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Carsharing in cities: will electric vehicles change the business? A comparison between France and Japan

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Abstract

Since the beginning of the 2000's, carsharing systems are developing fast in many cities in the world, as alternatives to car use. Initially developed through private initiatives (associations and companies) for a specific population who have no car or use it weakly, these systems are now called to play a greater role in cities to encourage a reduction of car use. Two different systems can be identified. The 'traditional' one offers users to pick up a car in a specific station (in a parking lot or close to home) to do round trips they cannot do by other means of transport (public transport, cycling or walking). The 'technological' one benefits from the ITS development to favor instant rent, through a dense network of stations all over the city, on the basis of one-way trips. Based on available surveys on the characteristics of customers, this paper analyses the situation in France and Japan for the development of these two systems which generates different types of uses.

The merge of electric vehicles could change the situation. Carsharing appears to be a good opportunity for the visibility of electric cars (showcases), and can be adapted for small clean trips in the city. In Japan, as well as in European countries, many companies are appearing to propose e-car sharing services, with the development of recharging stations for EVs parking. But often, these vehicles are small ones and will not satisfy the diversity of the demand of customers. The paper will discuss the consequences of introducing EVs for carsharing, on the nature of the market (type of uses), trying to make an arbitration between the advantages of clean vehicles and the trip demand from citizens.

1. Introduction: the emergence of carsharing systems

Some authors consider that the concept of carsharing appeared in the 50's, as a means to avoid high fixed costs of car ownership (Robert, 2007; Shaheen & Cohen, 2007). However as early as the late 60s, Friedman (1969) has clearly identified advantages of sharing the use of a car in terms of reduction of traffic congestion, limitation of space consumption for parking, reduction of travel costs, reduction of air pollution in peak periods, promotion of public transport, which means related to public or societal issues. The first experiment in 1967 in Philadelphia (University of Pennsylvania, 1970) intended to create a new form of "individual public transport system", with the "Minicar Transit System". This R&D project, implying General Motors and grants from the UMTA, was based on the technological development of a 3-seat hybrid car (!), with the idea of a self-service system with stations every 150 m... Some other demonstration projects appeared during the seventies in France (Montpellier, 1971-73: Procotip) or in the Netherlands (Amsterdam, 1973-80: Witcar). Lacking of a market and facing difficulties whatever technological or managerial (NTIC were not yet available), these experimentations stopped at the end of public grants. At that time in a context where households' revenue was still increasing while the cost of car ownership was reducing, carmakers were selling a lot of cars. Nevertheless, this first attempt to create a new service helped to identify the main technological barriers to overcome.

1.1 The emergence of carsharing systems

At the end of the 80's, in western countries, another concept of carsharing started developing through local initiatives from individuals. Far from technological developments, the emphasis was put on the service, delivered through cooperatives of members who had no cars or who were using

them rarely. Considering the use of car as an additional service for trips not easy to do by public transport (or soft modes), the approach was favoring environment-friendly behaviors. Although this concept of carsharing has quickly spread over many industrialized countries, especially in Switzerland (1987: ATG and ShareCom) or in Germany (1988, StadtAuto), it stayed limited for many years on a niche market. During the 90s, the development of such services became more significant with for example Mobility Carsharing in Switzerland (1997) or Communauto in Québec (1994), but it is only around the mid 2000's that commercial activity really reached a significant turnover.

During the same period of time, namely the 90s, a second technological development phase emerged under governmental support for carmakers. In the two countries Japan and France, on which this paper is focusing, several projects linked to the development of electric cars were launched, often under the leadership of carmakers. Progress having been made in the field of new technologies of information and communication, many applications for real-time information (booking, vehicle location and follow-up, pricing, access cards,...) now were available helping the system running.

In France, three main experiments can be noted:

- The LISELEC project: initiated in 1993 by the city of La Rochelle, with the assistance of EDF (French National Power Company), the system had 50 electric cars to be tested (rental for half a day). Due to the success of this first phase, the Autoplus carsharing system was implemented in 1995, including electric cars since 1999. The system still exists under the name of Yélobobile, and is operated by Transdev (50 vehicles, 13 stations, 606 members in 2012). <http://proxiway-larochelle.fr/>
- The TULIP project: Peugeot PSA conducted in the city of Tours, a demonstration of 2-seat electric cars, which could be charged in station by induction (1995-98).
- The PRAXITELE project: Renault experimented in the city of Saint-Quentin en Yveline a carsharing system with a maximum of 14 stations, 50 electric cars and 370 members (1997-98). The system was focusing on commuter trips between a railway station and industrial areas in the suburbs of Paris, but could be also used by residents.
http://halshs.archives-ouvertes.fr/docs/00/57/24/00/PDF/TEC1_Massot_2000.pdf

In Japan too, similar experimental projects were developed:

- The Honda ICVS (Intelligent Community Vehicle System): implemented in different locations, but especially in the Keihanna Scientific Park. This ITS carsharing was experimented through several phases (Nov/Dec 2002 – July/Nov 2003 – July 2004). Operated by the Foundation of the Kansai Research Institute, its aim was to test ITS with low pollution cars, and analyze how a membership-based collective use of non-polluting vehicles (carsharing and on-demand buses) could be combined with existing collective transportation. In 2003, there were 10 hybrid Honda Civic, 6 stations, 173 members. It was used for round trip during the day and as a station car during the peak periods (morning and evening) – (Takayama,2002).
<http://world.honda.com/ICVS/about/exp/exp.html>
- The Toyota Motor Company (TMC) launched a major demonstration in the city of Toyoda, called the Crayon System (1997-2002), with 50 small city-class electric vehicles (Ecom) and 10 stations. A maximum of 600 members (from TMC and Toyota City Hall) could use it for business trips, and partly commuting trips. Toyota also provided both vehicles and system support for the shared EV commuter system experiment in Tama New Town, Tokyo, under the direction of the Association of Electronics Technology for Automobile Traffic and Driving.
http://www.toyota-global.com/sustainability/report/sr/00/pdf/c72_73.pdf

- The ITS/EV City Car System (1999-2002) in Yokohama (Shin-Yokohama and Minatomirai 21 districts) was implemented with 30 EV, 12 stations and 460 members at its maximum, with a free access. It was managed by the Japan Association of Electronics Technology for Automobile Traffic and Driving (JSK). When the system became charged in February 2002 (and then managed by ORYX), only 10 stations were operational. The system had 23 contracts for 123 users. Focusing on professional trips in the city center where parking is difficult, it could be used for round trips but also for one-way trips. In the same way, the ITS/EV Residential District Second Car System (1999) in Inagi (Tama New Town, Tokyo prefecture) was developed with 50 EVs and 8 stations, then downsized to 30 EV in 2001 and to 6 stations in 2002. It was targeting individuals living in residential districts, where houses have only one parking lot and where it was difficult for a second car to park. When the access was free, there were 242 members, but when it started to be charged (October 2001), they were only 153.

It clearly appears that this second phase of technological development too was seen as a test bed for the development of electric vehicles but differing from the first phase of the 70s it also aimed at testing other technological components from the emerging field of ITS. Considered as technological demonstrators, these experiments which just lasted a couple of years were implying carmakers in both countries and were supported with grants from the concerned ministries. Indeed, given EVs technical constraints, researching and other related costs, once public grants were over, it appeared impossible to continue, especially since these systems were not able, at that time, to catch a market sufficient to justify a commercial activity. Nevertheless, they were an opportunity to promote the electric vehicle by itself, in order to favor the take-off of the market for carmakers.

1.2 Recent trends in the development of the carsharing market

During the 2000's, the carsharing concept really merged as an option, in a context where gasoline prices were increasing, public policies focused on sustainable development and households became more sensitive to environmental stakes. As it can be seen on Figure 1, the uptake of carsharing market really started in several countries in the world, and especially in the USA. France recorded a certain increase, although partly limited by institutional and legal constraints, while in Japan, carsharing exploded at the beginning of the 2010's.

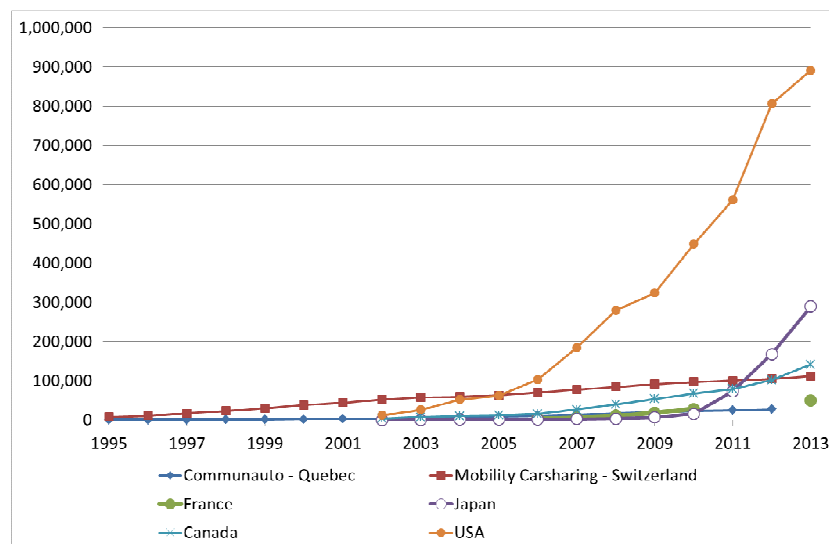


Figure 1. Evolution of carsharing members in different countries

Sources: Quebec : <http://www.communauto.com/images/usagers.html>; Switzerland: <http://www.mobility.ch/fr/medias/communiqués-de-presse/>; France: CERTU, 2008, L'auto-partage en France et en Europe – état des lieux et perspectives; Japan: Ecom Foundation; USA: Shaheen and Cohen, 2012

In October 2012, carsharing is implemented in 27 countries over 5 continents, accounting for nearly 1.788 million members and 43,500 vehicles (Innovative mobility, 2013). North America (51%) and Europe (39%) are the main carsharing regions, while Asia represents 9%. As a comparison, in 2006, the numbers of members was 346,000 for 11,700 vehicles: Europe (61%) was dominating, followed by North America (34%) and Asia (5%). This quick evolution can be seen on Figure 2, based on data collected by Shaheen (2013).

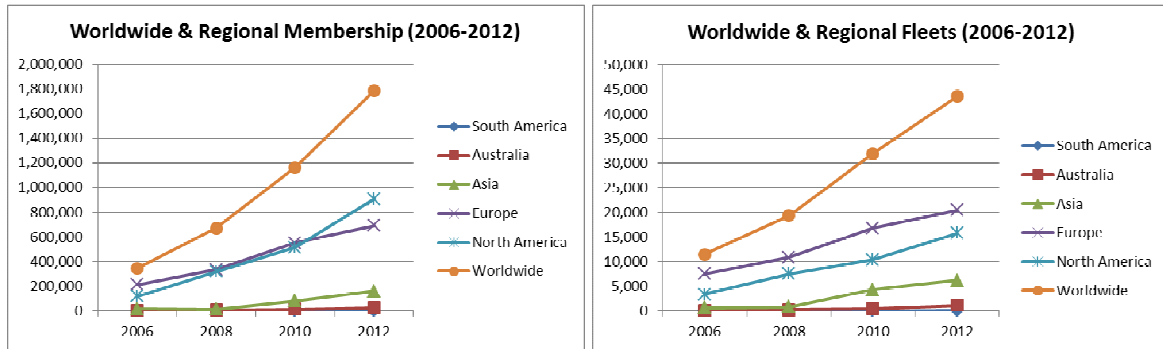


Figure 2: Worldwide trends in the car sharing market

Source: Shaheen, 2013

In the mid 2000's, France and Japan are still lagging behind other countries, when looking at the number of members compared to the population of the country (Table 1). This can be explained by different reasons, specific to each country.

Table 1. The carsharing market in 2006-07 (Data: Civitas-Mobilis)

Countries	Members (Thousands)	Members /10,000 inhabitants
USA	134	46
Germany	100	122
Switzerland	76	972
UK	29	48
Canada	22	66
Netherlands	20	121
Austria	16	192
Italy	9.5	16
Singapore	8	178
Belgium	6	57
France	4.4	7
Denmark	4	73
Japan	3	2
Spain	1.4	3

Source: CERTU, 2008

1.2.1 The carsharing development in France

In France public policies generally gives priority to the development of Public Transport networks. Carsharing was therefore seen as a niche market and often operated by local associations of

residents. This did not prevent a certain increase since while there were only 2 carsharing systems operating in 1999, there were 8 in 2003 and 19 in 2008 (CERTU, 2008), and now in 2013, more than 20 operators are covering about 30 agglomerations, totalizing more than 20,000 subscribers¹ (6-t Recherche, 2013). Progressively, these associations tried to organize themselves in a national network, as for example France Auto Partage (now named CITIZ - <http://citiz.coop/>, 16 locations, 700 cars), while some were replaced by semi-public companies, like the Lyon Autolib system, operated by the Lyon Parc Auto company (in charge of parking building and management). This 'traditional' model, is now challenged by new comers in the field thanks to two recent and interrelated events which have changed the situation.

First, the 2009 law on environment (Grenelle Environnement) encouraged cities to consider car sharing as a public service. This gave the possibility for municipalities to subsidize or to assist the associations for their development and to implement reserved on-street parking places for the carsharing.

Second, the entrance of Bolloré, a French company involved among others in batteries, in the EVs sector with the launching in 2011 of Paris Autolib' system. This new large-scale 'technological' system, the first to be implemented in a great city, should reach 3,000 EVs (Bolloré Bluecar), and 1,000 stations, mainly located on street (<https://www.autolib.eu/fr/>). Based on this success, the system was then developed in other French cities, like Lyon (Bluely) and Bordeaux (Bluecub) although on a smaller scale.

1.2.2 The carsharing development in Japan

Although the parking constraints in Japanese biggest cities, with the obligation to have a private parking place to own a car, could have been a key argument for the development of carsharing, it started rather late even though as we have seen before some experimentation of "technological" system were implemented in the late 90s.

Carsharing started to grow in Japan at a slow pace in the beginning of the 2000's but really increased quite recently. The quality and large number of available transport modes, in particular the public and private railway networks, which historically played a major role in the development of cities, are among the reasons of this rather late development. According to Barth and al. (2006) another barrier to carsharing development leads to its classification by the government as a "rental-car" business, which means that management operations had to be within 2 kilometers of the rented car. This constraint has been relaxed for carsharing organizations, but it might explain why there were many very small systems without cooperation between them.

ORIX Auto, a leading parking operator, became the first company to introduce a carsharing service in Tokyo in April 2002, followed by the second parking operator Time Plus, in 2005. According to the Eco-MO Foundation, the number of operators increased progressively: 7 (2004), 14 (2007), 34 (2010) and 33 (2013). The market is dominated by three services: Times Car Plus (4,671 stations, 7,455 vehicles and 298,344 members), Orix Car Share (1,262; 2,053; 100,082) and Careco Car Sharing Club (726; 819; 25,000) for a total of 7,565 stations, 12,373 vehicles and 465,280 members (Eco-MO Foundation, 2014). All the operators are not that big though: in most cases (81%), the number of stations and vehicles being under 100. In fact, what is quite noticeable in the case of Japan is the importance of business trips or in other words of business membership. Careco is developing stations in the 'convenience stores' (Combinis) for residential users, but Times Car Plus and Orix Car Share, the two main operators in terms of stations, vehicles and members are both focusing on business trips and greatly increased their markets thanks to contracts with companies since 2009-2010. Enterprises hit by the crisis tending to reduce their cost burden, turn to carsharing and limit company car fleet. It

¹ Should be added another 20,000 persons, practicing informal carsharing (P2P)

appears a good solution to cut not only cars purchasing costs but also in some cases parking rental cost and of course maintenance.

Through this brief comparison between France and Japan, it appears that the 'traditional' system is now developing faster, mainly for residents in France and for both, companies and residents in Japan. Constraints on car use in terms of cost, parking or even sensitivity to environmental stakes are key elements for the promotion of carsharing. But public policies are also drivers for this alternative to car use, moreover for the 'technological' system which appears as having now reached a sufficient degree of maturity, to achieve a significant step in its development, as evidenced by the Paris Autolib' system.

2 Two different visions of the carsharing market

These two paths for the development of carsharing systems are based on different visions, the 'traditional' one trying to cope with the mobility needs of a specific population, while the 'technological' one aims at an alternative use of car for a larger population living in the center of the cities.

2.1 Substitution versus complementarity

The basic idea of the carsharing concept is to favor a collective use of cars, rather than an individual one, based on car ownership. Advantages are for both the society and individuals. Indeed, it appears that, on average, a car is used about one hour per day, which means cars are parked most of the time and then request high parking capacities in the city, where space is rare and costly. Also, the high use of cars during peak periods induces congestion or needs the building of many large roads. This is the reason why municipalities are now encouraging people to use alternative modes of transport, such as Public Transport (PT) but also soft modes (biking and walking), which are more efficient in terms of space consumption. Moreover, the noise, the local pollution as well as the CO2 emissions, are other negative impacts which oblige to reduce car use in cities.

But it clearly appears that Public Transport and soft modes cannot satisfy all the mobility needs which are diversifying, in relation to inhabitants' life style. Soft modes are well adapted to short trips in the city center, as well as in residential areas. PT networks are pertinent when and where the demand is strong enough to insure its profitability. This means these alternatives are not satisfying for many market segments: off-peak trips, low density areas, peripheral trips, but also when people have goods to carry, for example. Then carsharing is seen as a **complementary system** requested to satisfy a niche market. Carsharing is expected to encourage people to reduce their car ownership (main car, as well as second car), but also to reduce car driven mileage, for the benefit of other modes.

Car ownership is costly and can be even more expensive for individuals living in the dense part of the city due to parking constraints. In such areas, car use is also penalized by congestion while PT supply being in general well developed, most of the daily mobility needs can be satisfied easily. Therefore, car ownership is not perceived as vital anymore especially since specific trips, for which alternatives have a weak quality, can be covered by short duration rental. In that case, the motivation for carsharing is mainly financial, as the system appears less expensive: carsharing can be seen as a **substitution** to car ownership, but also to the use of taxis for example.

2.1.1 Use of 'traditional' systems by individuals in France and in Japan

In the case of France, a recent survey conducted by 6-t Recherche (2013; 1,923 respondents, mainly 'traditional' private customers systems) shows that nearly 78% of the subscribers do not own a car, while before membership 39% were owning car(s). 53.4% of the customers are aged between 30 and 49 years. 45% are women, 60% have no child, 76% have a full time job and 68% have a high level of

education. Most of them are living in the center of the city (69%) and the location of their job is closer to their residential housing than other inhabitants. The main reason for subscription is that carsharing cost is lower than car ownership one (51%), that it is practical (21%) and that it is environmental-friendly (20%). These numbers appear close to those published by the MOMO consortium (Loose, 2010) who surveyed 14 European countries.

The present carsharing market segment concerns in fact a relatively small part of the population living in cities. This means that the concerned population has relatively high income as they can pay for a housing located in the city center. Thanks to that, they can benefit from the proximity of activities and services, as well as of a performing PT network for their daily mobility while carsharing provide a solution for specific trips. 60% of customers stated carsharing gave them the possibility to avoid buying a car or to sell their car.

Subscribers' decision to change travel habits is mainly due to professional changes, housing moves or changes in the composition of the family. But numbers also show that the proximity of a carsharing station matters as 80% of subscribers are living at less than 10 walking minutes. This also confirms some of the recommendations from the 2001-2004 MOSES European project (Koch, 2004), concerning the best locations for carsharing stations to be a success.

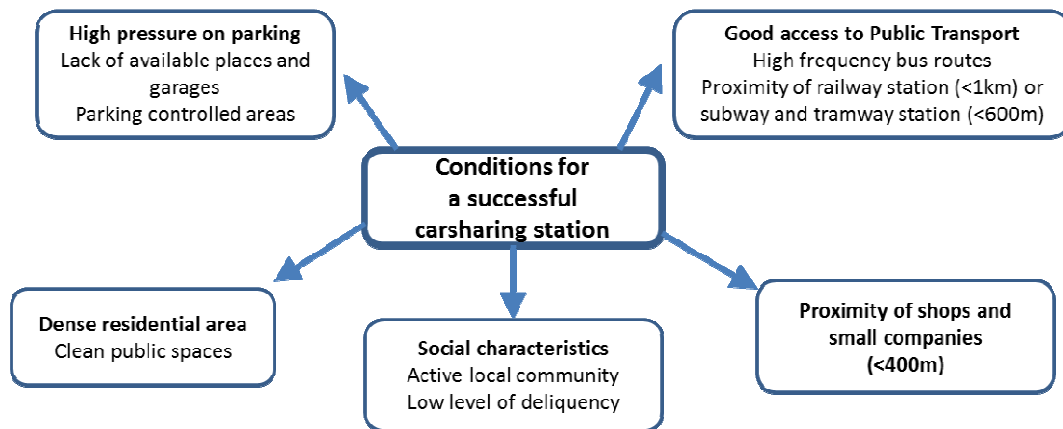


Figure 3: Conditions for a successful carsharing station success (adapted from APUR, 2008)

Carsharing is only used occasionally (Table 2), mainly for shopping, visit or leisure and rarely for professional trips. The peak period for the location of a car is in general in the afternoon and the evening, as well as during week-ends.

Frequency of use	%
everyday	0.7
2-3 times a week	4.9
once a week	11.8
2-3 times a month	32.3
once a month	26.6
less than once a month	19.2

Table 2: Frequency of carsharing trips for individual customers in France (1,923 respondents)

Source : 6-t Recherche, 2013

Being mainly used for such specific trips, users appreciate a diversified car fleet: small utility vans, small cars (but also bigger ones for intercity trips or when travelling with several persons), including sometimes luxurious or sport vehicles for leisure trips. It also means that the trips done by carsharing

are not in general short trips. For example, in the case of the Autolib system in Lyon², 50% of the trips have a length higher than 27 km (for a round trip), and last 5 hours, while the average distance is 62 km, and the average duration is more than 9 hours³.

In the case of Japan, even if as mentioned before, carsharing is more frequently used for business trips than in France, the majority of members still are individuals. A survey conducted by the Eco-MO Foundation (2013a) in 2012 (491 persons) gives an overview of the similarities and differences with the French case. The great majority of customers are men (81.5%) and between 30 and 50 years old (70.3%). They also use carsharing occasionally (Table 3) mainly during the week-ends and holidays only (59.2%) or during week days only (15.6%). The trip purpose concerns essentially leisure (43.4%) and shopping (32.8%). Like in the French case, the great majority of the users are living close to the carsharing stations: 72.8% at less than 10 walking minutes). In terms of distances, 39.0% of the respondents stated they drive less than 250 km per year, 16.3% between 250 and 500 km, and 20.4% between 500 and 1,000 km.

Frequency of use	%
more than once a week	9.2
more than 3 times a month	11.0
2-3 times a month	19.1
once a month	30.8
less than once a month	23.8

Table 3: Frequency of carsharing trips for individual customers in Japan (491 respondents)

Source: Eco-MO Foundation, 2013a

Statistics then show a relative similar structure of the private customers' characteristics between the two countries. Unfortunately, the two surveys being rather differently designed according to motivations for carsharing use, comparison is a bit hazardous.

JAPAN		FRANCE	
	%		%
the service is close to home	80	it is less expensive than owning a car	51
it is less expensive than buying a car	38	it was the time for changing an old car	29
it is less expensive than keeping a car	24	it is more practical than a private car	21
moving to a district with good public transport	21	for ecological reasons and life style	20
moving to a district where parking fees are high	17	change in residential location	9
the service is available in the places where I go	16	changes in the family	6
it was the time for changing an old car	13		
changes in the family needing the use of a car	10		

Table 4: Motivation for joining a carsharing system in Japan and France

Source: Eco-MO Foundation, 2013a; 6-t Recherche, 2013

Even if the Japanese customers highlight the proximity of the service, the main reasons for membership are clearly financial ones in the two countries. It could be also noticed that structural

² To avoid any confusion, the Autolib system in Lyon is a 'traditional' round trip one, now managed by LPA, a semi-public company in charge of building and managing parking lots. It has nothing to do with the Autolib' system implemented in the Paris region by Bolloré, which is a 'technological' one, using exclusively electric cars for one-way trips.

³ Source : LPA, 2013 – Interview by the authors - <http://www.autolib.fr/autolib/index.aspx>

changes (family, home location) appear as significant triggers, as it is often the case for behavioral changes in the field of transport.

The Japanese survey gives information about the type of car used by customers: small urban cars (Mazda Demio, Honda Fit, Toyota Vitz,...) are mainly used (70.4%), followed by middle sized cars (Toyota Prius, Honda Insight, Nissan Tiida, Nissan Leaf,... : 23.0%), while light cars (Suzuki Swift, Mitsubishi I-Miev,... : 4.4%) and foreign cars (0.6%) are neglected. The evolution of car ownership shows a significant decrease: 58.7% of the subscribers had no car before membership, and 86.4% after (+47%); those who own one car also decreased from 36.3% to 10.4% (-71%) (Eco-MO Foundation, 2013b). The annual driven distance by car is reduced from 4,047 km to 2,543 (-36.7%).

On the contrary, the French survey does not give information on the type of cars, but highlights a significant change in car ownership. Before using the carsharing system, 39% of the customers had no car, 50% had one car and 11% two cars or more. After using it, 78% had no cars, 18% one car and 4% two cars or more. This means a reduction of 64% of the number of cars in the sample of the survey. In the same way, the mileage per month by car before using the carsharing system was on average 437 km. After using it, the customers drive on average 123 km with the shared car, and still 136 km with their own car, which means a 41% reduction in the total mileage.

Moreover, the survey gives interesting information on the evolution of other modes of transport after becoming member of the carsharing system (Figure 4). It clearly shows that, for ‘traditional’ systems, car rental and taxis are the main losers, while soft modes, train and public transport are the winners. This will confirm the positive impact of carsharing systems, with a **substitution effect for private car** and a **complementary effect for public transport and soft modes**, which are the present objectives of urban sustainable mobility plans in cities.

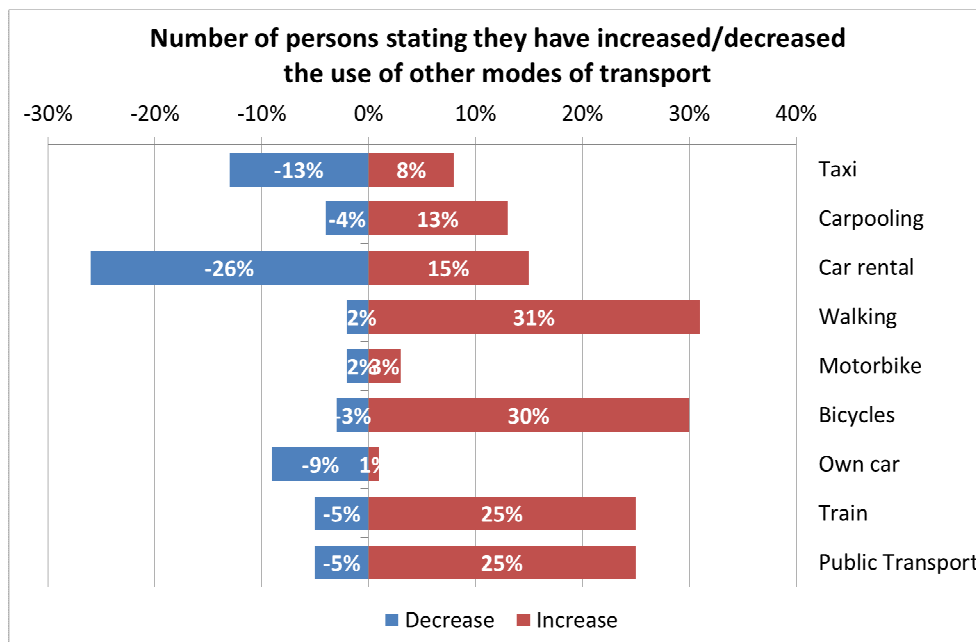


Figure 4: Evolution of the use of other modes after becoming member of the carsharing system (France) - Source: 6-t Recherche, 2013

2.1.2 Use of ‘traditional’ systems by business customers

In France, the use of ‘traditional’ carsharing systems for professional trips is not really developed. The 2012 survey (6-t Recherche, 2013) counts only 167 persons for business trips (7.6%) and 158 mixing professional and personal trips (8.0%). But several services are now trying to attract

companies, as it is already the case in Switzerland, where Mobility Carsharing Company estimates that the business carsharing now represents 23.5% of its turnover⁴.

In Japan, a recent survey conducted with the companies members of Time Car Plus (Times 24 company, 2014a) in December 2013 (1,638 companies) gives an insight concerning the business trips. Among the respondents, 72.7% were small companies (less than 50 employees). 41.5% stated they have no company cars and 48.6% less than 10. Finally, 31.6% stated they reduced the size of their car fleet after becoming members of the carsharing service.

As Table 5 shows, reasons for becoming member of the carsharing system are mainly financial ones, but it also highlights the constraints on parking for companies. Here the resort to carsharing is a **substitution to company car fleet**, and probably to taxis.

Reasons	%
Increase the business efficiency	37.4
Reduce transport costs	35.5
Avoid company car fleet	23.4
Insufficient company car fleet	22.8
Parking constraints	19.0
Reduce the size of the company car fleet	12.7
Others	11.7

Table 5: Reasons for companies' membership of the Time Car Plus carsharing system in Japan

Source: Times 24 company, 2014a

Another survey, conducted in 2012 by the Eco-Mo Foundation (2013a) gives more details on the characteristics of the business clients, even if the sample is limited (77 companies). 60% of the respondents are companies with less than 50 employees, but 18% are companies with 200-1,000 employees, showing that the resort to carsharing is not limited to small companies. Nevertheless, the use of carsharing appears more frequent than it was the case for individual subscribers (Table 6) but it generally concerns a limited number of employees (less than 10 for 31% of the companies; less than 30 for 75%). Most of the companies are located close to a railway station (less than 5 minutes' walk: 77%). 53% of the companies have no parking area (1/3 of them could rent a parking place close to the company though). 75% of the companies are close to a carsharing station (less than 5 minutes' walk).

Frequency of use	%
more than once a day	13
more than 5 times a week	9
3-5 times a week	19
1-3 times a week	32
more than once a month	18
less than once a month	5

Table 6: Frequency of carsharing trips for companies in Japan (77 respondents)

Source: Eco-MO Foundation, 2013a

⁴ https://www.mobility.ch/fileadmin/files/meta/media/media_releases/MM_F_Mobility_Jahresabschluss_2013.pdf

These different elements show that whatever in France or Japan, traditional carsharing systems work as **a substitute for taxis and car rental**, as many individuals do not own a car or business could reduce their fleet. They also show that the reasons to turn to carsharing do not differ that much between individuals and business subscribers. In both cases, financial motivations are at stake especially when car use does not appear as essential. In that sense, surveys confirms that the condition for a commercial success depends on several factors: a residential or business location in the center areas, where parking constraints are severe, and public transport supply is important. Likewise, the proximity of stations is requested, which means that although sometimes difficult to obtain from municipal government up to now⁵ or to implement due to regulations, benefiting of on-street parking might be a suitable solution for further development. This is particularly important for 'technological' systems which are now developing based on electric vehicles, self-service stations and single trips (one-way) services.

2.2 Round-trip or one-way?

Apart from this issue in terms of complementary/substitution to car ownership or PT and soft modes, on which we will come back later, the recent development (or restarting) of 'technological' systems leads up to another difference: round-trip or one-way, which is worth introducing to understand the future evolution of carsharing market.

2.2.1 Two different concepts of carsharing

A round-trip service is similar to a short-duration rental, made occasionally, for a relatively long distance. The car is taken at a station (for example a car park), but more and more in Europe at a mini-station located on the street (2 to 4 cars available), in order to be close to the subscriber's home. The subscriber has to make a reservation (usually the day before, but more and more now until 30 minutes before departure), and will state the duration of the trip. This is needed on one part to let the operator know about the availability of its fleet, and on the other part, to charge the trip (generally based on duration and mileage). This means the subscriber has planned his trip and will do a return trip back to the departure station. This is also the case for the "station cars" located close to railway stations, or even for business trips of members' companies. Although it might not be systematic, the 'traditional' system appears as resting on that type of round-trip services.

One-way trip corresponds more to a kind of instant rental or self-service, taking the vehicle at a station A to retribute it at a station B, located elsewhere in the city. The system is then very close to self-service rent-a-bike system, like Vélo'V in Lyon or Vélib in Paris. The reservation of the vehicle can be done through an Internet connection or apps for smartphone, usually little time before departure and often the system also offers the possibility to make a reservation of the destination station. This is then highlighted by operators as a real advantage, especially in areas where parking is difficult: the subscriber is sure to be able to park the car and for free! The main difficulty for the operation is then the availability of cars and free parking places all over the network of stations. Depending on the location of the station, the equilibrium can be hard to manage, and sometimes implies to mobilize persons to drive cars (named 'jockeys') from a station to another. For example in Paris, Autolib' subscribers living in peripheral areas are encouraged to drive back cars to the city center at the end of the afternoon, in exchange for free rentals.

Although recent surveys show that some 'traditional' carsharing customers would appreciate possibilities of one-way uses, such services are more representative of the 'technological' system. In 2012, one-way carsharing was already operating in seven countries worldwide (Austria, Canada, France, Germany, the Netherlands, the United Kingdom and the United States). The number of

⁵ The carsharing operator has generally to rent these places from the municipality. For example, in the city of Lyon, the price is 200€/year + 1.5% of the turnover of the station.

projects is still in progress in these countries while some others entered the market these last few years. It is the case of Japan where several experimentation are taking place in the framework of different public policies aiming at building the cities of the future (low carbon cities, future cities, smart communities...).

The first experimentations of one-way systems generally had a limited scale (less than 100 vehicles), as the priority was given to testing technical components (vehicles, stations, controlled access and pricing, operation management for real time rentals). The quick development of ITS technologies now authorizes the design of large scale projects, like in Paris: the Autolib' system was opened in December 2011, includes 841 stations with 4,266 charging facilities in 2013, and covers an area of 382.5 km², where 3.5 million persons (older than 18) are living and could be potential users⁶.

2.2.2 Two different carsharing markets?

Beyond differences between the two concepts, it is important to observe the differences in terms of use. Surveys on this topic are relatively rare in Japan, due to the still experimental stage of the one-way system. On the contrary, France although still limited has an experience in both, which can give a first insight on the practices.

The 2012 national survey on carsharing in France gives an idea of the compared frequency of use of both concepts (Figure 5). Even if the sample is limited for one-way carsharing systems (88 persons, compared to 1,835 for round trip systems), it clearly appears that the one-way system is used on a weekly basis, while the round trip system is used on a monthly one.

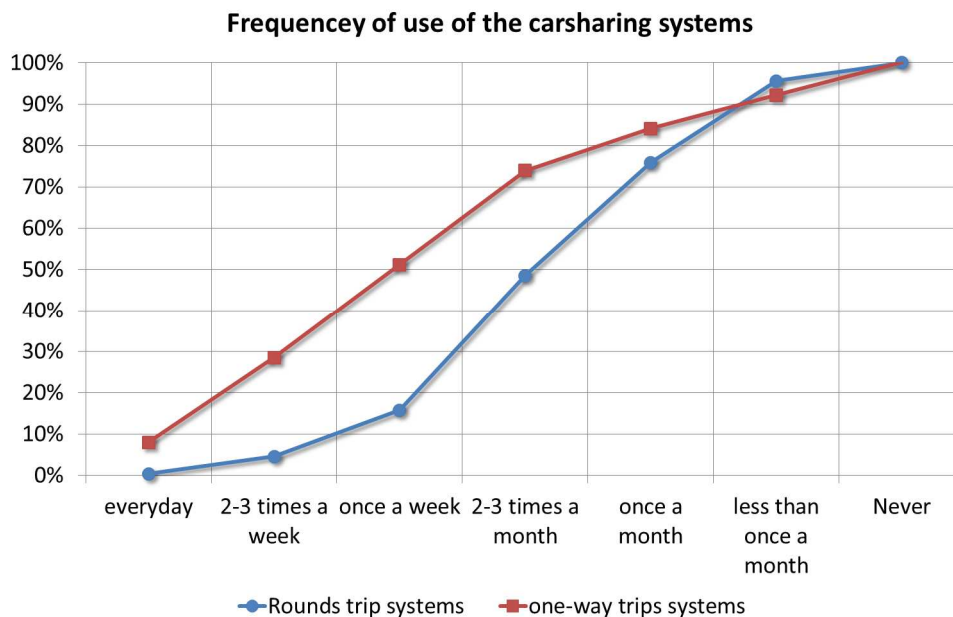


Figure 5: Comparison of the frequency of use of the carsharing systems in France

Source: 2012 National Survey on Carsharing, adapted from (6-t Recherche, 2013)

Another recent survey, conducted on the Paris region (6-t Recherche, 2014⁷) makes a comparison between the two systems: the 'one-way' Autolib' system (664 respondents) and the 'round trip'

⁶ To give an idea of the importance of the traffic by Autolib', note that there is on average, one rent every 9 seconds (source: Autolib' Metropole, 2014)

⁷ Published in May 2014, the full report of the survey is priced 2,700€... Comments are made here from the published synthesis.

Mobizen system (525 respondents). It shows that the type of rental is quite different between the two systems. In the case of the one-way Autolib' service, a rental is done for 40 minutes and 9 km on average, with a frequency of use of more than once a week (57%), while for the Mobizen round-trip one, the average is at 5 hours and 40 km, with a frequency of less than 3 times a month (80%).

Concerning Japan, although to our knowledge such data are not available, looking at the improvements wished by the customers in the Eco-MO foundation surveys, it appears that the most frequent request from customers concerns the implementation of one-way systems in Japan. It is followed by other requests such as the increase of the number of stations, both in the city and in its suburbs, and the possibility to have an access to cars and stations of other carsharing companies (Table 7). The diversification of the fleet comes later, in order to satisfy specific trips, while the introduction of electric or clean vehicles is far behind.

Requested improvements - private customers and companies in Japan	Private	Companies
Introduction of one way systems	32.4%	33.8%
Possibility to use cars and stations of another carsharing company	20.8%	14.3%
Increase the number of stations in urban area	19.1%	28.6%
Increase the number of cars per station	16.9%	16.9%
Increase the number of stations in peripheral areas	11.0%	28.6%
Offering SUV for 8 persons	15.3%	13.0%
Increase the number of stations in condominium	10.0%	0.0%
Offering wagon cars and light duty vehicles	10.0%	26.0%
Increase the number of sport and foreign cars	8.4%	1.3%
Introducing/Increasing the number of ecological/electric cars	10.0%	2.6%
Introducing a system free of reservation	6.7%	5.2%
Introducing a system indicating several locations where vehicles are available	3.1%	2.6%
Improve the simplicity of reservation by smartphone	11.2%	6.5%
Others	11.4%	6.5%

Table 7: Improvement requests for private customers (491 respondents) and companies (77 respondents) in Japan

Source: Eco-MO Foundation, 2013a

These requests from users are rather consistent with the topics highlighted in the survey conducted in France (Table 8). Apart from the diversification of the fleet to cope with specific trips, the one-way system is emerging as the main expectation, even if only 1/3 is ready to pay more for such a service. Electric vehicles are also requested, but the willingness to pay more for it is also very weak. Finally, it can be noted that the integration between carsharing and public transport through a common season ticket is also expected by 45% of the respondents.

Requested improvements - private customers in France	Private
Introduction of one way systems	71.7%
Agree to pay more for a one-way service	36.8%
Introduction of electric vehicles	63.4%
Agree to pay more for electric vehicles	15.7%
Introduction of automatic gear box vehicles	30.7%
Diversifying the size of vehicles	94.7%
Creating a season ticket valid for carsharing and Public Transport	45.3%

Table 8: Improvement requests for private customers of 'traditional' carsharing systems (1,923 respondents) in France

Source: 6-t Recherche, 2013

These elements underline a need for a one-way system, at least from a part of the present customers. Indeed, the observation of the frequency of use, the duration and the driven distance per trip lead to consider that it exists in fact two different markets. The 'round-trip' system matches well the expectations of people using mainly the public transport and soft modes for their daily mobility, or as an alternative to company cars for business trips, while the 'one-way' system is more attracting people using their car in areas where parking constraints are strong. Of course other reasons also explain the shift to carsharing as mentioned earlier, but parking seems really matter as can be evidenced by the last survey comparing the two systems in the Paris region (6-t Recherche, 2014). Among the stated motivations for the use of the 'one-way' carsharing system, the fact that the system provides a reserved parking place at destination is quoted by 67% of the users. Others reasons are: 'it is more practical than PT' (25%); 'it is cheaper than owning a car' (18%); 'for ecological reasons' (6%)⁸.

The impact of the adhesion to a carsharing system in terms of car ownership also reveals interesting differences among users. Figure 6 shows a different evolution related to the type of customers and depending on the type of system. The impact of the round-trip system seems to be stronger, as the number of individuals owning no car increased from 56% to 87%, essentially from individuals who owns one car and decided to get rid of it. In the case of the one-way system, the same impact can be observed, but at a quite limited level (from 50% to 60%).

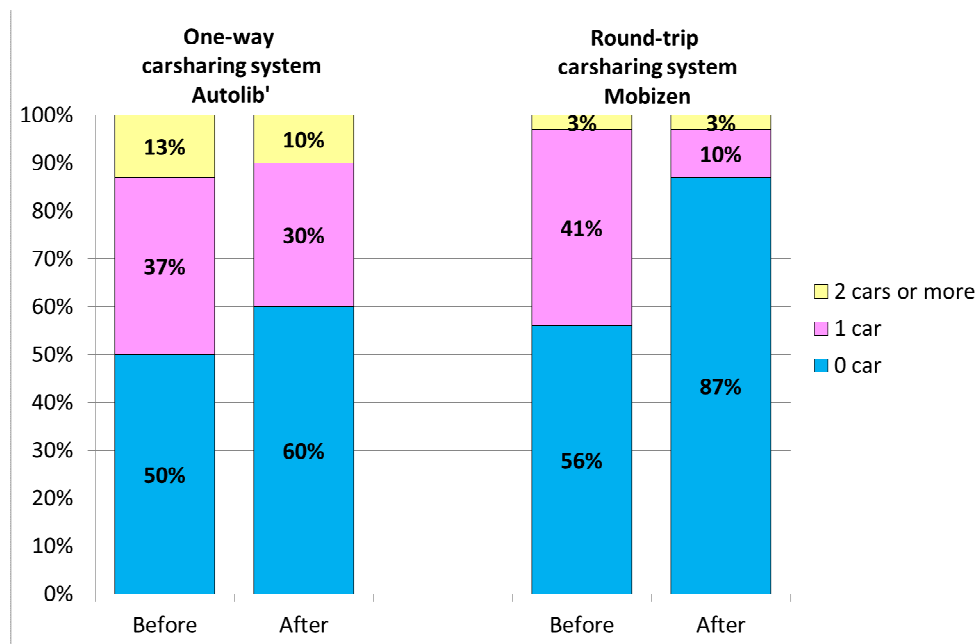


Figure 6: Impact of the carsharing systems on car ownership in France

Source: (6-t Recherche, 2014)

Sure before membership, some differences could already be observed between the two groups of population in terms of travel behavior, or car uses' needs for their daily mobility. Indeed, by comparing on the French case the daily use of each mode of transport for the two groups (Table 9) it appears for example that soft modes (walking, cycling,..) were more practiced by the second group than the first one. But, people who decided to become members of a round-trip or of a one-way system were both previously mainly using Public Transport for their mobility everyday (61% for the

⁸ In comparison, for the 'round-trip' system, main reasons were: 'it is cheaper than owning a car' (31%); 'it is more practical than PT' (1%).

one-way system; 64% for the round-trip one). The use of their personal car was also limited in both cases (respectively 13% and 9%), which can explain they have been questioning its ownership.

Percentage of persons using a given mode everyday(*)	One-way carsharing – Autolib' (664 respondents)			Round-trip carsharing – Mobizen (525 respondents)		
	Before membership	After membership	Evolution	Before membership	Before membership	Evolution
Personal car	13%	5%	-63%	9%	1%	-93%
Public Transport	61%	50%	-18%	64%	65%	+2%
Bikes	3%	2%	-25%	11%	10%	-6%
Automated Rent-a-Bike (Vélib)	4%	4%	0%	5%	7%	+30%
Walking	25%	23%	-7%	35%	36%	+4%
Motorbikes	9%	5%	-42%	8%	8%	0%
Carsharing		16%			0.2%	

(*) the total per column can be higher than 100%, due to combined use of several modes for trips

Table 9: Evolution of travel behavior before and after using a carsharing system in Paris Region

Source: 6-t Recherche, 2014

But interestingly enough, after membership, the change in traveling behavior became much more distinct. The customers of the round-trip system achieved a very strong reduction of the daily use of their personal car (-93%) which has not been counterbalanced by the use of carsharing (0.2% daily). It means they radically changed their travel behavior, partly due to the reduction of car ownership (Figure 6). They succeeded in doing without a car, by using other modes extensively, such as public transport or soft modes.

On the contrary, the customers of the one-way system are using it relatively often (16% use it every day), and thanks to that, could reduce the use of their personal car from 13% down to 5%, or their motorbike⁹ from 9% to 5%. But surprisingly, they have also strongly reduced their use of public transport (from 61% to 50%), which means that the one-way system is partly a substitute of public transport! This might not be exactly what policy makers have in mind when they implement promotion schemes or support experiments of one-way car sharing systems.

Whatever the case, these elements seem to confirm that the two systems are catching two different market segments. The round-trip system seems well designed for a population which is already using mainly public transport and soft modes, but can have sometimes the need to use a car for specific and rare trips: **this system really acts as a complementary system**. On the contrary, the simplicity of use of the one-way system is really attractive for a population which is using their personal car (or motorbike) rarely and has to face the difficulties for parking: **the system acts mainly as a substitute for car use but also for public transport**. By the way, it appears that the one-way system is also competing with taxis: the number of members who are using a taxi each week is divided by 3 (from 19% to 6%), while the number of members who never use a taxi increased from 11% to 20%.

Thus, considering that one-way systems have a lesser impact in terms of car ownership reduction than round-trip systems, meaning that people still can use their own car for week-ends or longer distance outer cities travel, and that it solves the problem of having to park the car at temporary destination (no need to find a parking place or to pay for it while shopping or during a business

⁹ The use of motorbikes has recently strongly increased in the Paris region. This is due to the congestion of traffic, as well as the fact that parking motorbikes is still free (mainly on the pavements).

meeting) it seems that the potential market for one-way systems could be greater than the round-trip systems market. But of course, the attractiveness of the one-way market segment will even more than the round-trip one, depend on the density of stations all over the city. It questions the issue of funding of such an infrastructure, which remains important for the development of EVs, one-way systems being often related to the 'technological' system.

3 The new deal with electric vehicles

The recent uptake of electric vehicle market results from the convergence between a social demand (mainly expressed through public policies in favor of the reducing of GHG emissions) and the overtaking of several technical constraints, in particular on the batteries and the limited range of vehicles. But the uptake of the market is still limited for several reasons. As for any new product, the price of EVs is still high, and customers are not ready to pay more for a limited range vehicle, as their environmental sensitivity remains low. On another side, the limited infrastructure for battery charging remains a strong brake for a purchase decision. To overtake these barriers, many countries first gave priority to electrifying car fleets for public and private companies. On the one side this has the merit to provide volumes orders of vehicles to carmakers and on the other side, it facilitates the implementation and the management of charging stations, although still in a limited number of locations.

The development of carsharing systems then appears as a good opportunity to quickly incorporate EVs in the fleets. Moreover, as carsharing members are already low users of cars, the charging duration constraints for batteries are supposed to have a limited impact. But as the previous part of this paper has underlined it, depending on the carsharing concepts taken into account, the type of use differing between both, it might more or less cope with EVs constraints.

3.1 Limited opportunities for 'traditional' carsharing systems

Even if the recourse to electric vehicles is quoted by customers as an expectation (more strongly in France than in Japan, where such a demand is very weak for business trips –Table 8), the relatively long distance and long duration of rentals show that a limited range (driving distance without charging, time to charge) will not cope with part of the mobility needs of the members. But as the technical improvements of batteries now allow to foreseen ranges of more than 200 km, this argument may disappear progressively. Overcoming this barrier is probably linked to the development of a quick charging station network all over the country, for example in gas stations on roads and highways.

But the main barrier can come from the carsharing company managers, as introducing electric vehicles needs heavy investments. Taking the example of the Lyon Autolib traditional system¹⁰, the company does not own the vehicles, which are at its disposal through a long-term rental contract. The cost for a small-sized diesel car is about 200€/month, while it can be 250€ for a small hybrid car and up to 700€ for an EV! Furthermore, looking for electricity based on renewable sources means presently a 20% increase of the cost... Then the introduction of EVs will mainly depend on their cost, as well as on the emergence of a second-hand market (resale value). Moreover, the company should invest in charging stations, while the present legislation prohibits the implementation of quick charging station in underground parking lots for safety reasons (fire risk). The company also tried to introduce middle-sized hybrid vehicles, but results were disappointing: as customers are not trained for an eco-driving of such cars and were using them for long distance trips, the fuel consumption was quite high (8l for 100 km)...

¹⁰ Interview of the Lyon Autolib/LPA managers, conducted by the authors. The system has 1,350 subscribers (1,800 drivers), 90 cars, 34 stations (partly in parking lots and residential on-street parking) – 02/02/2014

3.2 EVs more adapted to small urban trips and 'technological' carsharing systems

Depending on the increase of the market and of the customers' request for clean vehicles, the introduction of EVs in the 'traditional' carsharing systems will probably increase a little bit in a near future, but essentially in the perspective to diversify the fleet. In fact, EVs appear to be more adapted to short trips in the city, which is the natural market of 'technological' carsharing systems. Let's first take the example of the city of Lyon:

- The implementation of one-way systems started in June 2012 with the Daimler Car2Go system, using Smart cars. But the experiment stopped 4 months later, due to a commercial conflict¹¹.
- In October 2013, the Bolloré Group opened the Bluely one-way system (identical to the Paris Autolib' system) with 130 Bluecar EVs, 51 stations and 254 charging facilities. The objective is to reach 250 EVs, 100 on-street stations and 500 charging facilities in 2014. In February 2014, the number of subscribers was 880¹², and the objective for the end of 2014 is 4,000, which means that return on investment could be achieved within 4-6 years (for a cost of 25 million euros, totally supported by the company). For the moment, the number of stations is still small and surveys show that customers tend to use it as a round-trip service although it is a one-way system. Compared to Paris Autolib', the Lyon city Bluely service registers much longer durations of car rental. This confirms that the number and location of stations are crucial elements for the attractiveness, development and well running of such systems.
- Finally, a third carsharing service also started in October 2013, as part of the Lyon Confluence Smart Community project: Sunmoov designed by Toshiba, and managed by Transdev, uses Mitsubishi I-Miev and Peugeot Ion EVs. This system includes 30 vehicles and 6 on-street stations, but is mainly designed for testing a charging system using photovoltaic electricity produced by the buildings of the smart community. The system which implementation is limited to the smart community district area is a round-trip system meaning that subscribers are taking a car in the district to go anywhere in the city before coming back to Confluence. The project was to encourage businesses (enterprises and commerce) located in the district to use Sunmoov as company fleet during the day and to have the cars used by inhabitants at night or week-ends. Three months after launching, at the time of survey (Transdev interview 2014 January 28), the number of subscribers was still very small (80 inhabitants)¹³ and mainly composed of individuals using the car to pick up somebody at the airport or to go shopping outside the area.

In Japan, similar projects are emerging too, such as:

- The Toyota Ha:Mo Ride one-way system, launched in October 2012: it includes initially 10 COMS one-seat EVs to be tested by students and employees of Chukyo University for trips between the train station and the campus. It was expanded in October 2013 to 100 vehicles (COMS a one-seat small vehicle) and 22 stations. The number of subscribers reached 950 and is expected to grow to 1,500 in 2014 (Japan Smart City Portal, 2013). This system is part of the Smart MELIT project (the smart community experimentation of Toyota city), driven by

¹¹ The name of the company was close to a French car-rental company (Car Go)

¹² Interview of the Bluely managers, conducted by the authors – 11/02/2014

¹³ This low level of use come from the fact that this new district is still under building.

TMC¹⁴. As previously planned, the service which was free at the beginning is paid since December 2013: 200 yens the first 10 minutes, then 20 yens per minute with a special price when the vehicle is parked, 1 or 2 yens per minute depending on the period of the day. There is however no membership fee. Reservation can be made until 30 minutes before use.

- The Nissan Choi Mobi project in the city of Yokohama started in October 2013, with 30 Nissan Mobility Concept ultra-compact EVs (close to the Renault Twizy) and 45 stations. In one month, the system reached 2,700 rentals. Since November it was extended to 50 vehicles and 54 stations in the Port district of the city, and as of March 2014, 70 vehicles are circulating while 60 stations have now been opened (giving parking space for 115 vehicles). Registered members are some 6500: 83% are men and 17% women; 40% inhabitants of Yokohama city and 60% outsiders (people who do not live in Yokohama city but may work there) (Ondanka taisaku tokatsu honbu, 2014). The experimentation is planned to last one year.

As these one-way systems are designed for short trips in dense urban areas, small-sized EVs appear to be well adapted for these occasional trips. Most being experimentations it is still difficult to know if they will stop after the end of public grants as former 'technological' system experiments did or if they will develop further following the example of Paris Autolib' which proves that a large scale systems can be implemented as a complementary supply to the daily mobility of citizens.

4 Conclusion

The observation of the recent development of EV carsharing leads to conclude to an increasing separation between the 'traditional' round-trip carsharing system (which experiences an increasing interest mainly for households in European countries and for companies in Japan) and the new 'technological' one-way systems. In the first case, subscribers are mainly people who are looking to reduce the cost of a car ownership, as they do not use it a lot. On the contrary, customers of one-way system are attracted by the simplicity of use for an 'instant rental' for short trips in cities. This last system will better cope with the constraints of EVs (limited range, charging facilities) and its implementation in dense areas will also benefit from their image of 'clean' cars. The initial idea of an 'Individual Public Transport' as imagined in the 70's will then compete more probably with collective public transport as well as with taxis. But, to be really attractive, such one-way systems need a very dense network of stations in the city. Besides the correlated cost of such a network, the implementation of stations will need the cooperation of municipalities to favor on-street parking places and probably further changes in the regulations/legislation in Japan as for example the case of Choi Mobi shows. Until the authorization by the MLIT and national police, vehicles had to go back to the management center to be charged. This was leading to a high rate of immobilization of cars which (9%). The authorization to charge vehicles in stations, which was given in March 2014, will allow a much better utilization rate of vehicles and therefore a better service to customers and finally a reduction in running costs. ChoiMobi is now starting to install chargers in its stations in a way to expand the service.

Technically, one-way system might also be implemented on a smaller scale, as for example in a residential district, both as a 'one-mile' system which can be useful for the elders as well as for disabled people, or even for longer trips for residents, now that EVs range overtakes frequently 200 km, but as business model of large scale system are still not really ensured (without public grants¹⁵), what would be the one of such small scale ones? Present experimentation should also verify what

¹⁴ For more details, see Faivre d'Arcier and Lecler, 2014.

¹⁵ In the case of the Paris Autolib' system, there is a Public Service Delegation contract with Bolloré. Investment costs were estimated to 200 million €, with a public subsidy of 35 million €. The operating cost is 80 million €, with a revenue of 95 million € (Source: Autolib Metropole, 2014)

would be a viable business model for such services. But we still have to keep in mind that the number of carsharing subscribers remains quite low. Even in the Paris region where the Autolib' system is the most important of the world, they still represent 1-2% of the residents only.

The incorporation of such systems in the emerging development of smart communities for example might constitute an opportunity to encourage the use of renewable energy sources (through the Vehicle-to-Grid energy management system, using the storage capacities of batteries), but this will really happen if the environmental awareness of population increases. As surveys have shown, although some carsharing users ask for more EVs in the fleet, it remains quite low.

But, using electric vehicles in carsharing systems is also an opportunity to make them visible in the city, both when they are parked in on-street stations and when they are circulating. In that sense, EVs one-way carsharing can also be seen as a kind of showroom. Sure the main aim is to test technologies (EVs and batteries, charging facilities, ITS management). But the visibility of these vehicles can also have an impact on the EVs image and encourage citizens to look at these cars as a possibility, even for ownership. Carmakers, especially in Japan but also in France use their experimentation for their communication. Bolloré for example, who operates its Bluecar now in 3 main French cities (Paris, Lyon, Bordeaux) and recently exported it in Indianapolis (USA)¹⁶, decided to sell them directly to individuals or companies, opening its charging network (carsharing stations) to its cars owners. Several versions of the car are proposed, including a cabriolet and soon a utility car.

But another advantage to promote electric car ownership appears via the development of charging stations all over the city. At present, the number of charging facilities in France are estimated to 5,500 units, and 4,300 of them are implemented for the Bolloré carsharing system (78%), making of this company the most important provider of charging service. In Japan, where efforts are made since 2010 for the uptake of the EV market, there were 1,700 fast and 3,000 regular chargers in 2013, and the government intends to increase these numbers by respectively 4,000 and 8,000, through a \$ 1 billion national charging infrastructure plan¹⁷. The development of EVs carsharing in cities could accelerate the development of such infrastructure.

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¹⁶ Planned for early 2015, with 500 EVs and 1,000 charging facilities in 200 stations (source: <http://green.autoblog.com/2014/05/21/bluecar-car-sharing-affiliate-will-debut-in-indianapolis-early-n/>) accessed on 24/05/2014

¹⁷ <http://www.greentechmedia.com/articles/read/japan-automakers-go-all-in-on-massive-ev-charging-plan> accessed on 24/05/2014

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