances and reduce the environmental impact of delivery services. In the existing European legal framework, services like MMHs are defined as “services of general economic interest” (European Union 2012, Art. 14, p. 54) [62]. These are defined as market services provided in the public interest with specific obligations for general welfare.

#### 4.2. Functionality

One of the primary functions of an MMH is to enable charging for a variety of vehicle types. However, building such a hub solely for this purpose is neither economically nor socially viable. Logistics operators and parcel service providers do not rely on charging at the hub as they operate from distribution centers located outside the city and can use their own infrastructure. Therefore, the availability of charging capacity must precede considerations of ownership or the commercial use of a hub.

Although coordinated time slots could facilitate the shared use of charging infrastructure, all interviewed experts highlighted the need for various systems, including combined charging systems (CCSs), pantographs, and standard domestic outlets. Fleets also differ in their required charging power, which must be considered to ensure effective charging times without overcapacity. Car sharing services, which use cars or vans, usually rely on CCS connectors and require between 11 and 150 kW. These are already standard components of most mobility stations. This form of mobility, widely used in cities, helps reduce private car ownership. Bike sharing—especially non-electric—offers a sustainable solution for short trips, while shared e-bikes are often used for medium-distance travel, less as feeders to transit [63,64]. Electrified bikes are usually charged through low-capacity standard outlets (0.5 kW) or battery swap systems requiring flexible infrastructure. Public buses use CCSs or pantograph systems with power requirements ranging from 11 to 300 kW, reflecting the broader trend toward electric transit. Courier, express, and parcel (CEP) services rely on cargo bikes, vans, and utility vehicles that charge at 22 to 150 kW, and many are already

integrated into micro-depot models. Their inclusion demonstrates that hubs can effectively support logistics operations. Similar requirements apply to other urban fleets, such as waste collection or street cleaning vehicles. Garbage trucks, for example, charge via a CCS at 22 to 150 kW. Street sweepers also show comparable charging needs.

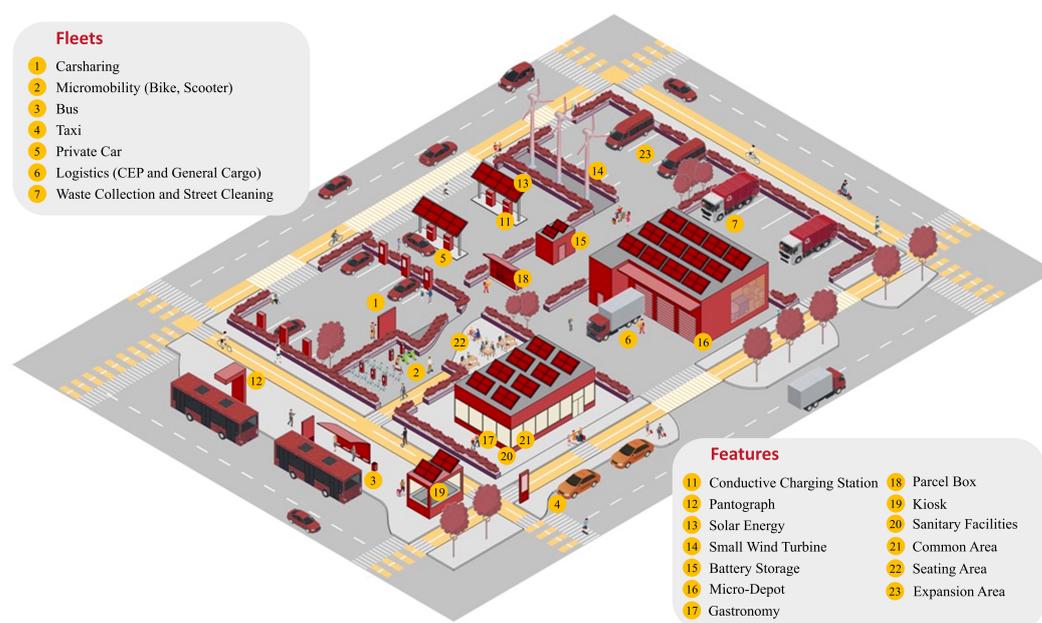
Several infrastructure components—charging systems and employee and customer amenities such as restrooms, break rooms, or food services—can be shared across fleets. Existing surrounding infrastructure should be considered to avoid redundancy. Moreover, ensuring interoperability among charging systems and fleet platforms is critical to maximizing utilization and enabling coordinated planning across operators. This requires not only harmonized hardware interfaces, such as standardized charging connectors but also integrated software systems that facilitate real-time booking, usage monitoring, and energy management. Such systems should ideally be linked with fleet management and touring plans to optimize charging schedules and reduce downtime. Lastly, logistical operations at micro-depots must be clearly separated from passenger movement at mobility stations to prevent interference.

#### *4.3. Location, Size, and Design*

When designing the MMH, the idea of an “electrified gas station” can serve as a source of inspiration. All required charging modes must be available in a differentiated number (e.g., many for micromobility charging, initially few for hydrogen charging). In addition, the complementary functions that a modern fossil-fuel filling station offers should be provided: toilets, snack and beverage sales, and services (e.g., cleaning and other maintenance of the vehicles). The hub should also include storage for micromobility batteries, cargo bikes, and parcels, as well as personal lockers. Facilities for professional drivers—such as changing rooms and showers—should be available. The required space exceeds that of existing concepts. The space MMHs require exceeds anything previously discussed. Given the huge and still increasing volumes of parcels that CEP service providers deliver, micro-hubs for e-cargo bikes and scooters are the wrong approach in terms of size to measurably reducing trips within the city. CEP providers need another type of MMH. With a minimum size of 1000 square meters, scalable up to 3000–5000 square meters, at least four and at best twelve MMHs would have to be developed in a city the size of Berlin in order to measurably reduce the traffic of CEP service providers. The locations would have to be close to the city center with the required infrastructure provided 24/7 without causing major problems for residents.

The hub should be strategically located in an open space in the city center, with street access from all sides. Unlike existing multifunctional hubs, this design deliberately omits a parking garage to present an alternative implementation model and clearly showcase the potential components. Implementing such a hub poses challenges in urban areas with limited capacity. The draft (see Figure 3) serves solely as an illustration of possible components. In practical applications, these components could be arranged vertically within a parking structure. The hub features a variety of supply options, including a centrally located dining area with seating and sanitation facilities accessible to all users. Sustainable energy generation on site is achieved through solar panels and a small wind turbine, contributing to a localized energy supply, with storage capacity provided by a local energy storage system. The infrastructure is designed to accommodate EVs, with most parking spaces equipped with charging infrastructure to enable direct vehicle charging. At the front of the hub, shared mobility services are co-located to enable seamless modal transitions. The car sharing section includes five parking spaces for station-based services and five for free-floating providers. A dedicated area for micromobility offers six scooters, twelve bicycles, and six mopeds from various sharing providers. In the immediate vicinity, eight

parking spaces are available for private vehicles, allowing individuals to park and charge their vehicles for up to three hours. Additionally, there is a bus stop and a pantograph-equipped parking space for buses. The hub serves as a terminus for a specific bus line and accommodates occasional stops for other lines. Taxi stands are also provided. Logistics operations are allocated in a dedicated area with a micro-depot, distinctly separated from the mobility station. This micro-depot is available for use by various service providers. The draft intentionally excludes general cargo fleets to reserve space for service providers already needing such solutions. A white-label solution is currently not considered viable due to anticipated implementation difficulties. Three roll-up doors allow trucks to deliver goods, and the area also supports parking for ten cargo bikes and five small electric commercial vehicles. At the rear of the hub, five dedicated parking spaces are reserved for special vehicles used in street cleaning and waste collection. These fleets exhibit synergies and are thus grouped together. Adjacent to the hub is an expansion area, currently serving as a parking lot, which could be adapted for various future needs, including additional components or new mobility solutions. To meet the varying demands, different types of charging infrastructure and power levels are available for fleet vehicles. The charging points are strategically positioned to be accessible from multiple parking spaces. Most vehicles utilize CCS interfaces, while a pantograph is used for the bus. It should be noted that the depiction in the accompanying figure is not to scale and does not show all charging points. The existing literature, practical examples, and expert interviews lack specific data that could be used to dimension the charging infrastructure accurately.



**Figure 3.** Design proposal for a multifunctional mobility hub based on [65].

## 5. Outlook

MMHs represent a significant innovation in urban mobility and logistics. By integrating mobility stations, micro-depots, and charging hubs into a single space, they optimize land use and avoid redundant infrastructure development. This integration not only addresses urban space constraints but also facilitates the transition to sustainable mobility options by supporting the use of electrified vehicles and renewable energy sources. Stakeholder interest in the concept is strong, as evidenced by expert interviews. Public transport providers, car sharing operators, and logistics companies recognize the potential benefits of shared infrastructure, including reduced costs and operational synergies. The collaborative design process further enhances the feasibility of these hubs by aligning

them with diverse stakeholder needs while preserving operational efficiency. Despite their potential, MMHs face several implementation challenges. One of the primary barriers is the heterogeneity of stakeholder requirements. Public transport operators, logistics companies, and private fleet owners have distinct operational needs, making standardization difficult. For instance, different fleets require varied charging solutions, from CCSs to pantograph systems, and each has unique space and energy demands. Moreover, only three examples of integrated MMHs have been identified globally so far. This limited number of real-world implementations restricts the empirical basis for drawing generalized conclusions and hampers the identification of best practices. This scarcity makes the design and operationalization of these hubs more challenging. Furthermore, the economic feasibility of MMHs depends on the development of sustainable financing models, including public–private partnerships and government incentives. Spatial constraints in urban areas also complicate implementation, particularly in densely populated cities, where space is already at a premium. The technological aspects of MMHs are critical to their success. The diversity of charging infrastructure required to support multiple fleet types underscores the need for robust planning. Additionally, integrating renewable energy sources, such as solar panels and wind turbines, can enhance the environmental performance of these hubs while reducing reliance on external power grids. Emerging technologies, including autonomous vehicles and hydrogen-based energy systems, offer exciting possibilities for future hub developments. These innovations could further enhance the efficiency and sustainability of urban mobility systems, although their integration will require significant investment and technological standardization.

Ecologically, MMHs hold the substantial potential to reduce urban congestion and greenhouse gas emissions. By promoting shared mobility and electrified transport options, these hubs align with broader climate goals. However, careful planning is essential to minimizing the ecological footprint of hub construction and operation, particularly in terms of land use and energy consumption.

From an economic perspective, MMHs present opportunities to stimulate local economies. By creating spaces that combine transportation, logistics, and commercial activities, these hubs can attract investments, foster entrepreneurship, and generate jobs. Their economic viability is further enhanced by additional revenue streams, such as leasing space and advertising.

Socially, MMHs can promote inclusivity by offering accessible and affordable mobility options. By serving as hubs for community interaction, they also foster social cohesion and create vibrant urban spaces. Ensuring active community participation in the planning and implementation of these hubs is essential to tailoring them to local needs and preferences. The successful realization of MMHs will require pilot projects as fast as possible to test their design and functionality under real-world conditions. These projects will provide critical insights into operational efficiency, environmental benefits, and user acceptance. In addition, longitudinal studies can help refine the concept and address the identified challenges. The exploration of synergies with cutting-edge technologies, such as smart grid systems, AI-driven logistics optimization, and dynamic pricing shared infrastructure, offers perspectives for future innovation.

A collaborative, multi-stakeholder approach is essential for scaling the concept. Policymakers must provide clear regulatory guidelines, financial incentives, and infrastructure investment to support the rollout of MMHs. Collaboration between public and private entities will be crucial in overcoming financial and operational challenges while ensuring that the hub meets diverse user needs. Standardization efforts, such as guidelines for hub design and operation, will also be critical to ensuring scalability and adaptability. While this paper provides a conceptual foundation, it does not include a quantitative assessment of

costs, benefits, energy flows, or operational efficiency. Future research should incorporate simulations and numerical estimations such as potential CO<sub>2</sub> savings, reduced vehicle kilometers, and expected charging demand. In addition, technical specifications and economic analyzes will be essential to validate the viability of MMHs and guide practical implementation, especially as real-world examples remain scarce. Ultimately, MMHs have the potential to redefine urban spaces. They can help create cities that are not only sustainable but also inclusive and economically efficient. By bridging the gaps between mobility, logistics, and community needs, these hubs can become a cornerstone of sustainable urban development for cities that are adaptive to future demands while remaining obliged to the needs of their inhabitants. Targeted research, pilot projects, and collaborative efforts can unlock the full potential of this innovative concept.

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