Evolution of E-Mobility in Carsharing Business Models

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Abstract

Carsharing continues to grow worldwide as a powerful strategy to provide an alternative to solo driving. The viability of electric vehicles, or EVs, has been examined in various carsharing business models. Moreover, new technologies have given rise to electromobility, or e-mobility, systems. This paper discusses the evolution of e-mobility in carsharing business models and the challenges and opportunities that EVs present to carsharing operators around the world. Operators are now anticipating increased EV proliferation into vehicle fleets over the next 5-10 years as technology, infrastructure, and public policy shift toward support of e-mobility systems. Thus, research is still needed to quantify impacts of EVs in changing travel behavior toward more sustainable transport.

1 Introduction

Carsharing enables a group of members to share a vehicle fleet that is maintained, managed, and insured by a third-party organization. Primarily used for short-term trips, carsharing can provide affordable, self-service vehicle access 24-h per day for those who do not have a car, want to reduce the number of vehicles in their household, or do not use their vehicle during the day for long periods of time. Rates include fuel, insurance, and maintenance. Ideally, carsharing works best in a neighborhood, business, or campus setting where users could walk, bike, share rides, or take public transit to access the shared-use vehicles. Carsharing has evolved through several phases since the first carsharing system began in Europe in 1948. As of October 2012, carsharing was operating in 27 countries on five continents, with almost 1.79 million carsharing members sharing over 43,500 carsharing vehicles worldwide [1].

Recently, new business models have emerged due to increasing visibility and roundtrip carsharing usage (i.e., short-term auto access used for roundtrips), as

well as new technologies and the development of electromobility, better known as e-mobility. Evolving aspects of e-mobility in carsharing include: electric vehicles (EVs) and scooters, gasoline-electric hybrid vehicles, keyless access, open-ended reservations, and the ability to conduct one-way trips. These have been catalysts to new e-mobility carsharing business models, which have increased membership and given carsharing greater flexibility and lower vehicle emissions [2]. EVs in particular appear to flourish in carsharing's pay-per-trip business models, distributing the high capital cost of the vehicle's electric battery from one driver to many. This chapter provides an overview of the evolution of e-mobility in carsharing, with a focus on developments in EV pilot programmes, academic research, and vehicle technologies. It also provides a framework for emerging business models and discusses model challenges and opportunities, particularly as e-mobility in car-sharing continues to evolve.

2 Electric Vehicles in Carsharing

The e-mobility landscape consists of several business models to serve the needs of diverse members and land uses in the built environment. Each model presents opportunities and challenges. In this section, we discuss early station car programmes (i.e., vehicles primarily employed to provide a critical linkage between home, rail transit, and work locations). Next, EVs in roundtrip carsharing are explored. Several case studies of hybrid station car/roundtrip carsharing programmes are examined. The growth of EVs in one-way (also known as point-to-point or free floating) carsharing also is discussed. Finally, we provide lessons learned.

2.1 Station Car Programmes

EVs were a major part of station car programmes in the 1990s, particularly in the United States (U.S.) as a way to relieve parking constraints at rail transit stations [3]. The station car model placed shared vehicles at public transit stations, enabling its users to take transit to the station, and complete their trip with a station car, thus relieving the first-and-last mile problem. EVs were seen as an enhancement to the environmental benefits of station car programmes, since most trips were short distances suitable for zero-emission, all-electric propulsion.

The first large-scale station car program, Praxitèle, was launched in 1997 as an experimental demonstration in Saint-Quentin-en-Yvelines, a suburb of Paris. Overall, the EVs were well received by Praxitèle members who stated that the vehicles were compatible with the types of trips that they made [4]. Although the demonstration succeeded in its technical implementation, it struggled with costs and sustaining demand and ended after two years [5].

2.2 Roundtrip Carsharing

EVs also were integral to many roundtrip carsharing fleets in the 1990s [5]. Liselec launched in 1993 in La Rochelle, France to test EV use in carsharing. The program was successful and still exists today as Yelómobile, the longest operating EV carsharing program [6]. Yelómobile also operates as one-way carsharing, allowing users to drop off an EV at any of the program's charging locations rather than returning it to its original station. Since trips stay within La Rochelle, they keep within the EV maximum range of 130 km (81 miles). Unlike other EV carsharing programmes struggling with economic sustainability, Yelómobile continues to receive governmental support for its operations [7].

Many carsharing programmes in Asia, particularly Japan, began as project-based, EV carsharing programmes to provide mobility to downtown business customers [8]. The Second Car System (SCS) launched in the Tama New Town District of Inagi City in Japan in 1999. Most of its 300 users reported that the service met their travel needs. SCS included a reservation system that calculated the charge time needed to complete a planned trip and verified that a vehicle with enough battery life was available before confirming a reservation. In this way, the limited vehicle range of 160 km (99 miles) did not present an obstacle. However, the program lost users after implementing fees and closed after three years [9].

Automakers have experimented with EV carsharing as well. Toyota Motor Company deployed the Crayon System in Toyoda City, Japan in the late 1990s. Toyota's employees used the program's ECom vehicles for business trips or for commuting between home and the office. The program consisted of 50 vehicles, 13 stations, and 700 members [10]. Crayon employed advanced ITS technologies including: (1) automated reservations, (2) telematics to communicate between the vehicles and system management, and (3) GPS technology to track the cars. Nissan Motor Company also entered into EV carsharing in 1997, with the Minato-Mirai 21 experiment in Yokohama. The program's field studies began in 1999 and grew to 30 vehicles and seven stations in the Yokohama area. The trials ended in March 2002, and the system transitioned to operators to determine system viability. This program spread to Yokohama, Kawasaki, and Tokyo and was called the Intelligent Transportation System/Carsharing Electric Vehicle (ITS/CEV) City Car System [11, 12]. It later became known as OrixCarsharing, comprising from 6,000 to 8,000 members sharing approximately 400 vehicles. OrixCarsharing discontinued exclusive EV use and now employs gasoline vehicles and gasoline-electric hybrids [13].

Since these early programmes, EV carsharing has waned in Asia, with the industry evolving toward the roundtrip carsharing model. Moreover, it has drastically reduced its use of EVs in carsharing fleets. Outside of Japan, Singapore, and South Korea, carsharing has experienced slower growth than in Europe and the Americas [8].

2.3 Hybrid Station Car/Carsharing Models

Several research studies investigated the viability of blending the concepts of station cars and carsharing to create a hybrid model. One was the CarLink field test, which ran from 1999 to 2000, which deployed 12 natural gas Honda Civics at the Dublin-Pleasanton Bay Area Rapid Transit (BART) District station in the San Francisco Bay Area. The program was deemed a success from an operational and user perspective [14, 15]. CarLink II followed this demonstration and was deployed from 2001 to 2002 at the Caltrain station in Palo Alto, California [16]. Flexcar (later merged with Zipcar in 2007) took over CarLink in 2002, but closed the service in 2003 due to financial concerns. Another BART station car initiative was the Hertz station car program, which included two Th!nk City EVs at the Fremont BART station from 2000 to 2003 [3].

Several research programmes at the University of California (UC) have also piloted hybrid models. UC Irvine continues to run the Zero-Emission Vehicle Network-Enabled Transport (ZEV·NET) research program today. Deployed in 2001, ZEV·NET enhances mobility from the Irvine Transportation Center commuter rail terminal to the employment sites of four companies and UC Irvine. The current fleet is comprised of Toyota RAV4 EVs, Mitsubishi iMiEVs, and Scion iQ EVs [17]. In addition, UC Riverside deployed an EV carsharing pilot named Intellishare, which began in 1999 and ended in July 2010 [18]. Intellishare was similar to ZEV·NET, as it added a station element to its EV carsharing system. Station cars were located at the downtown Riverside Metrolink train station and could be reserved for transport to the UC Riverside campus [19].

2.4 One-Way Carsharing

One-way carsharing—where members are not required to return a shared-use vehicle to the same station from which they borrowed it—began in Europe in the 1970s as experiments, with Procotip in Montpellier, France and Witkar in Amsterdam. Due to the lack of technology for system rebalancing and limited governmental support, these experiments failed after several years. One-way services resurfaced in the late-1990s under the station car model (see Sect. 2.1). The Praxitèle demonstration in Paris found that 90 % of trips were one-way trips [20].

In the U.S., UC Riverside's Intellishare program (mentioned earlier) was deployed as a one-way EV carsharing pilot. Intellishare's fleet had high usage—averaging 100 daily trips. To ensure a sufficient charge on the EVs (i.e., the EVs had a range of 160 km or 99 miles), the system would not allow depleted vehicles to be available for use until they finished charging. In this way, the limited EV range was not problematic; nevertheless, the project ceased operations in 2010 and was not commercialized [21].

Recent growth in modern one-way carsharing has been primarily in free-floating carsharing and one-way rentals between airports and cities. Daimler started the first free-floating EV carsharing service in October 2008 in Ulm, Germany, known as car2go. Its success has enabled international expansion. Since 2010, car2go has expanded throughout Western Europe, the U.S., and Canada. Globally, car2go has a fleet of 7,300 gasoline vehicles and 1,000 Smart Fortwo EVs, with 375,000 members [22]. BMW-Sixt launched a free-floating carsharing system in 2011 in Munich known as DriveNow and has since expanded to Berlin, Düsseldorf, Cologne, and San Francisco. Approximately 1,000 BMW ActiveE EVs and gasoline vehicles are accessible by 60,000 members. Both car2go and DriveNow have worked with cities to prepay for parking spaces for their free-floating vehicles. As of July 2013, one-way carsharing represented 12 and 16 % of North American carsharing membership and fleets deployed (roundtrip carsharing and one-way aggregate totals that do not include peer-to-peer carsharing), respectively [23]. In December 2011, Autolib' was launched in Paris, France by Bolloré. Today, Autolib' has almost 30,000 members accessing 1,800 Bluecar EVs at 800 stations throughout the Paris metropolitan area. The system boasts over two million trips taken [22]. Most recently, Communauto launched Auto-mobile, a pilot project planned from June to October 2013. The project consisted of a fleet of 20 EVs shared in a neighborhood of Montréal, Canada. In October 2013, Auto-mobile expanded to another neighborhood with plans for a third [24].

At the time of this writing, there approximately 11 one-way carsharing operators worldwide, with programmes in Austria, Canada, France, Germany, Japan, Mexico, Spain, the United Kingdom (UK), and the U.S. Several more systems are planned for launch in the next several years, notably, one in China.

2.5 Lessons Learned

Although most e-mobility programmes proved to be feasible in terms of driving range and user satisfaction, EVs gradually faded out of station car, roundtrip carsharing, and hybrid systems. Although EVs were noted as a successful part of station car systems, 60 % of all programmes ceased in the early 2000s [25]. By 2006, the vast majority of EVs in carsharing programmes had disappeared in favour of gasoline-electric hybrid vehicles. Numerous reasons were catalogued for failure: high costs; high insurance rates; low reliability of the first generation EVs; a preference for hybrid vehicles; decreased user demand and public support; operational barriers (e.g., limited vehicle range, few charging stations); logistical challenges (i.e., the need for centralized management and real-time data feedback); and economic downturn [13]. Nevertheless, shared-use mobility services have experienced a recent resurgence in EVs. Due to technological advancements, automakers have launched next-generation EVs at lower costs with longer-range batteries, such as lithium-ion.

Another key understanding involves the role of public policy in acting as a major catalyst in the introduction of EVs into vehicle fleets. In California, the Zero Emission Vehicle (ZEV) program was designed to achieve the state's emission reduction goals and requires automakers to sell more ZEVs (i.e., vehicles with zero tailpipe emissions, including EVs). Automakers can also receive additional ZEV sales credit by placing them in transportation systems that demonstrate technology-enabled vehicle sharing, such as carsharing programmes [26]. Moreover, monetary rebates encourage carsharing operators to purchase ZEVs and other low-emission vehicles [27]. Supportive parking policies also play a role in supporting e-mobility. Cities in Australia, North America, and several European countries have provided free or discounted on-street parking to carsharing operators as a form of nonmonetary support [28]. Agencies such as the Port of San Francisco have also considered mandating EV charging station allocations in lease renewals of off-street parking [29]. Finally, cities can consider investing in electric charging infrastructure to encourage EV proliferation in carsharing.

3 Current and Projected Growth of EV Carsharing

Building upon lessons learned from previous generations of EVs and carsharing models, many worldwide carsharing experts believe a trend over the next five years will be the re-emergence and growth of EVs in e-mobility fleets. Worldwide surveys of carsharing operators conducted in 2006, 2008, and 2010 noted a shift in vehicle propulsion between 2006 and 2010 toward gasoline-electric hybrid vehicles and EVs [30]. Several key trends are occurring: (1) automakers are taking a lead in launching e-mobility systems in cities in Europe, Japan, and North America and (2) existing carsharing operations are reintroducing EVs into their fleets.

3.1 E-Mobility Systems by Automakers

Automaker-sponsored e-mobility systems currently are a significant portion of carsharing membership and fleets. In January 2013, Daimler's car2go and BMW-Sixt's DriveNow represented 11.7 and 18.4 % of North American carsharing membership and fleets deployed, respectively [31]. Automakers are continuing to integrate EVs into new and existing carsharing operations. Nissan and the City of Yokohama launched Japan's first one-way carsharing program in October 2013, with 30 Nissan New Mobility CONCEPT EVs [32]. Renault began Twizy Way in 2012, a carsharing pilot in Saint-Quentin-en-Yvelines near Paris employing 50 Twizy EVs [33]. In September 2013, Renault transferred Twizy Way to web services and an automotive engineering company, Keymoov, to

operate [34]. Also in September 2013, Renault and Bolloré began a joint venture to launch commercial and industrial EV carsharing programmes in France and abroad. Moreover, they plan to develop a three-seater EV with a 200-km (124-miles) range, after Autolib' data found that 75 % of rentals involve three passengers or less [35]. Daimler continues to operate car2go in Europe and North America, with plans for continued expansion, many of which include EVs in their fleets. Peugeot Citroën Automobiles launched Multicity in Berlin—the first all-EV carsharing system in Germany—in September 2013 with 350 C-Zero EVs [36]. Bolloré, Daimler, Citroën, and BMW-Sixt are the top four EV carsharing operators, with a total of 3,280 EVs [22].

3.2 Re-Emergence into Existing Carsharing Fleets

Following the trends noted in the biannual worldwide carsharing survey [30], EVs have begun to re-emerge into existing carsharing fleets. Carsharing operators have been adding EVs into their programmes since 2011. Hertz 24/7™ (formerly Hertz On Demand) deployed Mitsubishi i-MiEVs in the UK in April 2011 [37]. Similarly, City CarShare deployed i-MiEVs in the San Francisco Bay Area in December 2011 [38] and maintain approximately 60 EVs in their fleet. Other recent EV carsharing introductions throughout North America include: Communauto's Auto-mobile in Montréal, I-GO CarSharing (now part of Enterprise CarShare) in Chicago, and Zipcar (now part of Avis Budget Group). Most recently, City CarShare in partnership with Toyota and the Transportation Sustainability Research Center at the University of California, Berkeley began a three-year EV carsharing pilot called Dash™ in September 2013. Scion iQ EVs have been placed at the Hacienda Business Park in Pleasanton, California, for employees and residents to use for short-distance trips [39].

Carsharing programmes outside of North America are continuing to expand into new cities, as well. After the success of Autolib' in Paris, Bolloré launched a similar program in Lyon in October 2013, and plans another EV carsharing program in Indianapolis, Indiana in late-2014 [22].

One country to note the emergence of EVs carsharing in is Australia, where EVs have had low sales [40]. In 2012, GoGet CarShare, the largest carsharing program in Australia, deployed Mitsubishi i-MiEVs and Nissan Leafs® into their Melbourne fleet [41].

As of late-2013, EVs have been deployed in carsharing programmes in approximately 14 countries: Australia, Austria, Denmark, Finland, France, Germany, Italy, Japan, Norway, the Netherlands, Portugal, Switzerland, the UK, and the U.S.

4 Conclusion

Carsharing operators continue to anticipate greater EV potential in e-mobility systems in the future. At present, EVs have been introduced into over half of the 27 countries where carsharing currently operates. E-mobility operators can employ next-generation EVs with longer travel range, but they must maintain sufficient charge across the vehicle fleet to support successful operations. To address this, some operators are deploying EVs in one-way programmes in higher-density areas to support shorter usage and rebalancing trips. Moreover, many operators are working with municipal governments to influence public policy to gain access to public transit and on-street station parking, as well as EV charging infrastructure. Governmental support can play a notable role in encouraging e-mobility systems and helping to achieve greenhouse gas emission reduction targets through policy adaptation, public outreach, and financial assistance. In light of growing EV demand, charging infrastructure, technological advance, supportive policies, and shared-use mobility integration, e-mobility systems are poised to impact travel behavior in many regions across the globe. Research is needed to quantify and understand e-mobility impacts on vehicle kilometers/miles traveled, household vehicle holdings, and modal shift and to guide future policymaking.

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