# Introduction: Car-Sharing Evolution and Green Move Project

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**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.

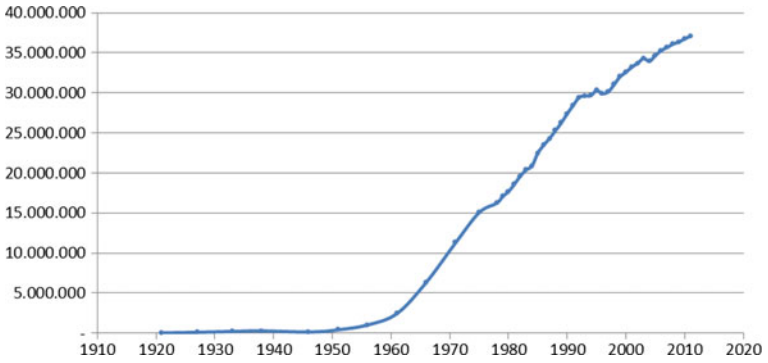


**Fig. 1** Increase of private cars ownership in Italy (ACI 2012)

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.

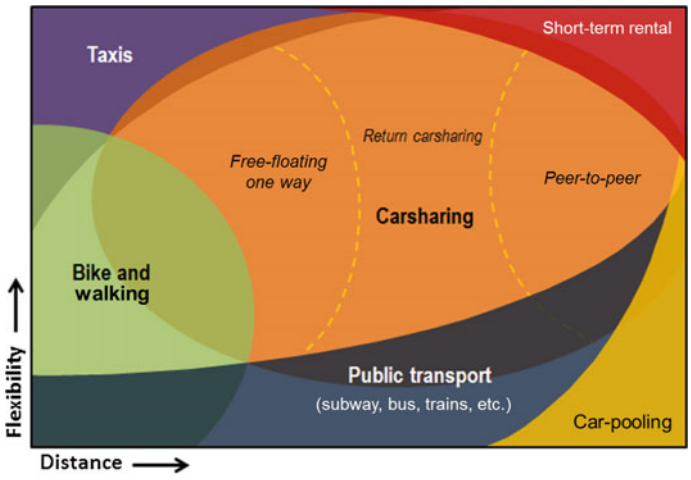


**Fig. 2** Multimodality in large urban centers, excluding the private car (http://www.inov360.com/en/car-sharing-yes-but-whichone/)

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).

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[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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