Civil Engineering

DOI: 10.23968/2500-0055-2022-7-4-36-48

SMART MULTI-FUNCTIONAL MICRO-HUB FOR NEIGHBORHOODS: SUSTAINABLE MOBILITY AND ENVIRONMENTAL RESTORATION IN HIGH-DENSITY SOCIAL NEIGHBORHOODS

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Abstract

Introduction: Outdoor parking lots have been a common and cost-effective solution for private mobility in European social housing districts built between the 1960s and 1980s, but this solution has significant, particularly environmental and spatial, impacts. The future of urban mobility requires changes to an electrified community model, based on shared vehicle fleets. **Purpose of the study:** We aimed to analyze the transport, social, and environmental improvements of a smart multi-functional micro-hub for neighborhoods — a theoretical proposal designed to facilitate the transition toward a decarbonized city. **Methods:** The literature is therefore reviewed and a case study of the city of Malaga is provided. **Results:** On the one hand, the findings show the environmental, economic, and spatial advantages of this model compared to traditional underground parking lots. On the other hand, the paper proposes the design characteristics that could be adopted by a particular type of buildings and their urban space. Finally, the paper discusses the implications of setting up a citywide network of micro-hubs and the ensuing benefits.

Keywords

automatic parking system, green parking, car sharing, public transport, active facades.

Introduction

Transport accounts for 50% of liquid fossil fuel consumption and for 25% of carbon dioxide (CO_2) emissions (International Energy Agency, 2017). The use of private cars as the main means of mobility in the urban environment causes serious economic (consumption of fuel and time spent looking for where to park in saturated spaces), environmental (noise and gas emissions), and spatial (related to undermining the public space and social relations) problems. The spatial impact of the extensive use of the private vehicle has led to the large surface area needed for parking, compared to low passenger occupancy rates. The ratio between the surface and the number of people transported is 6.7 m^2/person, which is very high as vehicles are parked for an average of 20 to 22 hours a day and between 82–95% of their useful life (Barter, 2013). Outdoor parking lots have been a common and cost-effective solution for private mobility in many European social housing neighborhoods built between the 1960s and 1980s and consisting of high-rise residential blocks without garages. Replacing those outdoor parking lots with underground ones in large tree-less areas partially solved the issue with the lack of parking. However, their building often required expensive construction work and only partially solved the spatial problem.

Research into sustainable and alternative urban transport plans is a priority in urban planning. However, public transport still cannot compete with private transport for many journeys (Graham-Rowe et al., 2011). According to Kane and Whitehead (2017), the future mobility disruption framework is based on a community mobility model using electrified, self-driving, shared vehicle fleets. Therefore, the incorporation of private-public interim systems based on the sharing economy driven by information and communication technologies (ICTs) is needed, particularly by means of developing car-sharing (Carlorosi et al., 2015; Kane and Whitehead, 2017; Shaheen and Cohen, 2013) and bike-sharing (Shaheen et al., 2010a) platforms. Furthermore, electrified vehicles can be charged while they are parked, unlike combustion vehicles that need to be taken to gas stations. This revolution in mobility offers new strategies to peripheral social neighborhoods with high population density and few parking lots, based on setting up a community car-sharing service for the local residents to supplement the available public transport. Thus, a resident does not need to own a vehicle but can rather choose from a diversity of different means of transport and thus can avoid having to invest in purchasing a vehicle, its maintenance and parking.

The Smart Multi-functional Micro-hub for Neighborhoods (SMMN) is a theoretical proposal designed to facilitate the transition towards a decarbonized city. This model combines both public transport and sharing system. The literature has focused on the intermodality of large urban or regional public transport systems, but there is little research at neighborhood scale. There are also few contributions that analyze public design, environmental and spatial improvements. In this vein, authors such as Maienschein-Cline (2014) highlight the crisis in the design and concept of garages and seek to turn parking into a catalyst for innovative suburban development. New parking systems based on automatic parking lots, which also include community amenities and facilities and are able to generate energy and important environmental benefits in the neighborhoods, are therefore needed. The first section reviews the scientific literature in relation to the main characteristics of this model at the neighborhood level. In the second section the methodology and case study are presented. The third section proposes its theoretical implementation in a high-density social housing neighborhood in the city of Malaga (Spain). Finally, in the discussion, the architectural and urban results can therefore be assessed and the impact of this model can be analyzed, along with its social and environmental improvements.

Background

The SMMN is designed to replace the model of privately owned vehicles parked in outdoor parking lots by an as-a-service mobility model. Furthermore, it is specifically designed to increase resources, green areas, and neighborhood spaces. The public space will thus be recovered for social and environmental uses thanks to a significant drop in the number of vehicles and space required for their storage. There are precedents in the literature that adress multi-functional hubs — architectural-engineering elements that combine multimodal mobility, public services, and parking zones in areas saturated by private transport (Carlorosi et al., 2015). Obsolete or underused major public transport infrastructures, such as train stations, are thus recovered. The Social Condenser concept of Soviet Constructivism, ecological theories, and the pedestrian Metropolis are incorporated, along with highly technological elements. However, this model is focused on large territorial ad urban mobility infrastructures. There is a gap in the application of those concepts at the urban microscale of neighborhoods and spatial results of their implementation. Similarly to multi-functional hubs (Carlorosi et al., 2015), the main characteristics of the SMMN are as follows:

(a) multimodal mobility hub that leads to a reduction in private traffic,

(b) environmental improvements with an increase in green areas,

(c) recovery of the public space,

(d) social hub and sustainable architectural design.

Multimodal mobility hub and reduction in private traffic

Multimodal hubs offer a minimum of two different means of transport. Their impact on reducing the use of cars depends on the size of the city area and the density of the existing public transport (Verbavatz and Barthelemy, 2019). According to Shaheen and Cohen (2020), the multimodal integration occurs at the meeting points of the mobility on demand (MOD) — consisting of sharing mobility services and public transport — with mobility as a service (MaaS). Alarcos and Ginés (2017) defined mobility stations as physical hubs of integrated multimodal mobility services managed using ICTs. Efthymiou et al. (2019) differentiated between seven categories of shared mobility, of which we focus on three: car sharing, bike sharing, and scooter sharing. The latter two are also known as shared micromobility. The use of shared mobility means an average vehicle reduction of around 50% (Martin et al., 2010), which leads to a drop in urban travel costs (Belk, 2014) and in private and public parking spaces (Shaheen et al., 2010b).

Car-sharing companies offer the residents of neighborhoods mobility without the need to own a vehicle. Car sharing — the model of hiring cars for short time periods and distances — stands out among the emerging transport systems driven by the development of ICTs (Tyrinopoulos and Antoniou, 2020). One-way car sharing or station-based car sharing is the most appropriate model for the residents of a neighborhood for their daily journeys, as the user will tend to use the vehicles for those trips and return to the same SMMN. Shared micromobility uses the same bicycle, scooter and other low-speed transport model (Shaheen and Chan, 2015), even though the use of shared electric scooters (e-scooters) is more desirable, as many of the journeys undertaken by the residents in a neighborhood are in the immediate vicinity (Bachand-Marleau et al., 2012; Fishman et al., 2015).

In the literature, we can find two types of neighborhood mobility hubs: those that come from an evolution of public garages and those organized by the residents themselves. In the first case, special mention should be made of *Mobiway* as a new concept of parking lot building that provides advanced services and the user with a multimodal selection system. It was developed in 2009 by Vinci Park in the business district of La Défense in Paris and had three characteristics (Bates and Leibling, 2012): (a) access to the greatest possible offer of transport in the district: private cars, public transport, car-pooling, taxis, motorbike taxis, bicycles, and hire vehicles; (b) a centralized system with specific information on all the mobility solutions available in the neighborhood; and (c) carefully designed parking waiting areas, integration with public spaces, and providing amenities such as news kiosks, car washes, baggage lockers, toilets, drinks dispensers, and umbrella hire. The model was implemented in one of the main financial districts and a wealthy residential area in Paris. There are no examples of its replicability in other types of middle-class neighborhoods.

In the second case, organized by the residents themselves, the Domagkpark residential complex with 1600 dwellings in Munich stands out. This is a sustainable mobility pilot project that is part of a residential complex. It has managed to reduce the vehicles/dwelling ratio to a rate of under 0.5 by means of shared electric vehicles with the possibility of their use being managed online (Alarcos and Ginés, 2017). However, the development of these multimodal platforms requires external factors (Efthymiou et al., 2019) offered by the neighborhoods for car sharing to be a success (see Fig. 1). Furthermore, the status of place has to be taken into account in the urban and architectural design of transport interchanges. Hernandez and Monzón (2016) made a distinction between at least three areas: commercial and amenities area, transport and transfer area — where the users deliver and receive the means of transport — and access area. The latter, with a greater urban ramification, must take into account the signage for the users (pedestrians, cyclists, and vehicles) and establish four access routes: vehicles, motorbikes, bicycles, scooters; the safe pedestrian area route; and the SMMN connection with public transport.

Environmental improvements of the Automatic Parking System (APS)

Incorporating APSs in SMMNs provides important environmental advantages. APSs are an alternative to conventional garages and traditional multi-level ramp parking, which occupy large spaces (Idris et al., 2009). APSs have a diversity of definitions and options (Wu et al., 2019), including automatic/robotic parking systems on several stories, which are an ideal solution for commercial and residential settings due to their four advantages — space efficiency, design flexibility, security, and sustainability — compared to traditional parking (Batra, 2014). APSs are high-density parking solutions that allow secondary vehicle access spaces, such as car ramps and lanes, to be eliminated; along with user access, such as space between cars, stairs, walkways, elevators for users, in addition to reducing the clear height. It is estimated that the building volume can be reduced by up to 50% compared to the same number of cars being parked in a multi-story conventional

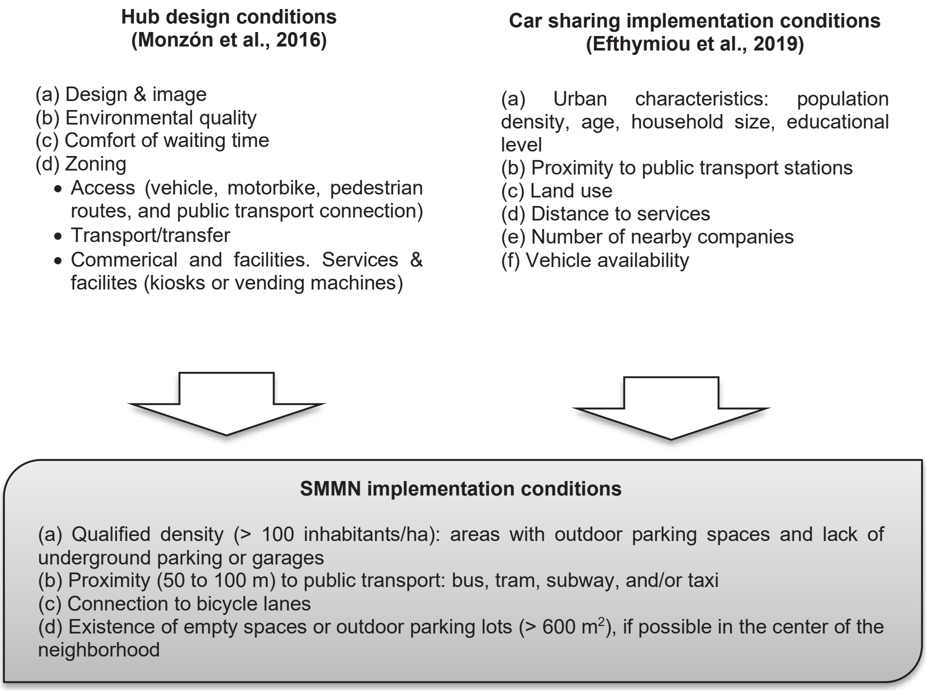

Fig. 1. SMMN implementation characteristics based on the design conditions of transport hubs and car sharing location. Source: authors

garage (Batra, 2014; Frankel, 1998; Robotic Parking System, 2020b). The design flexibility is achieved thanks to its modularity, and a 20-story-structure with an incorporated computerized system can be obtained. The greater safety and security is due to no access for users, and injuries, theft, or car damage can be avoided (Frankel, 1998).

Finally, in terms of an environmental approach, the green parking concept has been developed thanks to the smaller area occupied by the APS, which leads to a progressive gain in green areas due to the smaller need for parking space (Robotic Parking System, 2020b). This encourages the greening of compact areas of the city (Robotic Parking System, 2020a). CO_2 emissions can be reduced by over 80% due to the shorter time spent on construction and search for parking spaces (Batra, 2014). All these improvements are added to the reduction in traffic congestion and environmental pollution offered by an integrated transport system (Dacko and Spalteholz, 2014). There are also economic advantages due to the lower construction and maintenance costs (Robotic Parking System, 2020b). The construction cost is estimated to be 30% lower than that of a conventional underground parking lot (Frankel, 1998), or 55% if we take into account the maintenance and staff costs, particularly in large parking lots (900 spots) (Robotic Parking System, 2020b).

Recovery of the public space

The important space recovery by APSs increases opportunities for better urban design and increased walkability (Kane and Whitehead, 2017). The SMMN fosters the transit-oriented development (TOD) model (Loo and du Verle, 2017), as it reduces the neighborhood carbon footprint as well as improves quality and pedestrian/public transport. Neighborhood pedestrianization is a process that began with the traffic calming techniques developed in Dutch residential districts in the 1970s (Gehl, 1987) and which currently converge in the slow metropolis concept where the public space design is prioritized to encourage pedestrian mobility (Mezoued et al., 2021). As regards the size of the pedestrian residential areas, authors such as Rueda (2011, 2012, 2016) proposed the superblock as the optimum size for pedestrianization. It is roughly 400 x 400 metres in size and involves traffic calming measures to encourage walking and cycling, while the motorized transport is on the perimeter roads. Based on these dimensions, the location of the SMMN in a central position allows for 200–250 m ranges of journey, which would make equipping it with social amenities feasible, in a similar way to Clarence Perry's neighborhood unit (Perry, 1929), where its size is likewise restricted by pedestrian accessibility to local stores and amenities such as a school (Barcellos de Souza, 2006).

Social hubs and architectural renewal

In the literature, some authors advocate a necessary overhaul of the design and programming of uses of transport hubs and garages. The latter are traditionally side-lined in architectural culture (Kay, 2001), even with important values as elements of contemporary architecture (Henley, 2007). In this vein, APSs allow for a renewal of the design by adopting iconic photos of towers (Batra, 2014), either large ones such as the Car Towers (Wolfsburg, Germany, 20 stories and 400 vehicles), and the Emirates Financial Towers (Dubai, 9 stories and 1191 vehicles); or small ones of the Smart Car Towers project (Europe), transparent towers with a surface area of 100 m^2 (7 to 11 stories and a total of up to 43 vehicles). Furthermore, ARUP (2019) advocates for a new station concept adapted to the needs of the users and neighborhoods, with coworking facilities and even recreational activities. One such example is a mixed-used garage at Cincinnati University. In addition to parking spaces, it provides storage and meeting facilities for university departments (Seeley, 2008).

Methodology and case study

The methodology is structured into two phases. The first reviewed the literature on mobility hubs, green parking lots, APSs and shared mobility systems, with special emphasis on the neighborhood scale. We complemented the published literature with an online-based review. That allowed us to define a theoretical SMMN model. The second phase proposed the city of Malaga as a case study. According to Johansson (2003), the case study is fundamental in research fields with a practical component, such as architecture and urban planning.

Malaga is a coastal city in southern Spain with a population of around 569,000 inhabitants. Its metropolitan area includes 13 municipalities and a population of nearly 1 million inhabitants. The city is administratively organized into 11 districts and 297 neighborhoods. Its Sustainable Urban Mobility Plan (Ayuntamiento de Málaga, 2011) structures the city into large reduced mobility sectors demarcated by primary routes. Primary routes are the main arterial roads, which connect the main sectors. The study area is in the west of the city, within No. 27 reduced mobility sector (Fig. 2). It has an area of 19.3 hectares (193,280 m^2) and is demarcated by the Avenida de Andalucía (north) and Avenida de las Américas (east) primary routes and the Calle Conde de Guadalhore (east) and Calle Gerona (south) secondary routes. An area that is approximately the side of a 400 x 400 m superblock (Rueda, 2011, 2012, 2016) would facilitate its pedestrianization potential.

As of 2021, the sector had a population of 6094 inhabitants (IECA, 2022), which makes it an urban

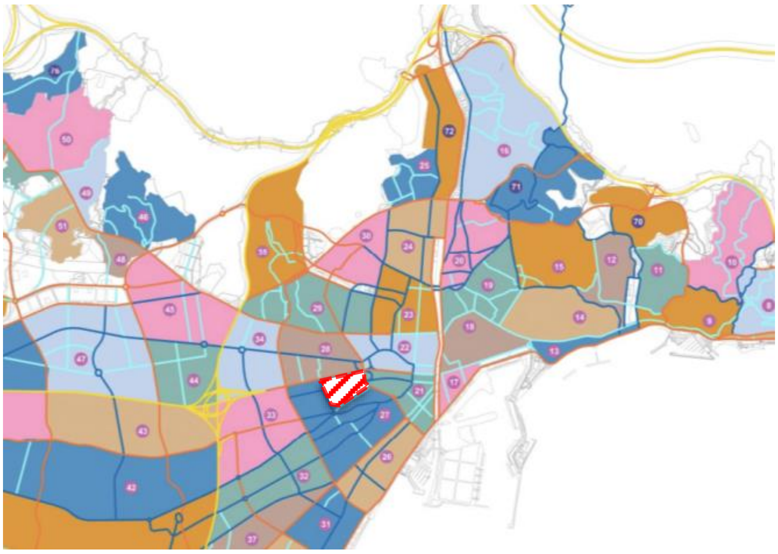

Fig. 2. Study area chosen from the sector structure established by the Malaga Mobility Plan. Source: Ayuntamiento de Málaga (2011)

area with a high average population density of 315.29 inhabitants/ha. The main age bracket in its age structure is between 16–64 years old (59.94%), followed by the over 65 (28.8%) and then the under 16 (11.26%). Fig. 3 shows the land use structure. The sector has two types of building: high-rise blocks (7–15 stories) with the plinth made up of offices on the first, second, and third floors, located in the north sector and built between 1975 and 1982; and 6-story residential blocks, with mainly neighborhood retail activity on the first floor, located in the east sector and built around 1967. It also has a district of single-family dwellings in the south sector. The amenities are limited to a school and a social services centre, with a rather low occupancy rate (2114 m^2, 1.1%). Green areas make up a very small surface area, with only 4832 m^2 (2.50%). Meanwhile, the surface area used for roadways is 33,700 m^2 (17.44%) and has a total of 1001 private surface parking spaces in outdoor parking lots and spaces alongside the road. That number is approximately the same as the number of dwellings without private garages (1096 dwellings).

The central outdoor parking lot is large and easily reached, as it is off Avenida de la Aurora and has good connections with public transport (buses), a

Fig. 3. Land use structure of the study sector with parking areas highlighted. Source: authors

bike lane, and pedestrian ways (Fig. 4). An SMMN located in this central area would mean that the outdoor parking lots could be eliminated and the central hub of the proposed superblock could be fitted out with amenities for its pedestrianization. Subsequently, the other outdoor car parking lots would be replaced by new SMMNs or by enlarging the existing one.

SMMN proposal

The creation of an SMMN environmentally restores an urban space that has been highly degraded by vehicle occupancy (Fig. 5) and provides a sustainable mobility solution for the neighboring housing. The three outdoor car parking lots provide a total of 236 public parking spaces, while the adjoining buildings have 919 private parking spaces in underground garages, which means a real current allocation of 1155 spaces. The parking needs according to the regulations are 1486 private spaces. The removal of the 236 spaces would mean that 567 parking spaces would be required. Those spaces could be provided by building a public parking lot or by opting for constructing an SMMN.

The three outdoor parking lots have a total of 4795 m^2 of tarmac and impermeable ground surface. The traditional option of building an underground parking lot with 567 spaces would require a three-story building with 190 parking spaces per level. For a ratio of 25 m^2/parking space, it is estimated that the building could have a built surface of 14,250 m^2 and a ground occupancy of 4750 m^2, i.e., the whole of the ground occupied by the outdoor parking lots. The SMMN option allows for a large area to be released by converting the outdoor parking lots into three green areas (Fig. 6) with a total of 3660 m^2 (2100 m^2 + 840 m^2 + 720 m^2), which accounts for 76.33%, in addition to the building roof with a surface area of 915 m^2, which would be used for allotments and relaxation areas.

The SMMN incorporates three distinct parts (Fig. 7): (a) the shared mobility module with a ground occupancy of 915 m^2, where the electric car-sharing storage is on the four upper levels and the first floor is used for the shared micromobility; (b) the facilities and amenities module of the neighborhood consisting of an 8-story tower with a ground occupancy of 220 m^2 metres; and (c) the first floor, which is a specially-

Fig. 4. Adaptation of the theoretical superblock model to the case study, showing the surface area renovated by the SMMN. Source: authors

Fig. 5. Photo of the outdoor parking lot being studied. Source: authors

Fig. 6. Environmental recovery of 3660 m2 as a result of eliminating the outdoor parking lots (left) after setting up the SMMN (right). Cycle lane (red line) and concentration of public transport: buses (red dot) and taxis (blue dot). Source: authors

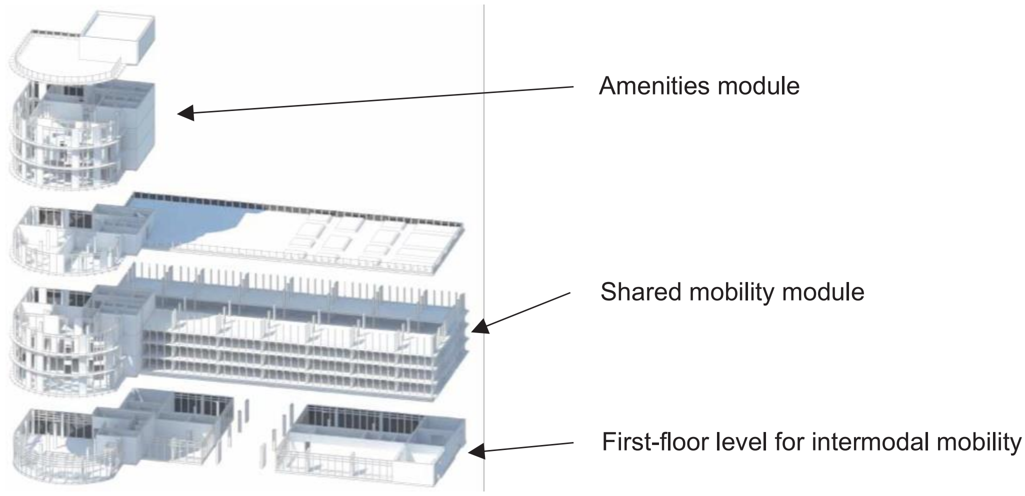

Fig. 7. SMMN modules and functional parts. Source: authors

designed area, as it is the contact area of the building with the SMMN and the connection point between the different means of transport. The car-sharing and bike-sharing office (85 m^2), the e-bike and bicycle storage, vehicle maintenance and cleaning are located there, along with shops and coffee bars. Furthermore, special importance is given to keeping pedestrian, bicycle, and vehicle access totally separate for greater security.

Given that the car-sharing module allows the vehicle fleet to be reduced by 50%, the size of the SMMN is designed for just 284 vehicles. The module to be used for car parking has a surface area of 915 m^2, with 5 levels and a built surface area of 3660 m^2. The low private vehicle occupancy rate, which ranges between 1 and 1.5 people per vehicle, allows a more diversified offer to be adjusted to the standardized size of family utility vehicles, which are usually 4–5 seaters. It is therefore possible to differentiate between three types of storage place size (Fig. 8): A1 for a maximum length of 3 m, single-seater (e.g., Renault Twizy e-tech electric) or two-seater (e.g., Smart EQ Fortwo); A2 for a maximum length of 4 m (e.g., Citroën C-Zero); and A3 for a maximum length of 5 m. Applying this differentiation can reduce the width of the building, compared to a traditional parking lot where all the spaces are sized for a private owner, who tends to purchase a vehicle with the greatest number of features (the same vehicle is used to travel alone to work and to travel with the family of 3 or 4 people). The SMMN would thus require 71 modules per story (23 A1, 24 A2 and 23 A3), with a total of 284 vehicles on the four levels.

Building a parking lot at the surface level means that its roof and façades can be used, unlike in traditional parking lots, where they play a minor role. The façades in SMMNs are active skins that play an important function in the environmental recovery of the urban space. There is a system

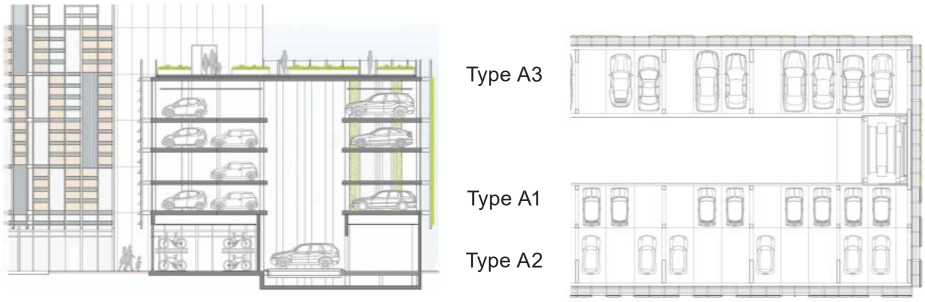

Fig. 8. On the left: mobility module section; on the right: different platform sizes for a diversified vehicle offer. Source: authors

to collect and reuse rainwater on the roof (Fig. 9). Demartini et al. (2019) showed the beneficial effects of water accumulation systems to avoid overloading the sewage network in climates with torrential rain such as the Mediterranean. Savings of 87% were reported in office buildings in the United Kingdom (Ward et al., 2012). Rain water can satisfy over 60% of the garden irrigation demands both in single- and multi-family buildings (Domènech and Saurí, 2011). In the case study and according to Malaga rainfall data, the average water catchment is 485 mm/year/m^2, which, for a roof surface of 900 m^2, means that a total of 436,500 l/year can be obtained. Its storage in tanks under the first-floor joists means the filtered water can be piped to irrigate the roof allotments, the hydroponic panels and used tp clean vehicles.

Tulpule et al. (2013) showed the feasibility of the charging points for plug-in electric hybrid vehicles and electric vehicles located in workplace parking lots. Part of this energy can be supplied by photovoltaic panels in the façades, an emerging and necessary system to harness solar energy in the built environment (Xiang et al., 2021) either as full panels or slats. Tablada et al. (2020) defined productive façades as systems integrating photovoltaic systems and vertical farming, which could contribute to transforming buildings and communities from consumers to producers. The incorporation of environmentally-friendly panels would add the possibility of capturing CO_2 (Yoshioka et al., 2013).

Thus, the north-facing façades in the proposed model would have passive systems to improve the air quality and create favorable urban microclimates by incorporating green concrete and plant panels, while the solar panels and photovoltaic slats to generate electricity for the building's self-consumption and the electric vehicle fleet would be located on the other façades (south-, east- and west-facing) (Fig. 10).

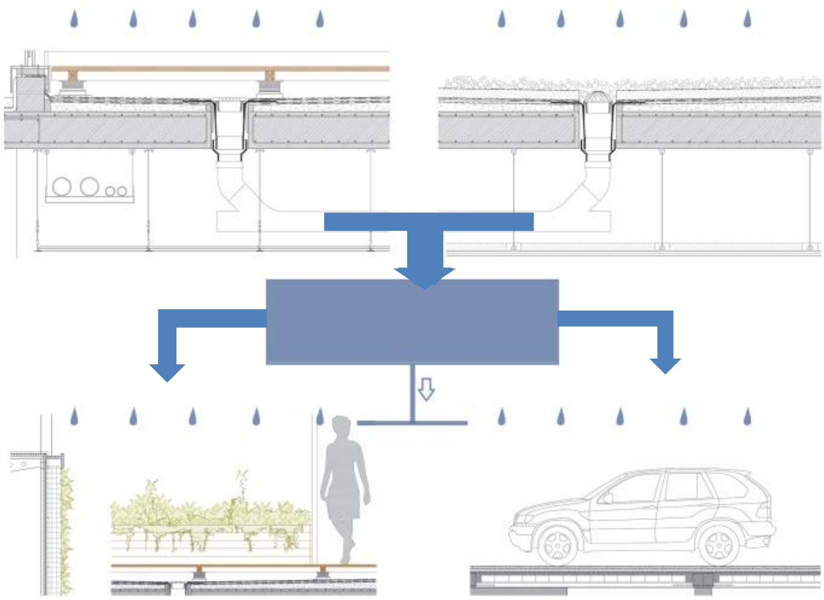

Fig. 9. SMMN active roof collecting rain water to irrigate allotments and clean vehicles. Source: authors

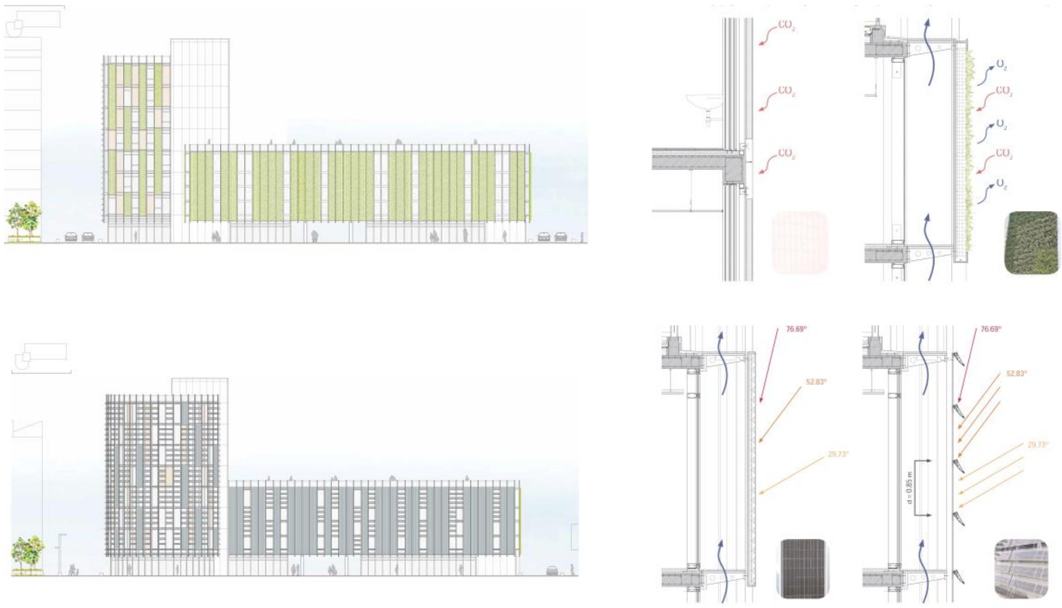

Fig. 10. Above: north-facing active skins comprising plant panels and green concrete; below: east, south- and west-facing active skins comprising photovoltaic panels and slats. Source: authors

Discussion

The SMMNs involve adapting the multi-dimensional hubs of large transport infrastructures (Carlorosi et al., 2015) to the intermediate or neighborhood scale. Therefore, environmental improvement — with the recovery of green space — and improving amenities are closely related to the residents' community benefitting from the mobility service. In this regard, the SMMN is at the intersection between the Mobiway model (Moran, 2009) and the model proposed in Domagkpark (Alarcos and Ginés, 2017). The first contributes to the concentration of mobility services and the second — to the relationship with the residents' community. In this vein, research should continue into the possibility of creating social-based cooperatives as the business model to manage this infrastructure. The SMMN is designed for residential neighborhoods and middle-/low-income population sectors. Thus, personalized mobility without having to purchase a vehicle can be an incentive, particularly as the change to electric technology requires a charging infrastructure and users do not have parking spaces.

On the other hand, its implementation throughout the city would generate a second level of interchanges. Thus, in the Malaga case study, whose intermodal system is currently made up of the metropolitan interurban and urban transport stations associated with large transport and/or social amenities (Fig. 11, on the left), the SMMNs would generate a secondary network associated with the residential blocks. For each of the Sustainable Urban Mobility Sectors (Ayuntamiento de Málaga, 2011), an area of opportunity can be pinpointed, which will also be a social and environmental regeneration space (Fig. 11, one the right). Thus,

Fig. 11. On the left: primary system of large transport interchanges in Malaga; on the right: overlapping of the secondary system consisting of the SMMN network in different superblocks. Source: authors

each resident would be able to travel using different SMMNs, which would generate a large network of interchanges and facilitate more sustainable mobility for the whole city.

The integration of the SMMN of the public transport system would foster transit-oriented development (TOD), help reduce the carbon footprint, reduce the number of private vehicles, and increase the public space. The latter offers important environmental improvements compared to the underground parking lots, as SMMNs release land that allows evapotranspiration, and, therefore, the environmental advantages are much greater as it helps to recharge the aquifers. It should be stressed that the case study allows the existing green area surface of 4382 m^2 to be duplicated to a ratio of 1.2 m^2/inhabitant. This results in the creation of a neighborhood network of green areas that would approve its accessibility and also foster, in tandem, the development of a network of urban allotments.

As regards the facelifts of the garages, SMMNs are not focused on iconic and aesthetic design but rather on being core elements in the environmental improvement of the existing neighborhoods and facilitate the transition to electricity mobility in urban sectors, with difficulties for vehicle charging due to the lack of space. In the new mobility revolution, parking lots can no longer be mere spaces containing vehicles, but rather they have to be active hotspots of mobility, accessibility, urban amenities, and obtaining energy.

Another advantage of SMMNs over traditional underground parking lots is that the ground occupancy is minimum, as what is occupied by the building itself is recovered on the roof. It also allows for the development of a large surface of active skins with environmental improvement functions (increasing solar and water capturing, and green façades). The development of façades to capture photovoltaic energy helps to produce electricity to charge electric cars and thus reduce electricity demand. Similarly, collecting rainwater allows water consumption for cleaning the vehicles to be reduced; and developing green façades turns the infrastructures into vertical allotments that foster food production at the neighborhood scale (Tablada et al., 2020).

Therefore, given the need to renew the architectural design (Kay, 2001), the SMMN shows that this renewal must not be exclusively aimed at a facelift inspired, e.g., by the Car Towers (Wolfsburg, Germany), but rather it must be focused on increasing the environmental improvement that this type of facilities may produce, particularly in the existing city. In this vein, it should be noted that the case study in question tallies with open block and high-density neighborhoods. This research should continue by analyzing the feasibility of the model in other urban areas such as low-density zones and in historical centers where free spaces are rare and where the introduction of this type of environmental improvement infrastructure seems not to be very viable.

Funding

This research was funded by the 1st Smart-Campus Plan of University of Malaga [project Microsol].

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