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# Exploring Electric Vehicle Carsharing As A Mobility Option for Older Adults: A Case Study of A Senior Adult Community in The San Francisco Bay Area

Susan Shaheen, Lauren Cano, and Madonna Camel

## Abstract

By the year 2030, 57 million people will be over the age of 65 in the United States. Baby Boomers drive approximately 17% more than other age groups and are active well past retirement. This paper examines electric vehicle (EV) carsharing (short-term vehicle access) as a future alternative to vehicle ownership for older adults living on fixed incomes in a gated community to provide reduced cost mobility and eliminate vehicle maintenance hassles. The authors conducted a study of the response to the EV carsharing concept in a senior community in Northern California, between Winter 2009 and Spring 2011, to gauge early adoption potential. The study consisted of in-depth interviews (n=7), four focus groups (n=31), and survey data collection (n=443) with residents of the Rossmoor Senior Adult Community in Walnut Creek, California. Eighty-three percent of survey respondents drive short distances often (eight kilometers (km) five times/month); 100% of interview participants plan their trips in advance; and 77% of focus group subjects made changes to their driving behavior due to high fuel prices. These findings are indicators that an EV carsharing program could potentially complement travel patterns and price sensitivity. Finally, the survey results indicate that 30% of all respondents were interested in participating in an EV carsharing program, while 36% were "maybe" interested. If the carsharing fleet also contained non-EVs, 71% of community-wide survey participants were interested or "maybe" interested in participation. Inclusion of EVs and non-EVs in the carsharing fleet would likely increase interest and participation overall.

## Keywords

## 1. Introduction

The older adult population in the United States (U.S.) is quickly growing in size. With the aging Baby Boomer population, the number of drivers 65 years and older is expected to double to 57 million by the year 2030 (U.S. Government Accountability Office, 2007). As a generation, Baby Boomers have historically driven more kilometers than other age cohorts. In 1983, when Baby Boomers were 19-38 years old, they averaged driving 30% kilometers more than their older cohorts (McGuckin and Lynott, 2012). When this generation was age 37 to 56, they averaged driving 28% more kilometers than other age groups. In 2009, this generation (45-63) drove 17% more kilometers than any other age group (McGuckin and Lynott, 2012). The dependence of the Baby Boomer generation on the private automobile, combined with declines in public transportation funding and service following the 2008 recession, presents challenges for providing safe, efficient, and economically feasible mobility options for older adults. Many destinations are too far to walk, and alternatives such as taxis are too expensive (DeGood, 2011) (Moore and Balaker, 2006). Often public transit or specialized transportation services are limited. Shared-use vehicle systems, such as carsharing, could provide a viable and cost-effective mobility option when combined with public transit services that are targeted at older adults in the future.

The principle of carsharing is simple: individuals gain the benefits of private vehicle use without the costs and responsibilities of ownership. Primarily used for short-term trips, carsharing can provide affordable vehicle access for those who do not have a car, want to reduce the number of vehicles in their household and/or maintenance hassles, or do not use their vehicle during the day for long time periods. Carsharing works best in a neighborhood, business, or campus settings where users can walk, bike, share rides, or take public transportation to access the shared-use vehicles. This mode has not yet been applied to older adults living in gated communities to the authors' knowledge.

The Rossmoor Senior Adult Community (Rossmoor) in Walnut Creek, California was selected to understand the potential for EV carsharing in an active senior adult community setting, as it could provide insights into early adopter response in light of the residents' active lifestyles, familiarity with EV golf carts, fixed incomes, and higher education levels. The authors and Nissan Motor Company conducted this study from December 2009 to May 2011 to determine the feasibility of an EV carsharing pilot program at Rossmoor. The study consisted of seven in-depth household interviews, four focus groups with a cumulative total of 31 participants, a community-wide survey of 357 residents (paper and online), and a six-question clipboard/short survey with 86 respondents. A total of 443 Rossmoor residents took part in one of the two study surveys (community-wide and clipboard/short survey); each respondent was unique. It is important to note that the surveys contained the same questions, but the community-wide survey was longer (i.e., 30 minutes to complete vs. five minutes for the clipboard/short survey). Findings from this research provide insights into the feasibility of an EV carsharing program in an older adult community ultimately targeted for use by the Baby Boomer population.

This paper includes five sections. First, the authors provide a brief overview of the Rossmoor community. This is followed by a literature review of the history of EVs in shared-use mobility and a discussion of transportation options for older adults. Next, the study methodology is discussed. The fourth section presents results from the interviews, focus groups, and surveys (community-wide and clipboard/short). This paper concludes by summarizing the findings and discussing the feasibility of an EV carsharing program in a senior adult community.

## 2. Rossmoor Senior Adult Community: Overview

Rossmoor is a non-profit gated community of approximately 9,500 senior residents in Walnut Creek, California (40 kilometers (km) east of San Francisco). Founded in 1963, Rossmoor spans 72.84 km$^2$ with 6,700 residential units comprised of three cooperative developments (i.e., the purchaser buys a membership in a corporation that owns land and buildings within the association); 12 condominium developments (i.e., the buyer owns a condominium unit and portion of association land); and one single-family-detached home development, consisting of 63 individual homes. The units vary from condos, homes, garden-style duplexes and four-plexes to mid-to-high-rises. In addition, Rossmoor provides a congregate living condominium, called The Waterford, for residents that are less able. Services and meals are provided for these residents. The four housing types, as well as their locations within Rossmoor, are shown in Figure 1.

**Figure 1  Map of Rossmoor Senior Adult Community by housing type.**
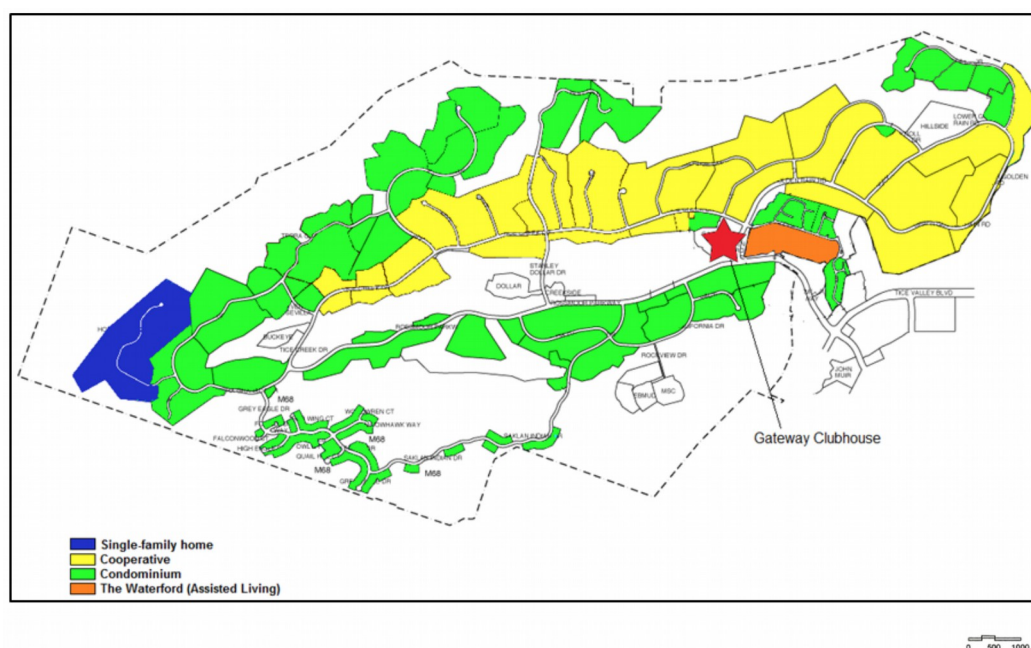
The cost per unit ranges from US$100,000 for cooperatives, US$500,000 for condominiums, and can be over US$1 million for single-family homes. At least one resident in each household is required to be 55 years of age or older to live at Rossmoor. Qualifying residents often have partners or family members that reside in the same household who work and commute on a regular basis; nevertheless, the majority of residents (57%) live alone. Figure 2 presents an overview of the Rossmoor population grouped by age. At the time of the survey, 11.4% of Rossmoor's population was born between 1947 and 1956 representing the oldest baby boomers in the age group of (55 to 64). Twenty-four percent were ages 65-74 and thirty-four percent of Rossmoor's population is between 75 and 84 years of age, while 27% is 85 to 94.

**Figure 2  Rossmoor population grouped by age.**
**SOURCE: Golden Rain Foundation 2010**
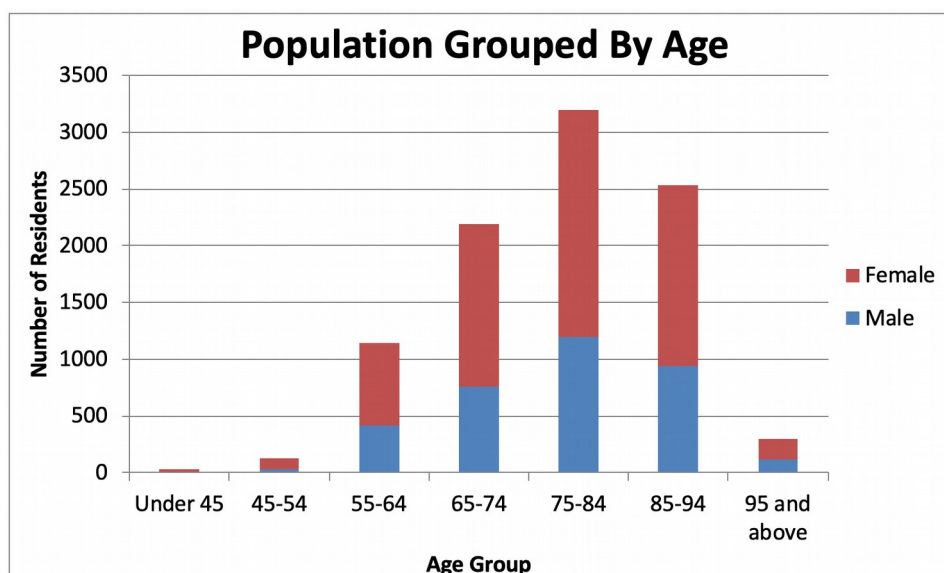


Of the 338 community-wide survey respondents who provided their educational background, 21% have a bachelor's degree, 22% a master's degree, and 22% have finished some graduate school (completed part of at least a master's or doctorate degree). Of the 357 total community-wide survey respondents, 327 answered a question regarding their 2010 household income level. Thirty-one percent had a 2010 household income of US$20,000 to $50,000, 23% US$50,000 to $75,000, and 16% US$75,000 to $100,000.

The community offers services and amenities catering toward the "active adult," which include: hobby shops (i.e., stores selling collectors' items and other niche goods); 200 clubs spanning a variety of interests (such as reading groups, ballroom dance organizations, and antiques associations); and two golf courses, tennis courts, hiking trails, open space, and a fitness complex. Rossmoor residents have access to various clubhouses within the community. The Gateway Complex, highlighted in Figure 1, is Rossmoor's main clubhouse, open to all residents, visitors, and staff, and possesses one of the complex's largest parking lots. Parking options include: parking lots, garages, and street parking; availability varies throughout the various Rossmoor neighborhoods, based on housing type.

Three hundred and six of the 357 total community-wide survey respondents answered a question regarding vehicle ownership. The majority of community-wide survey respondents, 97%, own a vehicle, and 65% of respondent vehicles were manufactured in the year 2001 or later. Sixty-four percent of these respondents either do not plan to purchase a new vehicle or would only consider purchasing one, if their current vehicle were to break down.

Rossmoor provides its own transportation services that travel throughout both Rossmoor's gated community and its surrounding areas. Residents do not pay per ride; rather, costs are covered in a monthly fee that ranges between US$550 and $800, depending on housing type. In addition to transportation costs, this fee covers facilities management, maintenance, utilities, property taxes (in cooperatives), and building insurance. There are four types of bus transit within Rossmoor: the fixed-route Rossmoor Bus, a fixed-route public bus, dial-a-bus, and paratransit (door-to-door services for the disabled). The fixed-route Rossmoor Bus operates on weekdays (8:30am until 6:15pm) on scheduled routes with a 30-minute headway. The fixed-route public bus operates daily with a one-hour headway. Dial-a-bus operates on weekday mornings and evenings until 10:00pm and from 8:30am to 9:15pm on weekends. The paratransit service is available during the same operating hours as fixed-route services, for those unable to use fixed-route or dial-a-bus services.

## 3. Literature Review

Shared-use mobility services have been growing in size and popularity since their introduction in 1948 in Switzerland. In many parts of the world, including the U.S., EVs were integrated into carsharing and station car (shared cars available at public transit stations) programs in the 1990s, demonstrating the ability to balance the mobility needs of many users with a limited EV driving range.

Due to logistical and operational challenges, however, EVs began to disappear from shared-mobility systems in the early-2000s. Recently, they have experienced a resurgence in popularity. Building upon lessons learned and notable EV advancements, many carsharing operators anticipate greater potential for EVs in shared-use vehicle systems in the future (Shaheen and Cohen, 2012). For example, one potential target group for EV carsharing is the Baby Boomer population—the largest generation in U.S. history (DeGood, 2011). The resurgence and advancements in EVs, coupled with the demand for alternative mobility options among the older adult population, present an opportunity to improve mobility and increase travel choices for seniors in addition to decreasing the negative environmental impacts of traditional auto use.

This literature review includes a history of shared-use vehicle programs and the use of EVs in carsharing and station car (shared vehicles located at public transit stations) programs worldwide. While carsharing in urban areas has been more carefully studied, the feasibility of implementing carsharing services in communities specifically designed for older adults has not been explored. Lessons learned from previous carsharing programs—as well as

understanding from earlier initiatives that incorporated EVs and alternative fuel vehicles (e.g., natural gas vehicles with a restricted driving range due to limited infrastructure and fueling time) —provide important background to the study of EV carsharing. This review also explores the body of work on the role of recent technological developments in expanding mobility options for older adults, in addition to addressing the growing demand for increasing mobility options.

3.1 Early Integration of EVs and Alternative Fuel Vehicles into Shared-Use Mobility Systems

*3.1.1 Station Car Programs*
EVs were a major part of station car programs in the mid-1990s, particularly in the U.S. EV fleets were frequently launched to relieve parking problems and to facilitate first-and-last mile connectivity at rail transit stations through a fleet of shared-use vehicles (Barth and Shaheen, 2002; Shaheen *et al.,* 2004). Station car trips are typically used for point-to-point trips in contrast to classic carsharing, which typically emphasizes roundtrips in neighborhood, employment, and university/college campus settings. EVs can complement station car programs well, as most trips cover short distances.

The first large-scale station car program, Praxitèle, was launched as an experimental demonstration in 1997, in a suburb of France's Saint-Quentin. Overall, the EVs were well received by Praxitèle members who stated that the vehicles were compatible with the types of trips that they made (Massot *et al.,* 2001). Although the demonstration succeeded in its technical implementation, it struggled with costs and sustained demand and ended after two years (Shaheen *et al.,* 1999). The CarLink field test, which ran from 1999 to 2000, blended the concepts of carsharing and station cars. It was deployed from the Dublin-Pleasanton Bay Area Rapid Transit (BART) District station and included 12 natural gas Honda Civics. Although the vehicles were not EVs, a limited number of CNG refueling sites and slow CNG refueling pumps restricted vehicle range, not unlike EVs. CarLink demonstrated the viability of alternative-fuel vehicles deployed in carsharing from an operator and user perspective (Shaheen, 1999; Shaheen *et al.,* 2000). CarLink II followed this demonstration. It was deployed from 2001 to 2002 at the Palo Alto Caltrain station in Northern California, with a fleet of 19 ultra low-emission Honda Civics (Shaheen and Novick, 2005). Flexcar acquired this program in 2002, but closed it in July 2003 due to financial viability Another station car initiative was the BART District-Hertz program, which included two Th!nk city class EVs at the BART Fremont station and ran from 2000 to 2003 (Barth and Shaheen, 2002).

Another hybrid station car/carsharing effort is the Zero-Emission Vehicle Network-Enabled Transport (ZEV·NET) program at the University of California (UC) Irvine, which was deployed in 2001 and continues today as a research program. The current fleet is comprised of Toyota RAV4 EVs, Mitsubishi iMiEVs, and Toyota IQs (ZEV·NET, 2010). The vehicles are stationed at the Irvine Transportation Center (ITC)—a commuter rail terminal. The program is designed to enhance mobility from the ITC to the employment sites of four companies and UC Irvine (Heling *et al.,* 2008). UC Riverside's Intellishare was a similar project that implemented a station element to its EV carsharing system in 2006 (note the

entire demonstration ran from 1999 to early-2010). Station cars were located at the downtown Riverside Metrolink train station and could be reserved for transport to the UC Riverside campus (Shaheen *et al.,* 1998) (Communauté d'Agglomération de La Rochelle, 2012).

Although EVs were noted as an integral part of station car systems, 60% of all programs ceased in the early-2000s (Shaheen *et al.,* 2004). Many closed due to the high cost and low reliability of first-generation EVs, while others cited insurance rates, economic downturn, and decreased customer demand as key operational challenges (Shaheen *et al.,* 1998; Shaheen *et al.,* 2004).

### 3.1.2 Carsharing Programs

EVs also were integral to many carsharing fleets in the 1990s (Shaheen *et al.,* 1999). Liselec launched in 1993 in La Rochelle, France. This program was designed to test EV use in carsharing and still exists today, under the name Yelómobile (Communauté d'Agglomération de La Rochelle, 2012). Yelómobile, now the longest operating EV carsharing project, allows users to drop off an EV at any of the program's charging locations rather than returning it to its original station. Because trips stay within La Rochelle, they likewise remain within an EV's range of 130 km. Unlike EV carsharing programs that have struggled with economic sustainability, Yelómobile continues to receive governmental support for its operations (McDonald and Vöge, 2001).

In Japan, Nissan entered into EV carsharing in 1997, with the Minato-Mirai 21 (MM21) experiment in Yokohama (Takayama, 2002; Barth *et al.,* 2007). 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 (Takayama, 2002). This program spread to Yokohama, Kawasaki, and Tokyo and was called the Intelligent Transportation System/Carsharing Electric Vehicle (ITS/CEV) City Car System (Barth *et al.,* 2007). It later became known as Orix Carsharing, comprising roughly 400 vehicles and around 6,000 to 8,000 members. Orix Carsharing discontinued using EVs exclusively and now also employs hybrids and gasoline vehicles (Cohen *et al.,* 2008).

In 1999, Japan began the project "Second Car System" (SCS) in the Tama New Town District, Inagi City. Most of its 300 users reported that the service met their travel needs (Fukuda *et al.,* 2003). 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 (i.e., 160 km) did not present an obstacle. After the program began implementing fees, however, many users dropped out. After three years of operation, the program closed.

Toyota Motor Company also deployed a carsharing experiment in Japan in the late-1990s, called the Crayon System. This system allowed Toyota's employees in Toyoda City to use the program's ECom vehicles for business trips or for commuting between home and the office (Barth *et al.,* 2007). The program consisted of 50 vehicles, 13 stations, and 700 members (Barth, 2001). Crayon used 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 (Barth *et al.,* 2007).

In the U.S., UC Riverside's EV carsharing project Intellishare began in 1999 and ended in July 2010 (South Coast Air Quality Management District, 2010). Also a one-way system, Intellishare's fleet was used an average of 100 times/day, each for a relatively short amount of time and distance. Due to the high amount of vehicle use, the program's EVs had to be well managed to ensure they retained sufficient charge, as they had a range of approximately 160 km. Vehicles with depleted power reserves were rendered unavailable for use by the system until they finished charging. The limited EV range was not found to be a problem. The project was not commercialized, as it was created as a test bed (Barth *et al.*, 2000).

Although most of the EV shared-mobility programs proved to be feasible in terms of driving range and user satisfaction, EVs gradually faded out of these systems. Numerous reasons were catalogued for failure: 1) high costs; 2) high insurance rates; 3) low reliability of the first generation EVs; 4) a preference for hybrid vehicles; 5) decreased user demand and public support; 6) operational barriers (e.g., limited vehicle range, few charging stations); 7) logistical challenges (i.e., the need for centralized management and real-time data feedback); and 8) economic downturn (Cohen *et al.,* 2008).

3.2 The Resurgence/Evolving Role of EVs in Shared-Use Mobility Services

Shared-use mobility systems have experienced a recent resurgence in EV use. Being almost completely phased out by the mid-2000s in favor of hybrid and internal combustion vehicles, there are new driving forces and interests behind EVs (Shaheen and Cohen, 2012). Due to technological advancements, automakers have launched next generation EVs at lower costs than before with longer-range batteries (e.g., lithium-ion). In addition, the California Zero Emission Vehicle (ZEV) Mandate requires automakers to sell more zero-emission vehicles. As an incentive, automakers can receive ZEV sales credit by placing EVs in transportation systems that demonstrate technology-enabled vehicle sharing, such as carsharing and station car programs. Monetary rebates are now available to encourage carsharing operators to purchase ZEVs and other low-emission vehicles (California Environmental Protection Agency Air Resources Board, 2012).

Worldwide carsharing experts believe a key trend over the next five years will be the re-emergence of EVs in shared-use fleets. Hertz on Demand began integrating EVs into its carsharing fleet in New York City in December 2010; these have expanded to locations in North America, the United Kingdom, and China. In 2011, Paris began an all-electric program called Autolib', and Nissan launched a pilot test in Yokohama, Japan incorporating the Nissan Leaf EV into a carsharing fleet with the option of a chauffeur driver.

Additionally, eight global automakers (BMW, Daimler, Ford, General Motors, Honda, Mitsubishi, Nissan, and Toyota) provide carsharing services and/or are integrating EVs into new and existing carsharing operations. BMW's DriveNow carsharing program was recently initiated in San Francisco with a fleet of 70 BMW ActiveE EVs (DriveNow, 2012). Similarly, car2go's carsharing program has all electric fleets in San Diego and Amsterdam and has implemented EVs into its existing fleets in Portland, Oregon and Austin, Texas (car2go N.A., LLC., 2011; car2go Nederland B.V., 2011). Also, many other carsharing operators have

incorporated EVs into their programs including: Buffalo CarShare in Buffalo, New, York; City CarShare in the San Francisco Bay Area; eGo Carshare in Boulder, Colorado; Enterprise CarShare in multiple locations throughout the U.S.; Hertz 24/7 in many sites throughout the nation; iGo in Chicago, Illinois (purchased by Enterprise CarShare in 2013); HourCar in Minneapolis-St. Paul, Minnesota (integrates Toyota Prius Plugins); and Zipcar in numerous locations throughout North America (City CarShare, 2012; I-GO Car Sharing, 2012; Zipcar, 2012; The Electric Generation, 2014).

3.3 Transportation Options for Older Adults

The Baby Boomer population is anticipated to "change the profile and expectations of old age in the U.S." (Himes, 2002). This age group is anticipated to maintain their independence, prolong their physical and mental health, have a longer life expectancy, and stay active longer (Himes, 2002). Because the Baby Boomer generation also possesses higher rates of licensed drivers than previous generations, the number of older drivers is expected to increase over the next few years. Thus, the automobile is often the primary form of transportation for both senior adults who drive as well as non-driving seniors. While adults aged 65 to 84 took 90% of their trips by car, non-drivers completed the same percentage of trips by automobiles as drivers did in 2001 (Rosenbloom, 2009).

The economic recession of 2008 and existing residential land use patterns in the U.S. underscore the need for more accessible and affordable transportation options for older adults. More than three-quarters of older adults are aging in suburban or rural areas "where daily activities require frequent car trips" (DeGood, 2011). Other than a personal automobile, viable options to connect senior adults to their destinations are limited, do not exist, and/or lack needed funding (DeGood, 2011). Additionally, even senior adults who own a vehicle experience times when driving is not feasible. A survey study conducted in Canadian Atlantic communities indicated that weather is a top contributing factor behind older adults choosing not to operate a personal vehicle. The study also showed reluctance among senior adults to ask someone else for a ride, which severely restricted their mobility (Weeks, et. al., 2013).

Driving limitations among senior adults exist regardless of whether travel is conducted through the use of a personal or shared vehicle. However, technological advances in EVs may provide part of the solution to the senior adult mobility problem. Technological advancements in EVs are now being developed to specifically accommodate the elderly. Features including camera sensors, positioning devices, and automated driving systems are being tested under the premise that senior adults will be the primary users of such vehicles (Wu, et al., 2012). However, EVs may also pose additional risks to older adults. For instance, a senior pedestrian is 33.4% more likely to crash with an EV than with a traditional gasoline engine automobile (Hong, et al., 2013). This safety risk is another aspect that improved EV technology could alleviate, if developed with mindfulness toward an older adult community, for instance.

While many senior adult communities currently offer transportation services for their residents, many of them fail to meet all of their mobility needs including: 1) making multi-destination trips, 2) transporting packages and groceries, and 3) traveling to rural or suburban

areas (U.S. GAO, 2004). Given these limitations, there is a need to further explore other mobility options. Carsharing, which is one such alternative, has yet to be studied as a potential solution for augmenting limited mobility options in older adult communities.

## 4. Methodology

From December 2009 through May 2011, the authors conducted a study at the Rossmoor Senior Adult Community in Walnut Creek, California. In this study, the authors applied qualitative and quantitative methods to evaluate the feasibility of an EV carsharing program within the community. Additionally, the study focused on understanding resident travel behavior and preferences for a shared-use mobility system.

The authors collected data in three separate phases. The first phase was conducted in December 2009 and involved seven in-depth interviews with Rossmoor residents. To recruit participants for the interviews, an announcement was posted in *The Rossmoor News*, a weekly newspaper delivered to each Rossmoor residence. Respondents were screened based on housing type, vehicle ownership, and possession of a valid driver's license. Three of the seven in-depth interviews were conducted with condominium residents and four with cooperative residents. Despite placing notices in *The Rossmoor News*, which specifically requested participation from single-family homes, the first data collection phase failed to include subjects from this housing type.

During the first phase, the authors gained preliminary information on residents' travel behavior and preferences, as well as their responses to an EV carsharing program at Rossmoor. Prior to the interviews, participants kept a seven-day travel diary of all trips taken. This diary included each trip's travel time, mode, purpose, destination, and number of passengers. Based on the travel diary, the authors conducted an in-depth two-hour interview with each subject to clarify points in their travel diary and to probe each respondent on their travel patterns. Reflexive questions were asked to gather information on trips that could have been made by alternative modes, timing flexibility, trip chaining, their use of or interest in EVs, and opinions about an EV carsharing program at Rossmoor. Each subject received a US$100 Amazon.com gift card for his or her participation.

The second data collection phase was conducted in September 2010 and provided the authors with qualitative data on the viability of implementing an EV carsharing program at Rossmoor. This phase consisted of four focus groups with a total of 31 participants, which provided insights into respondent preferences by housing type. Participants included 17 Rossmoor residents residing in cooperative units and 14 living in condominiums. No single-family home residents participated. Thus, these results may not be representative of the opinions of those living in single-family homes. Prior to the start of each focus group, an intake survey was administered to establish key socio-demographic and attitudinal variables. The survey also captured participant travel patterns, which were expanded upon in the group discussions. The authors developed a detailed protocol as a guide, which included: general travel behavior questions; vehicle ownership costs; an introduction to the carsharing concept

(i.e., existing programs and how they operate); ridesharing elements; vehicle technology; level of comfort with charging stations; and willingness-to-pay. At the end of each focus group, participants received a US$50 Amazon.com gift card as compensation.

The third study phase consisted of survey data collection. The authors employed insights gathered during the in-depth interviews and focus groups to develop the community-wide survey. This survey consisted primarily of individuals living in condominium and cooperative housing. Several methods of administration were employed to increase response rates. In February 2011, 7,000 copies of the questionnaire were inserted into *The Rossmoor News* and sent to all Rossmoor households. One month later, a link to an online version of the survey was posted in *The Rossmoor News*. Finally, in May 2011, the authors distributed the survey outside the Gateway Clubhouse. All Rossmoor residents were eligible to participate in the survey, and there were no screening criteria.

The questionnaire was pretested with four members of the Rossmoor administrative staff, including two members of the transportation department. The pretest provided feedback on question wording and length, font size, and overall design. A total of 357 residents completed the community-wide survey—342 from the newspaper insert, eight via the online survey, and seven from the table outside of the Gateway Clubhouse. This sample size gives a margin of error of approximately 5% (at a 95% confidence interval). This questionnaire consisted of 71 questions and required approximately 30 minutes to complete. The survey obtained data regarding resident travel behavior, public transit use, vehicle ownership, interest in an EV carsharing program, anticipated use, and willingness-to-pay for the program. In addition, data describing age, gender, household annual income, and education level were collected. The survey also included stated-preference questions about how respondents might use carsharing for shopping trips, medical appointments, daytime, nighttime, and weekend travel.

In May 2011, a six-question newspaper and clipboard survey (i.e., the same instrument) was administered outside of the Gateway Clubhouse to obtain additional resident feedback. The survey asked five questions from the community-wide survey, plus a screening question to determine if the subject had already completed the longer survey. Questions included interest in an EV carsharing program, willingness-to-pay for such a service, and preferred carsharing vehicle locations. This effort yielded 65 complete clipboard surveys and 21 short newspaper surveys (a total of 86 short questionnaires were collected). Snacks and beverages were available to those who completed surveys at the Gateway Clubhouse. Incentives were not offered for completion of either survey instrument.

## 4.1. Study Limitations

As with any social science research, there are limitations to this study. First, the survey reflects a non-respondent bias, as limited incentives were employed. Second, the length of the community-wide survey (30 minutes) played a role in lowering overall response. While an effort was made to include residents from all three housing types within Rossmoor, no residents from single-family units responded to recruitment efforts for either the in-depth interviews or focus groups. Furthermore, less than 2% of respondents to the community-wide

survey and 2% to the clipboard/short survey represented single-family unit residents. Due to the lack of single-family unit residents, the following results and analysis are applied only to the population living in the condominium and cooperative units. Additionally, while the term "carsharing" was defined in the in-depth interviews, focus groups, and community-wide survey, the same detailed definition, employed in other study instruments, was omitted in the clipboard/short survey to reduce its length. Thus, the 86 clipboard/short survey respondents may not have clearly understood the carsharing concept. Furthermore, the in-depth interviews, focus groups, and community-wide survey informed participants that the Nissan Leaf had a recharging time of four to eight hours. This information may have introduced a response bias, as participants might have assumed they could not reserve a vehicle until it had charged that amount of time. As mentioned earlier, the authors did not collect socio-demographic, trip, or attitudinal data in the clipboard/short survey to reduce the number of questions asked, which limits understanding. Finally, since this study was administered in only one senior adult community with a limited sample size, it is difficult to generalize the findings to other locations, which could be more or less responsive to the service.

## 5. Results

The data collected from the in-depth household interviews, focus groups, and surveys provide key information on items, such as potential vehicle demand and usage, optimal locations for charging stations, and initial reaction to system pricing. This section includes the following analyses: demographics, travel interest in an EV carsharing program at Rossmoor, and willingness-to-pay.

### 5.1. Demographics

Table 1 illustrates the distribution of respondents by each of the study instruments. It is important to note that the interview and clipboard/short survey did not address each of the categories and are marked "NA" (not applicable) in Table 1. Forty-seven percent or more of all participants lived in cooperatives, and the majority of respondents (86% of in-depth interview, 65% of focus groups, and 72% of community-wide survey) had one vehicle in their household. Thirty-five percent of focus group participants and 25% of community-wide survey respondents had two cars.

**Table 1  Respondent Demographics by Instrument**

|  | Interview (n=7) | Focus group (n=31) | Community-wide survey (n=357) | Clipboard/short survey (n=86) |
|---|---|---|---|---|
| % Co-op residents | 57% | 55% | 52% | 47% |
| % Condo residents | 43% | 45% | 46% | 51% |
| % Single-family home residents | 0 | 0 | 2% [i] | 2% |
| % Single-car households | 86% | 65% | 72% | NA |
| % Two-car households | NA | 35% | 25% | NA |
| % No-car households | NA | 0% | 3% | NA |

[i]  1.49%

NOTE: NA = not applicable

Table 2 presents key demographics of the study participants from the focus groups and community-wide survey. This table does not include data from in-depth interviews or the clipboard/short survey because these instruments did not ask questions regarding demographics. Demographic data for the U.S.'s current population of older adults, specifically 55 years of age and older, is included in Table 2 for comparison to the study's sample. Some demographic variables are affected by non-response. The total responses for each question are indicated in Table 2. It is important to note that the U.S.'s racial breakdown represents the entire U.S. population, not just 55 years and older.

**Table 2  Demographic Profile of the Focus Groups,**

**Community-Wide Survey, and U.S. Population of 55 Years and Older**

| Demographic Attribute | Focus Groups | Community-Wide Survey | U.S. Population (55 Years and Older) |
|---|---|---|---|
| Age Category | n = 31 | n = 330 | n = 76,750,713 |
| 55-60 | 6.5% | 5.5% | 30% |
| 61-65 | 16.1% | 8.2% | 21% |
| 66-70 | 16.1% | 13.3% | 15% |
| 71-75 | 19.4% | 17.9% | 12% |
| 76 or older | 41.9% | 55.2% | 22% |
| Total | 100% | 100% | 100% |
| Education | n = 31 | n = 338 | n = 74,008,000 |
| Grade School | 0% | 0.3% | 8% |
| Some High School | 3.2% | 0% | 8% |
| High School | 6.5% | 4.7% | 33% |
| Some College | 12.9% | 19.5% | 24% |
| Bachelor's Degree | 35.5% | 20.7% | 16% |
| Graduate School, Master's, or Ph.D. | 35.5% | 52.4% | 11% |
| Other | 6.5% | 2.4% | NA |
| Total | 100% | 100% | 100% |
| Household Income | n = 31 | n = 327 | n = 47,190,000 |
| Less than US$10,000 | 0% | 1% | 8% |
| US$10,000 to $20,000 | 3.2% | 6% | 17% |
| US$20,000 to $50,000 | 38.7% | 31% | 33% |
| US$50,000 to $75,000 | 9.7%[i] | 23% | 16% |
| US$75,000 to $100,000 | 29.0%[ii] | 16% | 9% |
| More than US$100,000 | 9.7%[iii] | 10% | 17% |
| Decline to Respond | 9.7% | 13% | NA |
| Total | 100% | 100% | 100% |
| Race | n = 31 | n = 334 | n = 308,745,538 |
| White/Caucasian | 94.0% | 85.1% | 63.7% |
| Black/African American | 0% | 1.2% | 11.9% |
| Native American | 0% | 0.9% | 0.9% |
| Asian | 6% | 6.7% | 4.8% |
| Hispanic | 0% | 1.5% | 16.3% |
| Pacific Islander | 0% | 0.3% | 0.2% |
| Other | 0% | 1.2% | 2.3% |
| Decline to Respond | 0% | 3.2% | NA |
| Total | 100% | 100% | 100% |

Note: NA = Not Applicable

[i] US$50,000 to $79,900
[ii] US$80,000 to $109,900
[iii] More than US$110,000

In comparison to the U.S.'s 55 and older population, focus group participants were older, more educated, had higher incomes, and included a higher percentage of the population who identified as White/Caucasian. While the community-wide survey participants were older, more educated, represented a higher percentage of White/Caucasians, their incomes

were comparable to the national average. Both the focus groups and community-wide survey over-represented Whites/Caucasians and under-represented other races. Thirty-three percent of the U.S. 55 and older population's income was between US$20,000 and $50,000, which was well represented by both the focus group and survey respondents. In contrast, the focus groups and survey respondents mostly represented the age group of 76 years and older, which comprises only 22% of the U.S. 55 years and older population (Single Years of Age and Sex, 2010; Detailed Years of School Completed by People 25 Years and Over by Sex, Age Groups, Race and Hispanic Origin, 2011; Age of Householder--Households, by Total Money Income, 2010, Type of Household, Race and Hispanic Origin of Householder, 2011).

5.2. Travel Behavior

Participants from the in-depth interviews, focus groups, and the community-wide survey answered questions related to their current travel behavior including: How long is an average daily trip for you; what are the destinations you travel to inside and outside of Rossmoor and how frequently; and how often do you take public transit? The results in Table 3 provide a summary of travel patterns and responses to a carsharing service at Rossmoor (clipboard and community-wide survey).

**Table 3  Travel Patterns by Instrument Type**

| Possible responses | In-Depth Interviews (n = 7) | | Focus Groups (n = 31) | | Clipboard Survey (n=86) | | Community-Wide Survey (n = 357) | |
|---|---|---|---|---|---|---|---|---|
| | Count | % | Count | % | Count | % | Count | % |
| *Please indicate all trip distances that you drive five or more times a month* | | | | | | | | |
| 8 km | NA | | NA | | NA | | 208 | 83% |
| 16 km | | | | | | | 126 | 60% |
| 24 km | | | | | | | 82 | 48% |
| 32 km | | | | | | | 57 | 36% |
| 48 km | | | | | | | 34 | 27% |
| 64 km | | | | | | | 25 | 24% |
| ≥80 km | | | | | | | 27 | 16% |
| *Indicate all destinations you travel to inside of Rossmoor by frequency of trips (more than once a week)* | | | | | | | | |
| Gateway Clubhouse | NA | | NA | | NA | | 199 | 67% |
| Library | | | | | | | 56 | 28% |
| Gym | | | | | | | 150 | 65% |
| Visit friends | | | | | | | 144 | 59% |
| Theatre | | | | | | | 85 | 33% |
| Other | | | | | | | 109 | 69% |
| *Indicate all destinations you travel to outside of Rossmoor by frequency of trips (more than once a week)* | | | | | | | | |
| Downtown Walnut | NA | | NA | | NA | | 198 | 63% |
| Library | | | | | | | 17 | 9% |
| Visit friends | | | | | | | 87 | 37% |
| Theatre | | | | | | | 8 | 4% |
| Medical | | | | | | | 31 | 10% |
| Other | | | | | | | 120 | 59% |
| *How many hours would you use a carsharing vehicle for an average daily trip?* | | | | | | | | |
| < 1 hour | NA | | NA | | NA | | 10 | 4% |
| ~ 1 hour | | | | | | | 37 | 15% |
| 2-4 hours | | | | | | | 189 | 75% |
| > 4 hours | | | | | | | 15 | 6% |
| *How comfortable would you feel using an electric vehicle?* | | | | | | | | |
| Very comfortable | NA | | NA | | NA | | 171 | 57% |
| Somewhat | | | | | | | 79 | 27% |
| Somewhat | | | | | | | 26 | 9% |
| Very uncomfortable | | | | | | | 22 | 7% |
| *Please estimate how many kilometers you drive annually.* | | | | | | | | |
| 0 - 8,045 | NA | | 9 | 31% | NA | | NA | |
| 8,047 - 16,092 | | | 9 | 31% | | | | |
| ≥16,093 | | | 11 | 38% | | | | |
| *If you take public transit, please select all modes of public transit you take.* | | | | | | | | |
| Rossmoor Bus | NA | | 5 | 16% | NA | | 60 | 41% |
| County Connection Bus | | | 3 | 10% | | | 6 | 4% |

| BART | | | 17 | 55% | | | 71 | 48% |
|------|---|---|----|-----|---|---|----|-----|
| MUNI | | | 3 | 10% | | | 4 | 3% |
| Other | | | 3 | 10% | | | 6 | 4% |
| *During a typical week, how many times do you take public transit?* | | | | | | | | |
| 1 | NA | | NA | | NA | | 49 | 18% |
| 2 | | | | | | | 10 | 4% |
| ≥3 | | | | | | | 26 | 9% |
| None | | | 11 | 35% | | | 191 | 69% |
| *Do you typically plan your driving trips in advance?* | | | | | | | | |
| Yes | 7 | 100% | NA | | NA | | 236 | 70% |
| No | 0 | 0% | | | | | 29 | 9% |
| Sometimes | 0 | 0% | | | | | 72 | 21% |
| *If so, how far in advance do you typically plan your trips?* | | | | | | | | |
| < 1 day | 1 | 25% | NA | | NA | | 55 | 20% |
| ≥ 1 day | 3 | 75% | | | | | 214 | 80% |
| *Would you be interested in a carsharing system at Rossmoor?* | | | | | | | | |
| Yes | NA | | NA | | 42 | 49% | 88 | 25% |
| No | | | | | 13 | 16% | 133 | 38% |
| Maybe | | | | | 30 | 35% | 125 | 36% |

NOTE: 1.61 kilometers = 1 mile, NA = not applicable

Rossmoor residents made more frequent shorter driving trips than longer ones. As shown in Table 3, 83% of community-wide survey respondents made five or more 8-km trips per month (well within the range of an EV), while only 16% made five or more 80-km trips per month. Of participants who planned their driving trips in advance, 80% of community-wide survey respondents and 75% of interviewees planned their trips ahead at least one day prior. Such advanced planning/reservations could facilitate management of an EV carsharing fleet. The majority of focus group and community-wide survey participants were influenced by fuel costs. Thus, respondents stated they often chose to combine trips, make fewer trips, travel to closer destinations, or carpool. At the time of the survey, gasoline prices were approximately US$0.94 per liter (or US$3.55 per gallon) on average in the Walnut Creek area, where Rossmoor is located. Fuel price sensitivity could serve as an attraction to a carsharing service, which incorporates fuel/EV power costs into its usage rates.

Table 3 shows that study participants were not regular riders of public transportation. For example, only 18% used public transit at least once per week. While 55% of focus group and 48% of community-wide survey participants rode Bay Area Rapid Transit (BART) to Walnut Creek's surrounding cities—such as San Francisco, Berkeley, and Oakland—35% and 69% of focus group and community-wide respondents, respectively, reported never taking public transportation during a typical week. The Rossmoor Bus and BART are the most employed forms of public transit among Rossmoor residents. Very few respondents are regular public transit riders, which means this population is more auto dependent.

5.3 Interest in an EV Carsharing Program at Rossmoor

Throughout the in-depth interviews, focus groups, and community-wide survey, the authors defined carsharing as short-term vehicle use (i.e., a few hours or less) and explained that every automobile is used by several drivers. Users have access to the vehicle during their reservation time. It was also stated that members pick-up and return vehicles at shared-use lots (e.g., public transit stations and neighborhood parking lots), and fees are based on travel distance/time and cover maintenance, insurance, registration, and fuel.

Each study instrument, except the clipboard/short survey, explained that the carsharing service envisioned for Rossmoor would employ a fleet of Nissan Leaf EVs with a driving range of 160 km and a recharging time of four to eight hours. Upon receiving this information, participants were asked their opinions regarding carsharing in general, as well as the proposed EV carsharing program at Rossmoor.

Table 3 shows that 25% of community-wide survey participants and 49% of clipboard/short survey respondents were interested in participating in a carsharing service at Rossmoor. Thirty-six percent and 35% of community-wide and clipboard/short survey participants, respectively, were "maybe" interested. (Note this question did not specify whether the program would use EVs exclusively.) Interestingly, when asked how likely they would be to participate in a carsharing program, if non-EVs also were available, 71% of community-wide survey respondents were likely or "maybe" likely to sign up for carsharing, if they could reserve a non-EV for longer trips. Thus, the inclusion of non-EVs in a carsharing fleet would increase program attractiveness.

The community-wide survey results were cross tabulated to determine if there was a correlation between program interest and the age, income level, education, or race of the participants. The authors did not find any correlation of significance.

In the focus groups, a higher percentage of residents of cooperative units were more receptive to carsharing with EVs than condominium residents were of traditional carsharing programs. The majority of focus group participants and 84% of community-wide survey respondents felt comfortable (or somewhat comfortable) using an EV. Eighty-two percent of community-wide survey respondents were willing to try an EV carsharing program on a trial basis free of charge (i.e., for one or two trips), and 86% were either very or somewhat comfortable with plugging-in an EV. Thus, a high percentage of respondents seemed comfortable with trying an EV carsharing system.

Fifty-two percent of community-wide survey participants were willing to drive 80 km or more in an EV with a 160-km range, and 77% were willing to drive 48 km or more. Sixty-seven percent of community-wide survey respondents were comfortable operating shared EVs with a 120-km range remaining. Results show that 48 to 80 km is a long-enough range to accommodate most of the residents' trips. If a roadside assistance service were available, 80 to 145 km would provide a desired range. In other words, if the membership services included the availability of roadside assistance, residents would feel comfortable driving further. If a vehicle was less than 100 percent charged, 20% of the community-wide survey respondents would be most comfortable driving only 32 km, 14% 16 km, and 11% would only use the vehicle if it were fully charged. Many of the focus group participants expressed

concern about battery depletion and worried that there would not be an adequate amount of charge for their desired trip when they picked up the vehicle.

Due to the small preliminary fleet size envisioned (10 vehicles or less), participants were asked to choose one optimal location to place the carsharing vehicles. Forty-one percent of community-wide survey respondents, 57% of clipboard/short survey respondents, and all interviewees believed the parking lot at the community's Gateway Clubhouse would be the most convenient location to pick up and drop off a vehicle because it is centrally located, has ample parking, and is frequented on a regular basis by most residents.

In-depth interview participants reported typical travel outside of Rossmoor during the off-peak hours of 10:00am and 3:00pm. Most community-wide survey participants predicted they would use the carsharing service in the early afternoon and late morning, and 28% anticipated using a vehicle two to three times a week. Seventy-five percent of community-wide survey respondents would use a vehicle for two to four hours for an average daily trip. Potential users indicated that they would use a carsharing vehicle to go shopping, attend medical appointments, run errands, or go dining. Community-wide survey respondents would be willing to walk 400 to 800 meters to access a carsharing vehicle, and 37% would consider using the Rossmoor Bus to get to a carsharing station. The majority of focus group participants want to reduce the number of transportation modes they use per trip to reduce travel time and avoid taking the Rossmoor Bus when possible.

Many survey questions were focused on measuring behavioral changes and the modal shifts that might result from the proposed carsharing service. Sixty-one percent of community-wide survey respondents do not believe they would sell their household vehicles if they were to join such a program; however, 38% would or might. Fifty-nine percent of community-wide survey respondents thought they would or might take public transit and carpool more if a carsharing service were available, while 41% thought they would not. Two of seven in-depth interview participants would consider replacing their personal vehicles with carsharing, while another respondent reported that he would consider eliminating his second vehicle. The remaining four participants were concerned about vehicle availability in an emergency and thus were reluctant to sell or forego a personal vehicle.

Most community-wide survey participants (70%) were willing to use smart keys and personal identification number (PIN) codes to access vehicles, as well as an Internet-based system that provides information on vehicle availability, charging status, and vehicle reservations (62%). While there was a willingness to use advanced technologies in a carsharing service, 46% of community-wide survey respondents preferred a phone reservation system to an Internet-based one. All of the focus group participants preferred both online and phone reservations systems.

5.4. Willingness-to-Pay

Focus group and survey participants were asked about their willingness-to-pay for an EV carsharing service in their community. The focus group participants were presented with various payment schedules derived from those used by carsharing programs at the time; participants discussed their opinions of membership and usage fees. This discussion allowed

the authors to design willingness-to-pay questions specific to a Rossmoor carsharing service.

Forty-four percent of clipboard/short survey respondents were willing-to-pay for a service, while 39% were "maybe" willing. The clipboard/short survey did not ask respondents how much they were willing-to-pay. Community-wide survey participants were likely or willing-to-pay up to US$4 per hour for carsharing vehicle use, and they were definitely or likely willing-to-pay up to US$15 a month in membership fees. In comparison, this is significantly lower than current carsharing program costs—City CarShare charges US$10 per month for their occasional driver plan, and San Francisco's Zipcar charges a US$60 annual fee; however, their hourly rates are higher than City CarShare's (US$8 in contrast to US$5) (City CarShare, 2012; Zipcar, 2012). Since four out of seven focus group participants were unwilling to give up their personal vehicles, while the other three would only "consider" doing so, the carsharing costs could be interpreted as an additional transportation expense on top of personal vehicle costs (at least until participants became familiar/confident with service reliability and might consider foregoing a vehicle).

### 6. Conclusion

This study explored the feasibility of an EV carsharing program in an older adult community, as well as its potential to increase the mobility options. Rossmoor was selected as the location for this study, given its large population size, early adopter characteristics (e.g., higher incomes and education), and proximity to the research team.

The seven in-depth household interviews collected preliminary information about resident interest and response to an EV carsharing program, and all participants indicated that they were interested. Interview participants plan their trips at least one day in advance, and almost all of their trips are short distance (i.e., less than 16 km), which fall within the EV range. Advanced reservation/trip planning could aid EV carsharing program management and vehicle charging logistics. Interview participants reported that they would like the shared-use vehicle locations to be easily accessible.

Focus group results complement the interview findings in that the majority of respondents were interested in an EV carsharing program at Rossmoor. Participants living in cooperatives, which typically house those of lesser income levels, were more receptive to the idea. Many of the focus group respondents expressed concern about battery depletion, and some noted that they would only use a vehicle if it were 100 percent charged. Eighty-nine percent of community-wide survey respondents were willing to drive a vehicle that was not fully charged, and many respondents already drive shorter distances (8 km or less) and combine trips.

The surveys found that more individuals, living in either a cooperative or condominium unit, were interested in an EV carsharing program at Rossmoor. Specifically, 25% and 36% of community-wide and clipboard/short survey respondents respectively, were interested, while 49% and 35% were "maybe" interested. Only 36% of community-wide survey respondents and 35% of clipboard/short survey respondents had no interest. Interestingly, when asked how likely they would be to participate in a carsharing program, if

non-EVs were also available, 71% of community-wide survey respondents said they were likely or "maybe" likely to sign up for carsharing so they could access non-EVs for longer trips. Thus, the inclusion of both EVs and non-EVs in the fleet would likely increase interest and participation.

Overall, results showed support for an EV carsharing program at Rossmoor. Participants chose a central and convenient location for the shared-use vehicles (Gateway Clubhouse) and indicated that they would use the program frequently (two to three times a week). Most of the Rossmoor respondents do not use the community's transportation services often. This, as well as other logistical details, such as a reservation system and specific pricing structure(s), should be further researched and addressed prior to a pilot program. Studies focused on incentivizing payment for a carsharing service or how such a service can be marketed toward residents would be particularly relevant in similar communities. If successful in the Rossmoor community, other senior adult communities throughout the nation might consider and improve the mobility of residents through carsharing.

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