Service design in electric vehicle sharing: evidence from Italy

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Abstract: In recent years, the issue of vehicle road sharing has attracted growing attention from both researchers and operators, as a potential instrument to improve the sustainability of urban mobility or transport systems. Beside the general concept, different operational models, managerial and technological solutions have been developed, leading to a high diversification of possible vehicle sharing configurations. This heterogeneity entails a considerable complexity of the service design phase, though few academic contributions tackled this specific problem and most of the papers focused on the dynamics of adoption and use of the service itself. To fill such a gap, this paper aims to present the approach followed in the design phase of an electric vehicle sharing service for the city of Milano. The methodology adopted in this work is based on the idea that a vehicle sharing service needs to be configured to answer to specific mobility needs coherently with the characteristics of target customers. To explain this idea the methodology was articulated into four steps, which are reported in detail in this study: (i) mapping of mobility profiles and service performances, (ii) competitive analysis, (iii) development of the service configurations and (iv) development of the evaluation model.

1 Introduction

Car sharing has been introduced as an innovative approach to urban transportation, based on the idea of providing individuals with access to a shared fleet of cars, rather than a single privately owned one. It consists in a use-oriented service, where users can reserve a car when they need it and pay for it on a variable basis (e.g. per kilometre and/or per unit of time) [1, 2]. Car sharing services have a decades-long history, starting from the first experience documented in 1948 in Zurich. However, until the 90s, almost all car-sharing organisations resulted in failure [3], because of the difficulties of involving enough users to ensure the economic sustainability of these initiatives [4]. Some pioneering attempts of services using electric vehicles were conducted, for instance, in the late 90s in Turin with the project 'Elettra Park' [5] and in Paris with the project 'Praxitèle' [6]. Only recently, this situation started to change, with an improvement of the level of penetration of car sharing in urban areas and estimates for the next few years foreseeing a significant expansion. According to recent research, in fact, subscribers worldwide totalled 800 000 users, at the end of 2012, with about 22 000 vehicles and the forecast for 2020 is surprisingly high with 15 million users and a corresponding fleet of 240 000 vehicles [7]. One of the most successful experiences of electric car sharing is Autolib, which – by January 2014 – had deployed 2012 vehicles, 857 stations and centers with a total of 4358 parking and charging spots in and around Paris.

From a financial point of view, the expansion of car sharing service led to a global turnover of about one billion Euros (end of 2013) with a forecast of 6.3 billion by 2020 and with an average break-even time of about three years [7].

Coherently with these numbers, also in Italy the car-sharing market has been experiencing a period of growth, in particular thanks to the recent introduction, in Milano city, of a new service based on the free-floating model, for which vehicles are parked within predefined areas without allocated parking lots. In Italy, the number of subscribers in 2013 was of 90 000 people, with an estimate of 500 000 for 2020. This huge growth is confirmed by the results of the main operator free floating operator (Car2Go), which at the end of 2013 recorded an average of 25 000 hires per week with a mean duration of 25 min.

Car sharing allows one to pull resources – that is, cars – ensuring their more efficient exploitation, with potential benefits at both the individual and community level. Individuals, in fact, can reduce their journey costs waving the cost of ownership of the car [8, 9]; the broader community can benefit from positive environmental effects [10], such as a decrease in polluting emissions [11], vehicle-kilometres travelled [12], average number of vehicles per household [13, 14]. For instance, estimates state that, for every Zipcar rented car, there are 15 fewer owned cars on the road [15]. A recent study, carried out in

some metropolitan car-sharing markets in the US, seems to support such effect on ownership: one car-sharing vehicle would displace 32 vehicles that would have otherwise been purchased [16].

In terms of driving behaviour, according to [17], members drive 31% less than when they owned a personal vehicle. A survey made on members of major North American car sharing organisations seems to confirm these data, finding an average vehicle kilometres decrease in the before-and-after mean driving distance of 27% (observed impact, based on vehicles sold) and 56% (full impact, based on vehicles sold and postponed purchases combined) [18]. Considering the decrease of car sale among car sharing users, about 50% of members had either shed or waived the acquisition of a vehicle as part of their car sharing membership [18] and 45% indicated that they expect to avoid a future purchase [16]. The decrease in motorisation rate has a positive effect on road space use, a limited resource in urban area, even though this requires to reserve parking slots for car sharing fleets, limiting the areas available for the private use. This is just an example of possible trade-offs arising from the implementation of car-sharing services, which should be taken into account for a sound evaluation of its effects. As regards the latter effect, floating car services use efficiently urban space, because there is not a space assigned once for all to the car sharing system. More in general, some authors, for instance [19], challenge the guaranteed sustainability of car sharing services. The challenge is to integrate the car sharing service as one element of a multi-modal transport system, and not reproduce or incentive the dominant mode of private passenger car transport [20].

Over the years, different operational models have been proposed and implemented, leading to the rise of different service configurations. The original car sharing model (generally referred to as 'neighbourhood car sharing') is characterised by a network of shared-use vehicles settled in strategic locations, where the user accesses and returns the vehicle [21]. Instead, in the 'station cars' model, parking stations are settled at public transport stations, and commuters can pick up vehicles for covering the trip between their home and the station or the station and their working place [21]. In the 'multinodal shared-use vehicles' model, there are multiple stations that are placed at points-of-interest (hotels, shopping malls, tourist attractions and so on) and users are free to leave a vehicle parked at any station, without having to return it to the same location from which it was accessed [21]. In the 'free-floating car sharing' model, traditional fixed stations are substituted by extended areas where the car is allowed to be hired and left after the rental. The vehicles are distributed freely over that area and can be tracked by the customer via internet or mobile phone applications [11].

Beside the diffusion of different operational models, also the characteristics of car sharing initiatives have changed over time following different technological and social trends. For instance, there has been a shift from the idea of car sharing to the idea of vehicle road sharing, integrating different types of vehicles (bikes, motorbikes, small vehicles, cars and so on) and technologies (ICE, electric vehicles, low emissions vehicles and so on) [22]. Furthermore, the overall organisational structure, capital stock and liability underwent some relevant changes, through the introduction of the so-called personal car sharing ('peer-to-peer car sharing'), which involves short-term access to privately owned vehicles.

The increasing complexity and variety of car sharing approaches make the role of intelligent transport systems (ITSs) more relevant; ITSs are currently considered a critical element in connection to the development and management of vehicle sharing systems. In a generic service, a control centre (able to interact with both users and vehicles) and an on-board unit (the bridge between control centre, vehicle and user) constitute the core of the system. More and more often the interactions between user and system are mediated by a smartphone (through a dedicated app) [23], able to eliminate the need of a physical key (both a real key or a magnetic card) [24]. In a very close future, relocation in car sharing system will play a relevant role: free-floating car sharing systems, whose popularity is increasing, generally has not a well-defined relocation strategy. Because of that, vehicles can get stuck in areas of low mobility demand while needed in zones of higher demand. To make the system more efficient and more profitable, this imbalance of supply and demand could be adjusted by applying dynamic relocation strategies [25], based on the users or more traditionally on the operators [26], which require ITS tools to perform efficiently. Another improvement of the quality service, in a long term scenario, could be represented by autonomous driverless vehicles that could play a relevant role for many existing business models, including car sharing. Shared autonomous vehicles could provide a solution in avoiding users for searching for and walking long distances to an available vehicle. Moreover, they could provide car sharing organisations with a way of seamlessly repositioning vehicles in order to better match demand [27].

These trends have determined a rise in the complexity of the design phase of vehicle sharing services, highlighting the need of configuring the service so to answer to specific mobility needs. Different users are characterised by different mobility profiles, which correspond to different 'purchasing behaviours' in terms of trips performed by vehicle sharing users and different vehicle sharing services have the potential of responding to some mobility profiles better than other, depending on the specific performances of the service itself.

Moving from this consideration, this paper aims to present the approach followed in the design phase of Green Move, a project aimed at the development of an electric vehicle sharing service for the city of Milano (Italy) [28]. The main idea behind Green Move is to design a flexible service of vehicle sharing, based on electric cars and open to a wide range of users and different vehicles. The system is made easily accessible thanks to an add-on device, the Green e-Box [29], which represents a bridge between the user, the vehicle and the control centre, and allows any vehicle to join the service network, offering the possibility of establishing peer-to-peer approaches.

The rest of the paper is articulated as follows. Section 2 presents the research methodology, in terms of the overall approach followed to support the service design phase. Sections 3–6 go into depths of each phase and provide an outline of the key outputs. Section 7 discusses the results of the project and draws some more general conclusions.

2 Research methodology

The methodology embraced in this work relies on the assumption that the concept of vehicle sharing is articulated and complex and it can be configured in different ways,

leveraging on specific service performances. This is evident considering the key characteristics of the emerging operational models, compared to the original neighbourhood model. For instance, the station cars operational model stresses in particular the co-modality performance, because the positioning of car sharing stations at public transport stations favours the use of different modes of transportation. The multinodal operational model leverages on space flexibility, since it allows users to avoid some limitations related to the hire and release of the vehicles. The free-floating operational model further stresses flexibility, in terms of both space flexibility since vehicles can be released in any place, within the selected service areas, and time flexibility since vehicles can be hired and left based on their immediate availability. These different features of a vehicle sharing service enable the users to perform different types of trips, hence answering to different mobility needs.

Based on this consideration, the methodology followed in this work emphasises the link between different mobility needs of potential users and different performances of a vehicle sharing service. In details, the methodology is articulated into four phases: (i) mapping of mobility profiles and service performances, (ii) competitive analysis, (iii) development of the service configurations and (iv) development of the evaluation model.

The first step consisted in the mapping of mobility profiles and service performances based on a literature review on car and vehicle sharing. To guide the review, we first identified a set of keywords that could be used to search academic databases (such as car sharing, vehicle sharing, e-mobility and mobility sharing initiatives) and we identified a list of relevant sources in connection to the aim of the study. Collected papers were content analysed, leading to the identification of eight mobility profiles and ten service performances (see Section 3).

The second step consisted in the competitive analysis, aimed to outline the key characteristics of the vehicle sharing initiatives active in the area of Milano (GuidaMi, E-vai, Car2Go). Data were collected with semi-structured interviews to key informants in the organisations and documental analysis. Data sources include website of vehicle sharing operators, official documents and presentations, press release, internal presentations. This step allowed to position the new vehicle sharing initiative compared to the existing ones, in order to differentiate the service and capture a different market segment (see Section 4).

Then, based on the literature analysis and the competitive analysis, we proposed three vehicle sharing configurations, which answer to some specific mobility needs, not fully captured by existing general services and that appeared to be particularly suitable in connection to the territorial characteristics of Milano (see Section 5).

Finally, we developed a multi-criteria evaluation model to support the design of the service configurations, in order to specify the characteristics of the service performances (see Section 6).

3 Mapping of mobility profiles and service performances

This section reports the results of the first step of the research approach – that is, the mapping of mobility profiles and service performances.

3.1 Mobility profiles

Mobility profiles describe at a high level the basic characteristics of the trips performed by the potential users. A car trip is defined as a derived demand, implying that the primary benefit is not the travel itself, but rather the opportunity to access other goods and services. Hence, it is significantly characterised by the type of need, a person aims to satisfy by moving from one place to another and these needs can vary significantly depending on different characteristics of the user, such as age [30]. In fact, from the childhood, people have distinct mobility needs, which can largely be categorised by life stages: primary school children move to and from school, generally escorted, by car, cycling or walking, older children start moving independently, commonly by public transport, grown-up people travel to work, escort children to school, shop and so on.

Therefore mobility profiles represent the specific 'need of mobility' to whom the vehicle sharing service is aimed to answer [31] and the acknowledgement of the existence of different mobility profiles corresponds to the recognition of a potential segmentation of the target users of the vehicle sharing service.

Based on the literature review, eight high-level mobility profiles have been identified:

- *Commuter:* regular trips between home and workplaces (or schools);
- *Shopping:* recreational travel in the city centre, generally characterised by multiple and unpredictable stops;
- Neighbourhood trips: travel focused in local areas for daily activities (e.g. shopping, driving children to school);
- *Tourist in the city:* recreational travel aimed at visit different attractions;
- *Night life:* recreational travel during evening and night;
- *Business trip:* business travel between stations/airports and a meeting place;
- *Moving in the campus:* travel limited in certain space (e.g. campus);
- *Business fleet:* travel for business purposes performed by the employees using a vehicle sharing fleet.

3.2 Performances

Performances refer to the key characteristics of a vehicle sharing service that allow one to answer to different needs of mobility – that is, different types of trips. Since different performances often entails some trade-offs, a vehicle sharing service should be configured focusing on those performances that are coherent with the types of trips it aims to privilege.

Based on the literature review, we identified ten performance dimensions [32, 33]:

- *Capillarity:* number and location of the stations. Higher capillarity reduces the access time to the system, making a vehicle sharing service more similar to the car ownership and allows to capture a larger potential demand [12];
- *Flexibility:* lack of constraints in terms of choice of the release station and scheduling time. Flexibility can be related to two main dimensions:
  - *Space:* the customer is allowed to release the vehicle in a station other than where the vehicle was picked up;

- *Time:* the customer is allowed to access the vehicle without reservation and/or to make an open-end reservation, without fixed time limits [34];

- *Co-modality:* possibility to integrate the vehicle sharing service with other public transport (underground, train and so on). This concept can be declined into:
  - *Interoperability:* use of integrated access devices (e.g. a single smart card) valid for different types of transportation;
  - *Multimodality:* location of parking stations near the public transport;
- *Rate:* price charged to the customer for the vehicle's usage. It consists of different components, such as subscription costs, kilometre and hour rate, penalties, which can be totally waved or incremented;
- *Availability of incentives:* forms of facilitation to encourage service use; they include, for instance, access to free parking areas and limited traffic areas;
- *Vehicles:* number and types of vehicles available; the vehicles must be adaptable to different needs in terms of interior (seats and luggage) and range distances;
- *Easiness of access and use:* simplicity of the procedures to access and use a vehicle, so that it does not differ significantly from privately owned vehicles. It can be related to:
  - *access time:* opening/closing hours that determine when the vehicle can be accessed by users (the optimal situation is 24 h);
  - lock/unlock system;
- *Easiness of the payment system:* simplicity of the payment process, which allows the customer to quickly access the service without lengthening the total journey time or creating barriers to the service use (e.g. mandatory request of the credit card);
- *Easiness of the reservation system:* simplicity of the process required to reserve a vehicle and book the arrival station (in the multinodal service);
- *Additional services:* ancillary services that complement the basic performances.

4 Competitive analysis

This section presents the results of the competitive analysis concerning the main vehicle sharing initiatives active in Milano. For each vehicle sharing initiative, first, a brief description of the service is provided, then the analysis is structured along the two dimensions presented in section 3: performances and mobility profiles.

4.1 GuidaMi

GuidaMi is one of the oldest car sharing programme established in Milano. It was started in 2004 as a joint project of Milano Municipality and the Italian Ministry for the Environment. Later on, in 2007, it was officially assigned to the local public transport company, ATM SpA, and, in January 2010, through the acquisition of the other car sharing initiative active in Milano, 'Car Sharing Italy Srl', it became the only car sharing provider in the area and the largest at national level. GuidaMi adheres to ICS (Iniziativa Car Sharing), a project promoted by the Italian Ministry for the Environment, which brings together and coordinates the main car sharing organisations active in Italian cities, so that the users of any car sharing organisation can access car sharing services in any city that participates to the project, without subscribing a new membership.

Performances: GuidaMi relies on the neighbourhood operational model with parking stations located in different areas of the city, including residential districts and points of interest. Users can reserve a car on the internet or through a call centre, choosing time, pick-up station as well as their preferred vehicle. The range of vehicles offered comprises 14 different car models divided into five categories, and hybrid and electric cars. Vehicles accessibility is ensured by a smart card, and users find the keys inside the car. After completed their trip, they have to return the car to the station where they picked it up (two way service).

Concerning costs, members pay an annual fee of 120 €, which can be reduced by 50% if a member has a season ticket to public transport whereas the usage cost depends on the category of vehicle and considers both time and kilometres travelled.

Finally, it is worth noting that GuidaMi has established a partnership with IKEA with mutual benefits for the two actors. In particular, IKEA customers are entitled to a discount of 50% on the first subscription to car sharing and, conversely, GuidaMi customers are entitled to a discount of 5 € at IKEA going there with a shared car.

Table 1 summarises the performances of the service.

Mobility profiles: Based on available documents and customer surveys, the mobility profiles mostly served by GuidaMi resulted to be neighbourhood and shopping trips. According to a recent survey performed by the company almost half of the trips have occurred for motivations related to recreation, leisure and visits to relatives or friends. In a few cases, the service has also been used by corporate clients for business trips [35].

4.2 E-vai

E-vai is a mainly electric car sharing service promoted by the Lombardia Region and integrated with the regional railway system. It was founded in 2010 and it has gradually spread across the region covering different cities like Milano, Varese, Como, Erba and Pavia. E-vai stations are generally settled at railway stations of the cities involved, since parking stations are located inside the railway parking area. More recently, a station has been established at the two airports of Milano Malpensa and Milano Linate and in the next months the service will be extended to other hubs of the regional public transport system.

Performances: E-vai relies on the station cars operational model, since commuters can pick up vehicles for covering the trip between their home and the station or the station and their working place. However, recently, the company has tried to broaden its target market, addressing a new segment, which is represented by business fleets.

Users can reserve a car by calling a toll-free number, from the website or directly in the E-vai points. The service consists of several electric vehicles and of a bi-fuel one. In detail, in the car park there are cars like the Mitsubishi i-MiEV and the Fiat Panda, both with electric drive, the Fiat Punto EVO powered by petrol and LPG, and finally the Fiat 500 petrol but with twin air technology. Vehicle accessibility is ensured with a SMS codes or a mobile application. After completed their trip, users can return the car in a different station than the starting one (one way service).

Concerning the costs, users can choose among two different fee options: gold customers (regular users) pay a fixed annual fee and a variable fee, which depends on time of use; silver customers (occasional users) pay only on usage base, without

Table 1 GuidaMi performances

capillarity	72 parking stations in the city of Milano and 6 parking stations out of town
flexibility – space	two way service
flexibility – time	no open-end reservation
multimodality	some stations are located near the local public transport
interoperability	single card for car sharing and local public transport
rate	2.2–3 €/h and 0.45–0.8 €/km
availability of incentives	in Milano, access to bus lanes and the Limited traffic Zone. Area C and blue parking stripes 'Sosta Milano' are free, and it is also possible to park on yellow lines for residents
vehicles	14 different car models divided into five categories. there are also two types of low environmental impact vehicles
easiness of access and use	cars are available 24 h on 24, every day of the year. laying the smart card on the windshield of the car it is possible to open the doors
easiness of the payment system	automatically by credit card
easiness of the reservation system	it is possible to book a car online or through the call centre, from two months up to one quarter of an hour before use. The booking can be carried out all year round, 24 h on 24, 7 days out of 7
additional services	IKEA partnership, service discount for car scrapping and public transport users

Table 2 E-vai performances

capillarity	45 parking stations in the Lombardia region
flexibility – space	one way service paying an overcharge for drop-offs in different cities
flexibility – time	no open-end reservation
multimodality	stations are located near railway stations
interoperability	different card for car sharing and local public transport
rate	5 €/h for electric vehicles or 2.4 €/h and 0.48 €/km for petrol cars
availability of incentives	access to bus lanes and the Limited Traffic Zone. blue parking stripes are free and it is also possible to park on yellow lines for residents
vehicles	eight different car models
easiness of access and use	cars are available 24 h on 24, every day of the year. using a SMS system or a mobile application it is possible to open the doors
easiness of the payment system	by credit card, bank transfer or cash
easiness of the reservation system	it is possible to book the car by calling a toll-free number, from the website or directly at the E-vai points
additional services	no additional services

any annual membership fee, but the cost of the rental is 5 euros higher compared to gold members. Table 2 summarises the performances of the service.

Mobility profiles: Although E-vai operational model is inspired by the station cars paradigm in order to complement the public transport service, interviews performed with service managers highlighted that the mobility profiles mostly served by E-vai are neighbourhood or business trips. In particular, the cars are often used by people living in the surroundings of the stations for two ways trips aimed at shopping and other small activities or by professionals from small organisations to replace the taxi service.

4.3 Car2Go

Car2Go is a car sharing initiative promoted by a joint venture between Daimler and Europcar. The Car2Go system was rolled out in Ulm, Germany, in 2008 and is now operating in 20 cities in Europe and North America, mainly in Germany and the USA with over 7000 smarts in use. Milan is the first city in Italy to open the service in August 2013.

Performances: The service is based on the free-floating operational model. As with other cities part of the Car2Go car sharing programme, the smarts can be used when needed and then left in any public car park available in the area covered by the service. The initial fleet consists of 150 smart fortwos, with another 300 cars becoming available until the middle of September 2013.

To access the service, users must register on the Car2Go website. Then, to use the service, no forward booking is necessary: once registered, users get a chip card and a pin number. The card opens the car, drivers then insert their pin, answer a few questions about the condition of the car and drive off, leaving the vehicle at another place of their choice. Registered users only pay for their actual usage with an all-inclusive price per minute (taxes, insurance, fuel, parking costs and congestion charges linked to the so-called Area C). The full cost of the service is 0.29 €/min or 14.9 €/h. Table 3 summarises the performances of the service.

Mobility profiles: So far, there are no data available about the mobility profiles served by Car2Go in Milano. However, it is possible to make reference to the mobility profiles reported by the literature in connection to Car2Go projects in other countries. This service is in fact characterised by a very high heterogeneity of types of trips supported. Based on aggregate data collected through users surveys, the pattern of trips performed includes (reported interview with Car2Go CEO Nick Cole): moving downtown, towards offices and financial districts during the day, moving towards residential areas in the evening.

5 Development of vehicle sharing configurations

The literature review confirmed the existence of different mobility profiles, which can be better satisfied by configuring the performances of the vehicle sharing service in a coherent way – that is, matching service performance and mobility profiles.

The competitive analysis carried out on the vehicle sharing services active in the territory of Milano has identified some recurrent mobility profiles and highlighted the existence of

Table 3 Car2Go performances

capillarity	450 cars distributed on 80 sq km area
flexibility – space	one way service
flexibility – time	no reservation
multimodality	there are not physical station
interoperability	different card for car sharing and local public transport
rate	0.29€/min or 14.9 €/h
availability of incentives	area C and blue parking stripes 'Sosta Milano' are free, and it is also possible to park on yellow lines for residents
vehicles	smart fortwos
easiness of access and use	cars are available 24 h on 24, every day of the year. Laying the smart card on the windshield of the car it is possible to open the doors
easiness of the payment system	automatically, by credit card
easiness of the reservation system	it is possible to book the car from the website or with the mobile application
additional services	no additional services

potential gaps in the service currently offered. On the one hand, private users' mainly use the vehicle sharing service during their free time – to shop, go to the supermarket, post office, school and so on. In addition, there is an emerging market constituted by business segments, including both firms and public institutions and professionals of small organisations. On the other hand, current initiatives are characterised by a limited capillarity that prevent them to properly serve the market segment that insists on residential areas, which are poorly connected with the point of interests (e.g. shopping centres and leisure centres).

Starting from these considerations, the proposed service configurations attempt to fill these gaps, deploying the idea of vehicle sharing into three types of initiatives: the condo-sharing to serve neighbourhood trips, the network of services to serve shopping/recreational trips and the new business fleet targeted to business customers. These three configurations are discussed in more details as follows.

5.1 Condo-sharing

The competitive analysis highlighted that one of the mobility profiles most common among vehicle sharing users is the 'neighbourhood trip', which has its point of departure and arrival located in the user's district (ideally close to home). The existing services, however, have a limited capillarity, which reduces their ability to serve this travel pattern for a wide number of potential users, since some areas are totally uncovered and the average distance of the stations is quite high.

Therefore the basic idea of condo-sharing consists in an electric vehicle sharing service focused on a condominium basis. It brings to the extreme the neighbourhood operational model [21] narrowing, however, the base of sharing to the condominium. In this way, the users have the possibility of booking and picking up the vehicle inside their own condominium and use them for two way trips. Referring to the mobility profiles previously defined, this configuration aims to serve the mobility profiles connected to 'neighbourhood trips' and 'night life'.

In the condo-sharing, the capillarity is the main strength of the service. It helps us to overcome one of the principal barriers that obstacle car sharing use, that is, the distance from the station of collecting/delivery of the vehicle [36]. Other positive aspects concern the safety for both vehicles and users, as cars are kept within a protected area and the possibility to integrate peer to peer approaches because of the immediate community. On the other hand, the main weaknesses of this configuration consist in the rigidity of the system because of the possibility to perform two way trips only and the difficulties to provide common areas for the vehicles parking, in existing condominium.

Table 4 synthesises the main performances of the configuration.

5.2 Network of services

The second configuration focuses on shopping and recreation profiles ('shopping', 'tourist in the city' and 'night life'). Based on the competitive analysis, a widespread mobility profile resulted to be linked to free time and shopping related occasions. However, the existing services do not favour this travel pattern as they are not directly connected with recreational areas.

Hence, the second configuration bases on the multi nodal operational model in which cars are driven among multiple stations or nodes to travel from one activity centre to another [21] and integrates the electric mobility service with other services offered in key areas of the city (e.g. shopping centres, cultural centres, health structures, city centre, public

Table 4 Condo-sharing performances

capillarity	inside the condominiums
flexibility – space	two way service
flexibility – time	no reservation
multimodality	there are not stations near the local public transport
interoperability	potentially the configuration could be integrated with other service access systems but currently it is operated by a dedicated mobile application.
rate	preliminary hypothesis of 5 €/h (7 a.m.–7 p.m.) and 3 €/h (7 p.m.–7 a.m.)
availability of incentives	area C and blue parking stripes 'Sosta Milano' are free and it is also possible to park on yellow lines for residents
vehicles	two different car models
easiness of access and use	cars are available 24 h on 24, every day of the year. using a mobile application it is possible to open the doors
easiness of the payment system	automatically by smartphone
easiness of the reservation system	it is possible to book the car from the website or with the mobile application
additional services	no additional services

Table 5 Network of services performances

capillarity	stations located near the main city nodes
flexibility – space	one way service
flexibility – time	no reservation
multimodality	stations located also near the local public transport
interoperability	potentially the configuration could be integrated with other service access systems but currently it is operated by a dedicated mobile application
rate	preliminary hypothesis of 7 €/h
availability of incentives	area C and blue parking stripes 'Sosta Milano' are free and it is also possible to park on yellow lines for residents
vehicles	four different car models
easiness of access and use	cars are available 24 h on 24, every day of the year. Using a mobile application it is possible to open the doors
easiness of the payment system	automatically by smartphone
easiness of the reservation system	it is possible to book the car from the website or with the mobile application
additional services	service integration with main point of interest of the city

Table 6 New business fleet performances

capillarity	inside the firms
flexibility – space	one and two way service
flexibility – time	reservation is mandatory
multimodality	there are not stations near the local public transport
interoperability	potentially the configuration could be integrated with other service access systems but currently it is operated by a dedicated mobile application
rate	four different rate plans differentiated on the firm specificity
availability of incentives	area C and blue parking stripes 'Sosta Milano' are free and it is also possible to park on yellow lines for residents
vehicles	four different car models
easiness of access and use	cars are available 24 h on 24, every day of the year. using a mobile application it is possible to open the doors
easiness of the payment system	automatically by smartphone
easiness of the reservation system	it is possible to book the car from the website or with the mobile application
additional services	no additional services

transport stations, relaxation/fun centres, night amusement sites). In this way it can improve the accessibility of vehicle sharing users to key nodes, relying on the possibility of integrating vehicle sharing with the services offered by the nodes themselves [37]. The basic idea of 'network of services' is to involve other service providers in the vehicle sharing initiative by:

- positioning the stations the sites of these nodes to satisfy the needs of mobility of their users/visitors;
- integrating other mobility systems and services delivered by the node in a proper manner.

Key feature of this configuration is the possibility of performing one way trips between nodes, that is, releasing the vehicle in a parking station other than the departure one. To the users will be given the possibility to release the vehicle in the node more convenient to them and to interact with the service provider (for instance by purchasing the museum access from the vehicle). In addition, including the main public transport stations among the key nodes, the 'network of services' configuration could also support intermodal travels.

Table 5 summarises the main performances of the configuration.

5.3 The new business fleet

The business segment is an emerging market for vehicle sharing initiatives, hence the third configuration consists in an electric vehicle sharing initiative targeting firms and public institutions.

In this case, the main idea of the service is to both substitute business fleets owned by local companies with a shared one (i.e. each firm can purchase a mobility package) and provide an alternative mobility service to the employees. Accordingly, this configuration aims to serve the 'business fleet' and 'commuter' profiles.

The main characteristics of this configuration are:

- use of the vehicles from the companies on working time, and from their employees for private use on spare time (evening and weekend);
- availability of a parking lot for the vehicles inside the company premises.

This configuration has several positive aspects such as the possibility to integrate peer to peer approaches. In fact, confidence in colleagues and the much time spent at the workplace help a possible sharing of the private car. Moreover, the service improves the transparency and traceability of employee travels. Conversely, a weakness concerns the last mile problem. In fact, this model does not solve this issue that is a key topic for station cars configurations [21].

In the Table 6 the main performances of the configuration are summarised.

6 Development of the evaluation model

This section presents the evaluation model developed to support the deployment of the three service configurations, described at a strategic level in the previous paragraph (for a more detailed description, see [38]). Based on the performances described in the previous sections, we defined different possible service 'options', – that is, a combination of the possible values of the configuration performances.

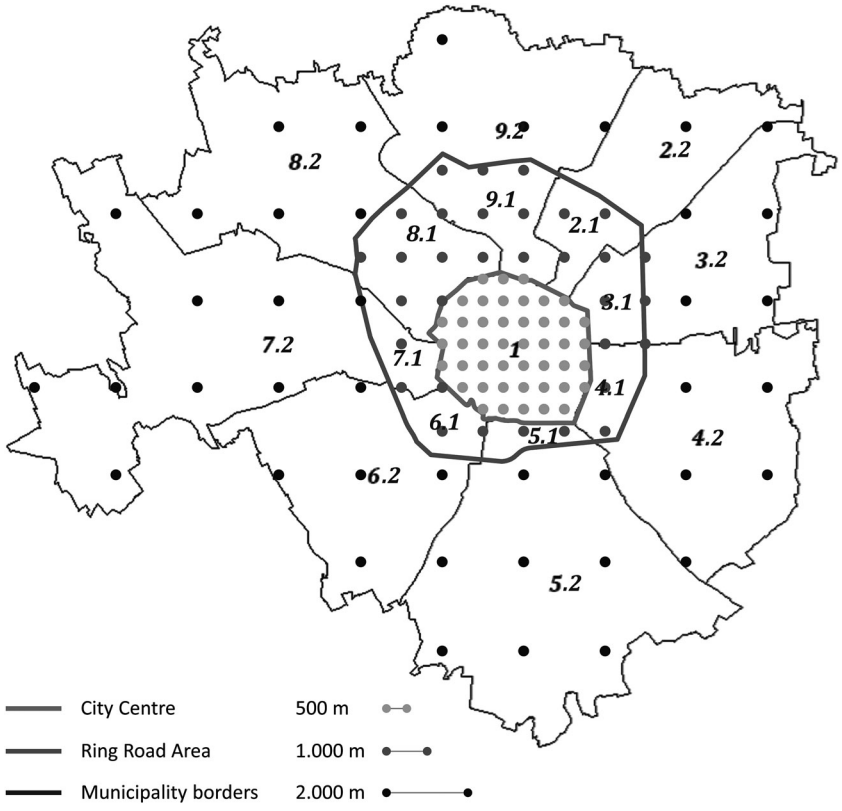

Fig. 1 *Example of localisation of the stations (capillarity) considered for the generation of the configuration options*

For instance, as regards the capillarity of the spatial localisation of the stations, three different areas have been identified: city centre, ring road area and municipality borders (see Fig. 1). For each area, we defined three possible values regarding the average distance between stations: 500, 1000 and 2000 m. Fig. 1 depicts one of the considered localisation of the car sharing stations, corresponding to a decreasing level of capillarity from the city centre to the municipal borders.

In order to support the identification and selection of the most promising options in terms of the overall level of sustainability, we developed a stepwise approach (Fig. 2).

The first step concerns the 'options' generation': in this phase, the configuration performances are combined in order to define different service options. Obviously not all the possible performance combinations do represent an option: some of them can be dominated by other options or be internally inconsistent.

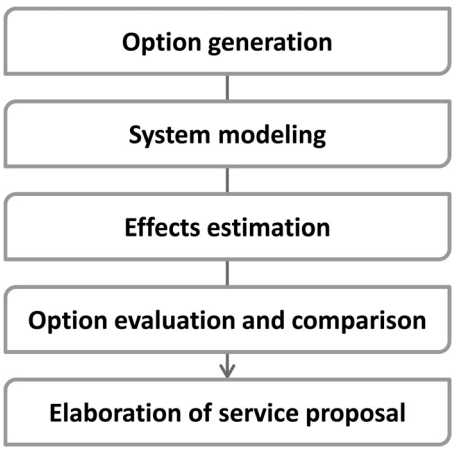

Fig. 2 *Analysis of the service configurations*

The second step of the approach consists in 'system modelling', where we structured the cause–effects relationships of the system with the support of cognitive maps. The aim is to graphically represent the ideas of an individual through a network of interrelated concepts [39], and to build a shared vision of the decisional problem in a group of persons [40]. We used cognitive mapping in order to support the mutual understanding between the researchers with different expertise within the Green Move team and the territorial stakeholders. Fig. 3 depicts a simplified version of the resulting network, which represents the cause–effect chains and explicates the interactions among the options and their effects. The left part of the network is represented by the 'configuration performances', whose combination identifies different service options. The performances are connected to some 'intermediate nodes', which depend on the specific service configuration (e.g. number of vehicle stations and number of users), and, in turn, determine the value of 'evaluation indicators'.

The third steps consists in the 'effect estimation' which requires the formalisation of a set of models that can explain the links between different nodes of the network. For example, the influence of some performance nodes on the node 'number of users and daily trips' is estimated through a statistical model that relies on data collect through a stated preference demand analysis [41].

Then, the fourth step consists in the 'option evaluation'. Evaluation indicators measure the extent to which the 'objectives' of the system are achieved; in this way, different service options can be compared based on their

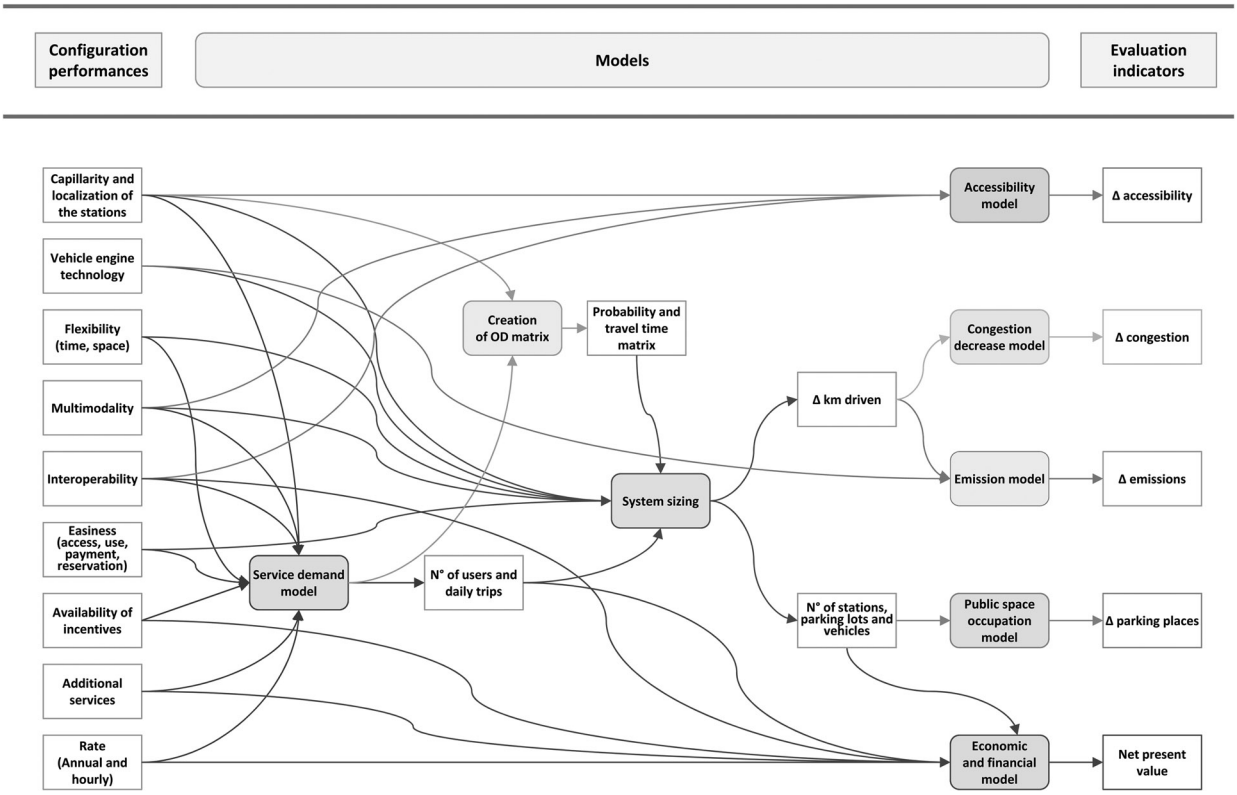

Fig. 3 *System modelling of the service configurations*

Configuration performances and the evaluation indicators are represented by rectangles; models by rounded rectangles

effects and the consequent level of fulfillment of the objectives. The problem of designing a vehicle sharing service is characterised by the presence of many objectives to be pursued that are in conflict with each other. For example, the expansion of the territorial coverage (an objective to be maximised) will increase the investment and operational costs (an objective to be minimised). The considered indicators (represented on the right part of Fig. 3) are the following:

- *accessibility:* variation of the level of accessibility to the urban mobility system;
- *congestion:* variation of the congestion level on the road network;
- *local and global emissions:* quantity of pollutant and of greenhouses gas emissions;
- *parking places:* variation of the public space occupied by private car;
- *net present value:* economic performance of the car sharing service.

Different methodologies have been designed, in order to classify and rank the options according to the set of objectives that the decision-maker considers relevant [42]. In first approximation, it is possible to identify two main categories of multi-criteria methods, characterised by a different approach:

- definition of an utility (or of an overall satisfaction) function to aggregate the effects of the options according to considered objectives. Two examples are represented by the multi attribute utility theory [43], and the analytic hierachy process [44];
- pairwise comparison of the options, using concordance and discordance criteria. An example is represented by the Electre outranking methods [45].

Such process allows one to gradually eliminate those options that are Pareto-dominated, or that have particularly negative impacts on a specific sector, gradually narrowing the problem [46]. We implemented the 'Electre tri' sorting method [47, 48], in order to sort the options in categories and to elaborate a proposal for each of the three service configurations.

7 Conclusions

The paper presented the methodology adopted in the design phase of Green Move, a project aimed at developing an electric vehicle sharing service for the city of Milano. The core idea of this work is that a vehicle sharing service, as many other products and services, needs to be customised to the specific mobility needs of the potential users. To deploy this idea, we embraced a methodology articulated into four steps: (i) mapping of mobility profiles and service performances, (ii) competitive analysis, (iii) development of the service configurations and (iv) development of the evaluation model.

This process lead to the formulation of three vehicle sharing configurations that are based on targeted classes of users, in the attempt to offer them a 'personalised service'. Therefore they aim to answer to different use profiles in a complementary way. For instance, the 'new business fleet' supports business journeys; 'condo-sharing' supports trips that departs from / return to a residential area and 'network of services' relies on the idea of integrating different types

of services. Moreover, two of the proposed configurations (condo-sharing and the new business fleet) are suitable for peer-to-peer approaches, coherently with most recent trends [49, 50]. Owing to these complementarities, the three services can answer to different mobility problems that are confirmed by both academic and practitioners studies. Still, they leave not covered some areas of use like trips with destinations not close to some aggregator nodes – this travel, however, is currently already covered by Car2Go.

This work has relevant managerial and academic implications. From a managerial perspective, it proposes some innovative configurations of electric vehicle sharing, which encourage also the private vehicle sharing. Furthermore, it presents a stepwise approach to support the service design phase and a general framework for the development and evaluation different electric vehicle sharing options on the basis of some key parameters and the main stakeholders involved. In addition, the proposed method is also transferable to the design of services in areas external to the mobility. From an academic perspective this paper explores a topic that is widely discussed in literature, but is often addressed from a 'general' point of view without a specific focus on the process of generation of new service ideas. In particular, most of the literature looks to vehicle sharing as a clearly defined and precise entity of which are evaluated the potential benefits in terms of sustainability. This work showed that different types of vehicle sharing exist and are able to respond to different needs and different sustainability goals. Finally, we conclude with the limitations of the study, which open the path for future works. First, this paper did not go into depths about the specific differences between e-vehicles and traditional ICE vehicles in the sharing system. Obviously the implications of the use of e-vehicles have been considered in the analysis of the ability of different configurations to answer to specific mobility needs, but a punctual comparison was not made. Second, we highlighted the potentialities of two of the proposed configurations to be integrated with peer-to-peer mechanisms; however, how this could be done in practice was not directly investigated.

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