Research for Development

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Electric Vehicle Sharing Services for Smarter Cities

The Green Move Project for Milan: From Service Design to Technology Deployment

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Foreword to the Book

Social and geopolitical transformations are modifying urban policies, metropolitan scenarios, and mobility systems, let alone the way people relate and interact. New and sustainable proposals are necessary to meet the continuing need for primary resources, health and well-being, culture, education, and vocational training. We are now witnessing one of the fastest and most disruptive technological developments of all time.

In a modern, multiethnic, and multicultural city, such as Milan, a public technical and scientific university has to guarantee a central role, a vision that includes the ability to drive great technological challenges, to cope with economic, social, and cultural transformations, to act as a leading institution in training, research, and innovation. Milan is working hard to be a "smart city," to integrate information and communication, to improve the efficiency of services and infrastructures, to work for and together with the community.

The mobility service described in the project Green Move is an example of the way Politecnico di Milano reflects this approach, a paradigm that counts on the interaction of diverse competences—like the ones represented here in terms of technology, services, and design—and the active involvement of citizens and end users. This is a pioneering initiative that moved its first steps in 2011 and that is now considered and acclaimed as a best practice.

I thank the former rector, Giovanni Azzone, for having promoted and actively contributed to this project, together with Regione Lombardia and all the partners involved in the project, Politecnico di Milano's departments, Poliedra Consortium, and our Foundation.

Milan, Italy

Ferrucio Resta
Rector, Politecnico di Milano

Foreword to the Project

Green Move is a project developed by several structures of Politecnico di Milano and co-financed by Regione Lombardia (Lombardy Region), with the aim of conceiving and experimenting a new car sharing system for the city of Milan by means of electric vehicles. A demanding task accomplished by qualified research and innovation teams representing specific competences and various approaches to the same topic: smart mobility.

Fondazione Politecnico di Milano, which I have the honor and the duty to lead as President, has supported this multidisciplinary and articulated project and worked side by side with the Department of Electronics, Information and Bioengineering (DEIB); the Department of Architecture and Urban Studies (DAStU); the Department of Design; the Department of Civil and Environmental Engineering (DICA); the Department of Management, Economics and Industrial Engineering (DIG); the Department of Mathematic Francesco Brioschi (DMAT) and Poliedra, the consortium promoting and supporting research and training activities in the fields of environmental concerns and sustainable mobility.

Environmental sustainability, a significant reduction in traffic and pollution, together with economic and social benefits for both citizens and the public administration are some of the ambitious goals that Green Move aims to achieve through the improvement of urban circulation. What the project has proposed, and what it has finally come up with, is a flexible service that addresses different targets and offers customized solutions that can be taken into account as a case study for other urban contexts. In fact, as the former mayor of New York Michael Bloomberg said, we are living in the "century of cities." For the first time in history, cities are more populated than the countryside. It is estimated that in 2050 more than 70% of the world's population will move into town. This process has been radically changing the way that millions of people interact with the environment as well as the socioeconomic model of reference.

Green Move has promoted and introduced elements of social innovation, the awareness and the acceptance that smart choices will drive smart cities. Technology can actually and truly improve people's lives, if it is developed in a reliable and sensible manner and, most of all, if it is adopted consciously. That is why

researchers and citizens have worked together in studying and testing different solutions without losing sight of the bigger picture, that of enhancing the potential and the well-being of future generations.

Green Move project is an example of how Fondazione Politecnico di Milano works to foster innovation and knowledge transfer enabling and favoring a firmer interaction among research activities and social and economic stakeholders.

Milan, Italy

Gianantonio Magnani
President, Fondazione Politecnico di Milano

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Introduction: Car-Sharing Evolution and Green Move Project

Daniele Fabrizio Bignami, Alberto Colorni, Alessandro Luè, Roberto Nocerino, Matteo Rossi and Sergio Matteo Savaresi

Abstract This introductory chapter briefly outlines the main characteristics of car-sharing services and the main assumptions that authors of this book took into account for designing the innovative service that was the outcome of Green Move project. The second part of the chapter illustrates the overall organization of the book, and the main contents of the three sections: the service, focused on the Green Move service design, the technology, illustrating the technologic solutions realized for the project, and the simulation model, implemented for estimating the performances of different alternatives of car-sharing.

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1 The Current State of Car-Sharing

Shared mobility is a rapidly developing domain; even though services such as bike sharing, ride hailing and flexible forms of public transport are growing rapidly, nowadays car-sharing is the most widespread form of shared mobility (Le Vine et al. 2014). A large number of car-sharing operators are present on the market, offering different forms of service, and several new mobility-related business models (and related services) are expanding their market (Shaheen et al. 2015).

Generally speaking, car-sharing is a service where a fleet of cars is shared by a group of people paying only for the actual use of the vehicles. The general idea of car-sharing is "pay-as-you-drive," which leads to a more convenient car usage for the drivers and optimized car usage for the car owners. Car-sharing fleets are usually organized by a private company or association, in certain cases subsidized by a local or regional government or public transport authority, and are generally offered to private users, and sometimes to corporate ones.

The wide variety of car-sharing services can be grouped in three main categories (Jorge and Correia 2013):

1. **Station-based car-sharing**: Cars can be picked up only at designated stations; usage can be round-trip (i.e., customers must return the car to the same place that it was accessed) or one-way. Examples: Cambio (Germany, Belgium), Co-Wheels (UK), Greenwheels (Netherlands, Germany), Guidami (Italy), Autolib (around 4000 electric vehicles in France), Zipcar (USA), Orix and Park24 (Japan), and EVCard (China).
2. **Free-floating car-sharing**: The service enables one-way journeys freely within a specified geographic zone, and usually, there are no dedicated parking lots (Firnkorn and Müller 2011). Examples of global operators are as follows: Car2Go (around 15,000 vehicles worldwide) and DriveNow (around 5500 vehicles in seven European countries), while examples of local operators are as follows: Enjoy and Share'ngo (Italy), GreenMobility (Denmark), EVO Carshare and Communauto (Canada, France).
3. **Peer-to-peer car-sharing**: The service operator offers a platform to bring private car owners in contact with passengers, matching supply and demand directly. The operator takes a certain percentage of the transaction cost between the car owner and passenger to provide appropriate insurance and cover their operating costs. Examples are as follows: Tamyca (Germany), Mywheels (Netherlands), Snappcar (Netherlands, Denmark, Sweden), CarUnity (Germany), Bluemove (Spain), Turo (USA), PPzuche (China).

Nowadays, new car-sharing schemes are going to appear, targeted to specific market niches, such as company car-sharing or community car-sharing, the so-called micro-car-sharing.

2 Reasons of a Growing Success

In Western countries, private transport models (essentially based on privately owned fossil fuel-driven vehicles) are well-established. Starting from the sixties, there has been a continuous increase of private cars, especially in the Western world: the cars owned in Italy, for example, rose from about 10 million in 1970 to over 37 million in 2011 (ACI 2012; Fig. 1).

This increase is essentially linked to socioeconomic factors, mainly the increase of the average wealth (Prettenthaler and Steininger 1999), but also to psychological characteristics of the users. The perception of a better comfort and flexibility of a private vehicle in comparison with the public transport is still well-established, even if often alternative options could have better performances.

Recently, the increase in the number of cars slowed down, and cars in the cities, which have been designed before the invention of motorized vehicles, are often seen as a threat more than an opportunity of mobility. The main reasons are as follows: Cars are polluting and noisy, and occupy a large amount of space in our cities. These elements are crucial variables to determine the quality of urban life in cities. The problem is exacerbated by other factors such as the difficult compromise between a safe vehicle and an environmentally friendly one, and the need to ease congestion in metropolitan areas and free areas of parked cars.

A further reason of the slowing down of car purchases is that the ownership of a car requires for many people a significant economic effort. Moreover, in many situations, a car is not the more efficient means of transport. Especially in cities, public transport, bikes, and walking are in many cases faster and more cost-efficient than cars.

But even if often bike, bus or metro are better mobility options, in some particular cases a car is the fastest, cheapest and more efficient transport alternative. Even if the ownership of a car is not the best choice for some city users, the availability of a car, when necessary, is still absolutely needed.

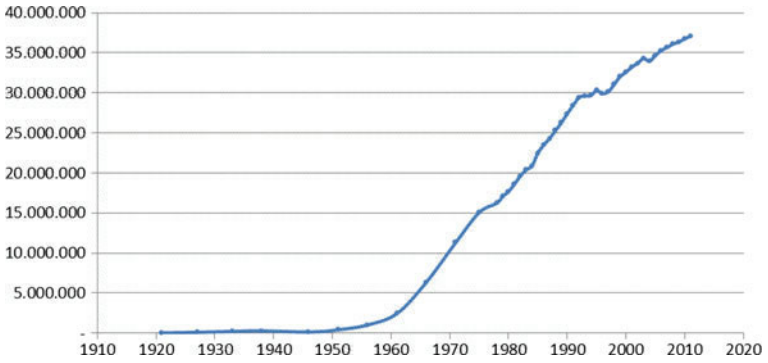

Fig. 1 Increase of private cars ownership in Italy (ACI 2012)

In this sense, cars will not disappear from our cities but their role will change in next decades; aside from autonomous vehicles, which will radically change the mobility scenario, three directions can be foreseen for the car industry:

- a reduction in weight and size of vehicles;
- a drastic reduction in the number of engines using carbon-based fuel and the consequent development of electric mobility;
- a change in the mobility model, moving from the traditional concept of privately owned vehicles to a model based on articulated mechanisms of vehicle sharing (Bert et al. 2016).

Small, electric, shared is probably the new scenario toward which models of urban and metropolitan mobility models will tend over the next decade.

Electric car-sharing can give a significant contribution to solve the threats and needs mentioned above. First of all, the replacement of the individually owned car with the availability of cars shared by many citizens and city users makes the overall space occupied by cars much smaller, which is a great benefit for many big cities. Furthermore, shared cars run much more frequently than private cars, which on average stay parked 23 h per day (Collaborative Fund 2012): that means that the life of shared cars is much shorter in time (assuming a constant distance run by a car in its lifetime) and the service has to replace the fleet with new cars more often than individual owners. Hence, with car-sharing, users drive cars that in general are newer than private cars. This means that, thanks to car-sharing, the vehicles traveling in the city are in general safer, less pollutant, and less noisy than before.

Summarizing, car-sharing produces three main categories of advantages: economic benefit, environmental sustainability, and flexibility for the user.

- **Economic benefit**: This point includes not only the choice to be a car-sharing user, but actually a wider range of choices. Becoming a car-sharing user has its highest economic benefit if it is part of a whole new mobility strategy, starting from the decision not to own a private car (or at least not to own the second family car). This decision frees many economic resources, since the yearly cost of a car includes purchase, insurance, maintenance, taxes, parking, cleaning. These resources can be partially used to purchase Local Public Transport (LPT) tickets, car-sharing subscriptions, and train tickets, to rent cars if necessary, and possibly to buy a bike. Many people would save money overall, depending on their mobility needs and routine: Users driving less than 4000 km per year would save about 40% of their expenses (Valenti and Mastretta 1999).
- **Environmental sustainability**: The process of switching from private cars to car-sharing is not immediate; buying or selling a car, or the decision not to buy a car, are long decisional processes that usually need time. This implies that the replacement of a car with a car-sharing subscription can occur with a certain delay (few years) since a car owner needs a period to adapt and trust the new service before taking the decision to sell his car or decide not to buy a new one. This has to be taken into account when monitoring the success of a new car-sharing service. It has been estimated that in a fully functioning system, each shared car can substitute

4–10 private cars in Europe and 9–13 private cars in North America (Shaheen et al. 2013). Moreover, shared cars have a short lifetime, meaning that more new cars, with low emission standards, are running. In case of electric car-sharing, the emission reduction is much higher. The lower usage rate of shared cars compared with private cars is due to an increase in LPT usage by car-sharing users. This means that with a fully functioning car-sharing system, the LPT will increase its volume of users and economical resources to invest in an increase of the level of service, with consequently environmental and mobility benefits. The main environmental effects are then a reduction of air pollution emitted by the car sector, a significant reduction in public space occupied by parked cars, and an overall reduction in traffic jams (Baptista et al. 2014).

- **Flexibility for the user**: This benefit is provided by those car-sharing companies offering different types of cars in their fleet (e.g., city car, sedan, minivan, or van). In this case, the user can choose the car fitting with his current need based on the number of people or baggage to carry, the length of the trip, the costs, etc. Flexibility can be increased through integration of car-sharing services provided by different operators, which in turn can be achieved thanks to standardized access systems.

Furthermore, car-sharing can produce benefits similar to those provided by a private car in terms of flexibility and comfort, but with significantly lower costs. Citizens that choose car-sharing services lower their mobility expense with a more rational choice among the available mobility options. Paying for the actual use makes the user wiser in his mobility choices, so cars become in many cases the last option, after public transport and bikes.

Figure 2 shows the best mobility options depending on the distance to be covered and the flexibility needed.

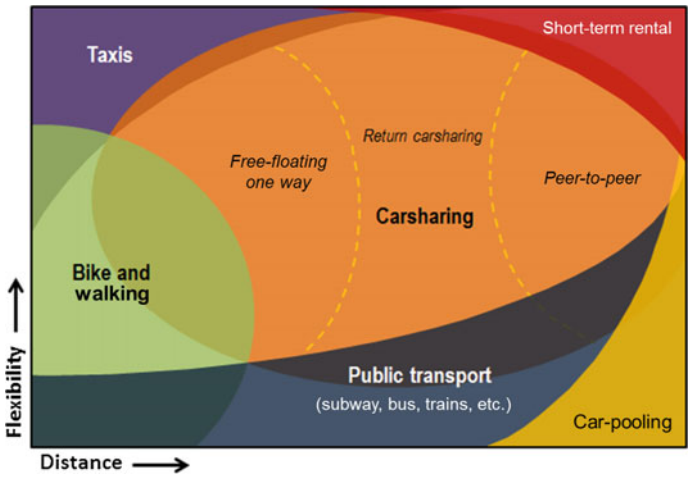

Fig. 2 Multimodality in large urban centers, excluding the private car (http://www.inov360.com/en/car-sharing-yes-but-whichone/)

Car rental is more efficient for long distances and high flexibility needs, whereas taxi provides the best flexibility, but only for short trips because of its high costs. Bikes and walking are the best choices that guarantee flexibility at a low/zero cost for short trips. When flexibility is not strictly required, the choice has to be made between public transport, for short-medium trips, and carpooling, for longer distances. Car-sharing appears as the right choice especially for medium distance trips and when medium-high flexibility is required, in comparison with the traditional means of transport.

Finally, a car-sharing is not a stand-alone service, but needs to be implemented in an environment equipped with a public transport network. In fact, car-sharing is a complementary service to public transport, which can fill those situational mobility needs that were covered by private cars, with overall higher cost, or by public transport, with a much lower level of service and flexibility (Millard-Ball et al. 2005).

3 History of Green Move Project

Green Move is a project co-financed by the Lombardia Region,[1] started in 2011 and concluded in 2013. The main idea behind Green Move was to create a flexible service of vehicle sharing, based on electric cars, and open to a wide range of different types of users. The system was designed to be easily accessible thanks to an add-on device, the Green e-Box, a bridge between the user, the vehicle, and the control center, allowing any vehicle to join the service network. For addressing the design of the innovative service envisaged, Green Move involved eight different departments and research centers of Politecnico di Milano:

- Department of Architecture and Urban Studies (DAStU) for demand analysis;
- Department of Civil and Environmental Engineering (DICA) for geographical information systems;
- Department of Design (DESIGN) for service design and communication;
- Department of Electronics Information and Bioengineering (DEIB) for information and communication technology;
- Department of Management, Economics and Industrial Engineering (DIG), for economic and stakeholder analysis;
- Department of Mathematics (DMAT) for mathematical models;
- Fondazione Politecnico for administrative management;
- Poliedra for evaluation and environmental analysis.

[1]Accordo istituzionale di R&S "GREEN MOVE" 11/02/2001—Decreti n. 5889 11/06/2010 e 1537 5/11/2010 Direzione Centrale Programmazione Integrata—Struttura Università e Ricerca di Regione Lombardia—Bando di invito a presentare proposte di accordi istituzionali per la realizzazione di programmi R&S nei settori energia, ambiente, agroalimentare, salute e manifatturiero avanzato—Fondo per la promozione di accordi istituzionali.

3.1 Working Hypothesis and Objectives

Green Move started from the following working hypotheses:

- **Multi-ownership**: Green Move worked on solutions able to allow single users, private companies, and associations to join the service both by using vehicles provided by the service itself and by sharing their personal electric cars or fleet;
- **Key-less-mobility**: The Green Move team, in their proposal in 2010, hypothesized that personal smartphones would be the access key to car-sharing services (and, more in general, to a wide range of services), avoiding the use of smart cards or physical keys;
- **Electric vehicles**: The engine technology chosen by the Green Move team was the Full Electric Vehicles (FEVs), as the most probable future solution for urban mobility.

A key element of the project was the planning and integrated development of an innovative vehicle-sharing system, based on light electric vehicles suitable for urban/metropolitan use. The main project objectives were the following:

- **Polluting-climate altering emissions and congestion**: Development of a solution able to drastically reduce not only the emission of pollutants and greenhouse gases, but also traffic congestion.
- **Use of renewable energy**: Proposal of a solution to the mobility problem integrating it with the evolution of renewable energy production systems with low environmental impact.
- **Monitoring and profiling**: The realization of methods and tools for effective capillary monitoring and profiling of users' behaviors.
- **Urban environment**: Activate an urban-level sustainable mobility system taking into account the need of a widespread recharging network.
- **Business model**: The project team worked looking at financial sustainability, exploiting ICT technologies, social networking, users' behavioral models.
- **Integrated approach**: Development of an integrated and complete solution that may have spin-offs in a number of directions, even beyond the solutions studied within the scope of the project.

4 Organization of the Handbook

Having in mind the car-sharing scenario described in the previous paragraphs, the Green Move project has been accurately structured by means of an approach aiming at taking into consideration both the *enabling technologies* and the *appropriate business model*. To pursue the three main categories of car-sharing benefits mentioned above (*economic advantages*, *environmental sustainability,* and *user flexibility*), the developments and related tests carried out within the Green Move project

have targeted the three chosen strategic priorities "*small*, *electric,* and *shared,*"[2] which have guided the evolution of the project ideas.

The handbook is organized into *three* different parts, each aiming at investigating transversely and in depth the crucial aspects of our priorities (to be tested and verified). It is, however, important to underline that the project activities have been carried out following a multi-disciplinary and original research path in which the three main groups of activities have been developed jointly, partly in parallel, partly taking advantage of frequent and repeated exchanges of outputs/inputs among the research groups of the Green Move project team. Therefore, the three parts of the handbook can be seen as the final re-elaboration of the work.

The *first* part illustrates the activities related to the service, starting from the service design, the configuration of the vehicle-sharing model, the Milan mobility pattern. The section goes on presenting the peer-to-peer car-sharing local demand-and-supply estimation, the tests of the "condominium-based electric car-sharing" prototype model, and the communication design for social engagement through the chosen and assessed participatory process.

The *second* part explains the technological choices and developments made in the project. First, it illustrates the architecture of the Green Move system, then it presents the technology, based on the notion of "dynamic applications" developed to provide users with highly flexible and customizable services. These chapters also give a brief comparison of the technological platform developed in the Green Move project with commercially available ones.

The book proceeds by describing some specific technological achievements of the Green Move project: the *Information Management* mechanisms, which are based on a context-driven, pervasive, and personalized approach; the developed smartphone-based energy-oriented *driving assistance system*; the simulation of an automatic *fleet balancing system* via closed-loop dynamic pricing; and the real-time monitoring of the Green Move vehicles' positions through a dedicate *geo-referenced database*.

The *third* part starts by describing the model that has been developed to simulate different car-sharing configuration options and to estimate their related effects. Finally, a model to estimate the potential users of the car-sharing system (and related Origin/Destination matrices of the service) and a model for a full-scale electric car-sharing service planning for the city of Milan are presented, making use of decision-aiding methodologies (showing a multi-criteria and multi-stakeholder rating of the car-sharing configurations).

Acknowledgements In addition to the authors of this book, several people have contributed to the project and have provided useful suggestions and feedback on the chapters of the book. For this, we would like to thank Luciano Baresi, Gabriella Bergonzi, Alessio Campi, Gabriele Carbone, Lorenzo Carrara, Antonio Conte, Silvia Cortesi, Luca Di Natale, Elisabetta Di Nitto,

[2]Whereas the target vehicles considered in the Green Move project were all electric, in fact the technology developed in the project could be adapted also to other kinds of vehicles, including those with internal combustion of hybrid engines.

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Part I
The Service

Service Idea: Creating Mobility Scenarios Through Service Design

Stefano Maffei and Beatrice Villari

Abstract The chapter discusses the initial stages of the development of the Green Move research. In particular, the authors focus on the generative phases developed in the early stage of the research process. The content mainly describes the different stages of the service idea development: (i) the research phase aimed at collecting examples of mobility solutions worldwide, (ii) the creative session aimed at sharing ideas among participants to identify design opportunities to be developed in the next steps of the process and (iii) the development of the service ideas in order to describe possible scenarios to support the implementation phase. Moreover, few considerations on challenges and opportunities to deliver the service are outlined. To describe the framework that influences the design choices, the chapter briefly introduces few concepts on service design approach used in the journey.

1 The Service Design Approach: Putting Users at the Centre of the Process

Nowadays service design is becoming a crucial element to differentiate businesses and public organization around the world. The first attempt of defining what a service is came from the service marketing and management field.

In this disciplinary area, some scholars have built the basis of service design starting from interpreting and defining new service development and delivery process (Shostack 1982, 1984; Scheuing and Johnson 1989; Gummesson 1990), service design still lacks a unique and common definition (Nisula 2012). Nevertheless, scholars and practitioners agree on considering service design as a multidisciplinary process characterized by a user-centric approach and by the

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interactions and the encounter between providers and users (Holmlid 2009; Stickdorn 2010; Meroni and Sangiorgi 2011). Negro (1992) describes the service as an interchange process aimed at solving problems for users through the reciprocal flow of information, knowledge, skills and work done in a period of time. Lovelock and Wirtz (2004, p. 9) define a service as an "act or performance offered by one party to another" that creates value for providers and customers.

Thus, service design discipline can be considered as a huge field of intervention that implies collaboration between different disciplines to propose, design, develop and deliver a holistic experience targeted to specific users or communities and provided by a system of stakeholders playing different roles.

Mager and Sung state

> … Service design aims at designing services that are useful, usable and desirable from the user perspective, and efficient, effective and different from the provider perspective. It is a strategic approach that helps providers to develop a clear strategic positioning for their service offerings. Services are systems that involve many different influential factors, so service design takes a holistic approach in order to get an understanding of the system and the different actors within the system… (Mager and Sung 2011, p. 1).

Service design is based on the idea that users are the core of the service design process, and it uses a great variety of tools and techniques to involve different stakeholders in the creative process. The collaborative processes are also supported by visualization methods and prototyping techniques that enable people to share ideas, define solutions and make concepts visible. In some cases, we can describe this journey as a real co-design processes where experts and non-experts work together in order to provide innovative solutions derived from the participation and representation of different perspectives (Jégou and Manzini 2008), like those of citizens, enterprises and institutions. This helps to share different types of diverse expectations and expertise that different stakeholders might have and stimulate a dialogue among different disciplines and group of people. Moreover, service design is a holistic approach (Stickdorn and Schneider 2010) that means that service touchpoints (such as digital interfaces, physical elements, people and places) and intangible elements (such us the user experience, the service values and people interactions) need to be coherent and well orchestrated in order to provide a performance that creates values both for providers and users.

The Green Move approach is based on these service design drivers: it is aimed at developing a mobility service using a collaborative approach, involving different stakeholders with different roles (such as public administration, researchers, firms, users) to envision and experiment a new mobility service able to fit with specific users' needs and based on electrical vehicles sharing (Villari and Luè 2013).

In particular, the service design process within its development has been focused on different levels: the creative phase, the service idea and the business model development, and the design of the system of touchpoints.

In the following paragraphs, we describe in detail the approaches and the tools used to frame it.

2 The Service Context: Sharing Economy and Collaborative Services

One of the main Green Move research hypotheses is based on the idea that collaborative and participatory approaches are fundamental to the development of innovative solutions for electrical vehicle sharing, in order to face urban challenges. This could be an innovative way to fuel new connections among social, environmental and economic issues. Accordingly, to orient the generative phase about service ideas, particular attention was given to define the concept of collaborative consumption and sharing economy (Botsman and Rogers 2010) and to include the social innovation and sustainability issues (Mulgan 2007) to create value for local communities and citizens. Since the beginning of the project, we put emphasis on the importance of peer-to-peer activities and the opportunities to adopt sharing concepts to orienteer mobility solutions. Another input to boost the idea of sharing was to consider the ICT as an enabler of people activities and as a way to create more tailored services.

The sharing economy models are generally based on the idea of access (especially using a pay-per-use approach) rather than ownership to promote a more efficient use of tools and resources. Since the past few years, the debate on sharing and collaborative economies has grown constantly (Pais and Provasi 2015) also due to the fact that some companies such as Airbnb, Uber, eBay or Etsy are climbing the market in a very fast way. But this has also shifted the focus on the possible critical issues about the sharing economy models, such as the IP regulation, the transformation of the labour market and the international tax regulations. Notwithstanding, many companies are investing in a sharing economy approach, and many start-ups are entering the market allowing consumers to play new roles and tasks that were normally conducted by businesses (Dervojeda et al. 2013).

In the mobility area, sharing economy has totally changed the way of accessing transport systems. We are progressively moving from owing a car (B2C model) to new business models and services based on rental or sharing (B2C services). Milan has led the way: in the past few years, the use of car sharing and bike sharing has rapidly grown. Hybrid and electric vehicles such as cars, motorbikes and bikes are offered by the municipality and by private companies to support urban mobility in accordance with the idea to offer even more citizen-centric services. This shift is especially true in the emergent area of the collaborative platforms, where P2P services are growing faster. Examples such as Uber and BlaBlaCar are interesting phenomena related to these new ways of using transports, based on peer-to-peer approach.

The main drivers related to sharing economy and shared mobility have influenced the Green Move service concepts. In particular, some aspects were considered as crucial ones:

- the central role of digital platforms as enabler of new user behaviours focused on matchmaking between demand and offering of mobility;
- the importance to have different service possibilities to access the service itself, i.e. renting, lending, subscribing, donating and so on;

- the change in consumption models based on collaborative social interaction;
- the value of a well-recognizable identity and process able to create trust and activate and maintain reliability and continuity in users' engagement.

The development of Green Move concept for an electrical vehicle sharing has been influenced from this emerging framework and from the holistic approach of service design putting together users' needs and perspective with value creation process of the enterprises.

3 Defining Service Design Scenarios for EV Mobility

One of the early stage activities of the Green Move development process has been dedicated to the service idea development. The process involved all the academic stakeholders and the external players such as experts, mobility companies and public administrations.

The ideation phase has been strictly connected since the initial steps to a literature review process and to a collection of best practices cases of mobility services to support the service ideas development phase. In particular, this phase supported the understanding of the most important design issues related to the technology choice, vehicle performance, service (user) experience and the nexus between the service offerings and the contexts of use. To structure the service ideas, some phases have been structured:

- Organizing and systematizing the best practices collected about mobility services (Sect. 3.1);
- Generating ideas of product-service systems through participatory workshops (Sect. 3.2);
- Developing mobility scenarios based on electric vehicles (Sect. 3.3).

In the following paragraphs, these activities (the design process and the tools used) are described.

3.1 Organizing and Systematizing the Best Practices Collected About Mobility Services

The research teams selected thirty-three existing cases of worldwide mobility services. These have been divided into four categories describing the main characteristics of the service offering and the mobility model: (i) services which use traditional vehicle sharing, (ii) services which use peer-to-peer approaches, (iii) services that use electrical vehicles and (iv) services that offer direct production of energy (Maffei et al. 2011). The first category includes mobility services that are characterized by innovative models in service or in business and use non-electrical vehicles; the second category encompasses that services characterized by a

collaborative approach in experiencing or delivering the service; the third focuses on "green" vehicles; the last one considers some cases that include energy production as an element of the service system.

The analysis of best practices and the study of the literature have been useful to define the main design problems to be discussed during the creative phase and understand what are the current business models and the solutions adopted to make the services efficient and user-centred. In the following boxes, main characteristics of services analysed are presented.

Autolib (Paris)—The pioneer of electric car sharing
Autolib started in 2011 in the inner circle of Paris. In the recent years, the served area expanded so that now the whole Paris area plus some of the surrounding towns are included. The service aims to fulfil mobility needs for citizens, commuters and tourists. Today more than 2000 vehicles are shared in the city of Paris by more than 150,000 subscribers. The vehicles, named "blue cars", are electric and have a 250 km range. The parking places are well spread in Paris and in the surrounded cities and are equipped with electric charge station, partially available also for private electric cars. With the registration, the user receives a smart card which is required to open the vehicles. The reservation of a vehicle can be performed 20 min in advance or in real time at a station, online or with a proper app. The car has to be returned to a station where the lot can be reserved in advance with a one-way approach. Autolib, a multi-nodal car sharing, is designed to foster the sharing concept, facilitating short and frequent uses of the cars. To pursue this objective, Autolib offers a quick and automatic system to reserve, unlock, drive and return cars. One-way trip is essential to allow an easy and instant use of the car sharing. Also a variety of subscription fees and fares help to wide potential users.

Car2Go—An easy replicable urban car sharing model
Car2Go started in 2009 in Ulm, Germany. After 6 years, the service is in more than 30 cities in Europe and North America. Since 2013, Car2Go is available also in the main Italian cities. Depending on the characteristic of each city, Car2Go offers either ICE or EV cars, while a mix of the two has not been set yet. The fast growth of Car2Go is mainly due to the successful, simple and innovative system that can be replicated in different urban environments. Car2Go does not have its own parking places, but it defines a wide area (e.g. the whole municipality area), called Home-Area, where the trips have to start and end. The one-way trip configuration guarantees a strong flexibility to users. The available cars can be searched on the map on the Website and on the app. Then the car can be reserved for half an hour. Once reached the parked car, the doors can be opened with a smartphone or with the Car2Go card. Car2Go fleet is made only by Smart cars models to facilitate the driving in the

city and the search for the parking. In the car, there is a touch screen that controls the communication user-vehicle-central station and helps the driver with a navigation system. It also evaluates the environmental sustainability of the driving style based on acceleration, constant pace and braking.

Enjoy—An integrated urban mobility model of car and scooter sharing
Enjoy is an Italian car sharing available in Milano, Roma, Firenze and Torino. This service is a joint venture between Fiat, Eni and Trenitalia, and this fact enhances the opportunities linked to car, fuel and train activities. Fiat can provide cars and the related system of services (e.g. maintenance stations), Eni can offer special price in its gas station for Enjoy cars, while Trenitalia can provide special offers for a combined use of trains and shared cars. The cars can be parked everywhere within the operating area, and one-way trip is allowed. The cars availability can be checked on the Website and on the app, and a reservation can be set. The fleet is composed by Fiat 500 and Fiat 500L, which is a car bigger than 500 and is useful for extra carriage. Moreover, Enjoy is the first scooter sharing in Italy with a fleet of 150 Piaggio scooters. Each scooter is equipped with two helmets and disposable cuffs for the driver and the passengers. The service covered a huge area of user needs that were not yet satisfied by the current car sharing and bike sharing services.

Hereafter, the cases were described through brief descriptions (cards) and clustered using some parameters such as the partnership characteristics, the pricing, the use of energy, the capillarity of the infrastructures, the community of users, the service accessibility, the quality of touchpoints and the presence of support assets.

The main characteristics of each case were described also through a scheme illustrating the customer journey (Fig. 1): this has pointed out the user interaction through the main touchpoints. Some elements were considered: (i) the access to the service and the vehicle (using desks, Web, smartphones, RFID), (ii) the service elements that support users while using the service and during the returning/leaving the vehicle in the station/parking (using internal/external drives, key box) and (iii) the infrastructure and parking areas (considering charging stations).

3.2 Generating Ideas of Product-Service Systems Through Participatory Workshops

The idea generation activity has been based mainly on the results of the context analysis (characteristics of the mobility system and electrical vehicle offering in Milan) and the best practice collection.

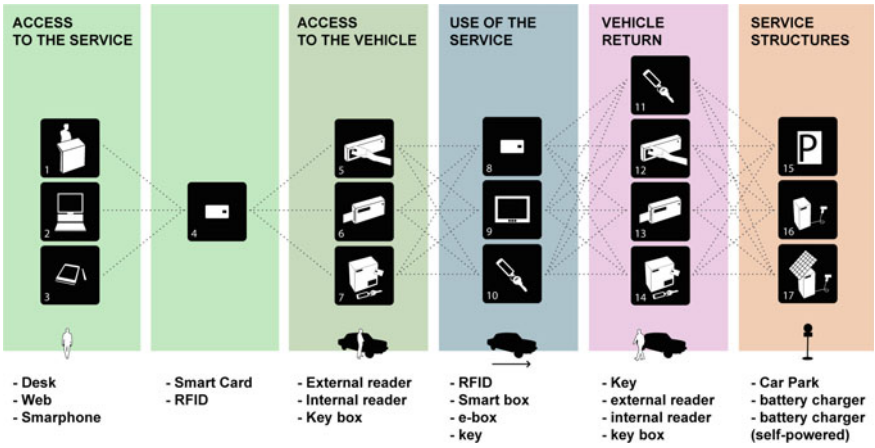

Fig. 1 Example of the general steps of customer journey derived from the case analysis

The concept generation has been developed through a participatory workshop that involved different stakeholders: the complete Green Move research teams together with some representatives of institutions and companies. This activity focused on sustainable urban mobility solutions describing the user experience, the use of technology and energy, the development of new business models and the possibility to include cooperative and participative models between users and user/service providers. Imagining new service solutions and new ways to structure service offer have an impact on vehicles design and performances, the whole service system and its organization, and the users' behaviours and experiences, moreover on the urban context and its mobility system.

For these reasons, the idea generation process has been structured in order to propose a large number of service ideas that consider future challenges for electrical mobility and urban sustainable mobility scenarios.

The creative phase of Green Move research involved, beyond some institutional and entrepreneurial stakeholders, a multidisciplinary team composed of designers, engineers, researchers and students that actively participated in brainstorming phase and in the subsequent reflection on service proposals. The brainstorming activities have been done during a design workshop to imagine—in a collaborative way—new service and new business models and new offering structures.

In order to facilitate the brainstorming activity, three cross schemes have been proposed each defining four design directions considering three main levers of innovation:

1. the user experience (active/passive users—community/single users);
2. the use of technology (relieving/enabling system—personal/shared technology);
3. the energy production/energy management (energy producers/consumers—B2B/B2C approach).

Participants were asked to propose different service ideas/mobility models for each of the cross schemes presented in order to obtain a large number of concepts. The collaboration between researchers with different backgrounds and external actors helped the creative process, the knowledge sharing and the discussion on different design perspectives and strategies considering, for example the users' experience, the technology and the technical issues related to the energy production.

3.3 Developing Mobility Scenarios Based on Electric Vehicles

The rough ideas generated during the brainstorming activity (total number of 67) were subsequently clustered into six design scenarios (areas of innovation). The description of the service scenarios considered the design challenges derived from the case study analysis and the heterogeneous stimuli derived from the concept generation.

In particular, the final six macro scenarios for mobility services are based on six innovation areas: (1) business model, (2) information management, (3) user interaction, (4) cooperation/peering, (5) co-production services, (6) energy infrastructure/energy management. These scenarios included the main design topics to be considered while defining the choice of a new electrical vehicle, coherent with the urban system and resources and the needs of users and communities involved.

For each scenario, some promising service concepts have been identified as starting point to be further developed in the next stages, these are:

- Pricing/incentives (adopting different fares for urban zones and trips);
- Fleets management (using external firm fleets to widen the service offering, for example during the night);
- Procurement/Consulting (defining specific offers for B2B services);
- Education (fostering education about the use of the EV sharing also through social technologies);
- Real time on the move (intercepting a wider demand connecting car pooling and car sharing);
- Feedback management (improving the idea of service community using the users' feedback);
- Customization/profiling (designing services for specific users'
- communities);
- Communities (adapting/scaling the service to particular communities such as co-housing models);
- Coop (proposing collaborative models for the service production, delivery and management using peer-to-peer approaches);
- Micro-entrepreneurship (expanding the service offering including other small companies—as co-producers—that can provide additional services).