UBC Social Ecological Economic Development Studies (SEEDS) Sustainability Program

Student Research Report

Residential Environmental Assessment Program (REAP): Community Carshare Credit

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University of British Columbia

PLAN 528A

Themes: Transport, Climate, Community

May 12, 2019

Residential Environmental Assessment Program

Community Carshare Credit Exploratory Study

Project Stakeholders

THE UNIVERSITY OF BRITISH COLUMBIA

Campus + Community Planning

We are the urban planners, designers, engineers, public consultation professionals, building inspectors and sustainability experts dedicated to creating a vibrant, sustainable, live-work-learn community at UBC. Our key responsibilities include long-range planning, land use regulations, campus and landscape design, licensing and permits, in addition to managing sustainability, community-building and programs that bring life and vibrancy to campus.

UNA UNIVERSITY NEIGHBOURHOODS ASSOCIATION

The University Neighbourhoods Association was incorporated as a not-for-profit society in 2002 to provide the residents of UBC's residential neighbourhoods with services that encourage a sustainable community life at UBC. The University Neighbourhoods Association oversees the major residential neighbourhoods around UBC's campus: Wesbrook Village, Hampton Place, Chancellor Place, Hawthorn Place, East Campus, and the newly developed Central District. The purpose of The University Neighbourhoods Association is set out in its constitution and by-laws. It manages infrastructure, such as street and sidewalk repairs, and regulates matters of concern in the public realm, such as parking and noise.

UBC PROPERTIES TRUST

UBC Properties Trust mission is to assist UBC, through optimization of land assets, to achieve the academic and community goals of its Place and Promise mandate. This includes the following services: service and market lands for residential development; develop, lease, and property manage two rental portfolios: Village Gates Homes (Staff and Faculty Rentals) and Wesbrook Properties; develop, lease, and property manage an office and retail portfolio; analyze projects as requested by UBC; project manage the construction of institutional projects; lead the community development and marketing for Wesbrook Place.

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Acknowledgements

First and foremost, I would like to thank the project stakeholders for their guidance and assistance throughout the duration of this study. This includes Adam Hyslop, Penny Martyn, and Ralph Wells from Campus + Community Planning; Paul Young from UBC Properties Trust; and Emily Lomax and Wegland Sit from The University Neighbourhoods Association. Second, I would like to thank Sylvain Celaire from Modo for his direction and knowledge. Third, I would also like to thank David Gill from SEEDS for his support and kindness throughout the process. Finally, I would like to thank Martino Tran from the School of Community and Regional Planning and Hadi Dowlatabadi from the Institute for Resources, Environment and Sustainability for their mentorship and assistance with the survey's format, questioning, and analysis

Executive Summary

In 2004, Campus + Community Planning, The University Neighbourhoods Association and UBC Properties Trust brought carsharing to The University of British Columbia residential neighbourhoods through a partnership with local carshare operator Modo. This was done with the aim of reducing single-occupancy vehicles traveling to and from campus, a policy that can be attributed to both the *20-Year Sustainability Strategy* as well as the *2014 UBC Transportation Plan* (UBC, 2014a; UBC, 2014b). The agreement between the organizations specified that carshare vehicles would be purchased by UBC Properties Trust and operated in-full by Modo. Carshare vehicles would be financed through a mandatory community carshare credit within the *Residential Environmental Assessment Program*, which is administered by Campus + Community Planning. Vehicles would be provided at a ratio of 1 vehicle per 125 units and dispersed throughout the Neighbourhood Housing Areas, with The University Neighbourhoods Association allocating on-street parking for the vehicles. As of April 2019, fifteen Modo vehicles have been purchased through this program and five more are scheduled to arrive.

While the community carshare program is generally thought to be a success, it has not been reviewed since its inception. *The Residential Environmental Assessment Program Community Carshare Credit Exploratory Study* provides an opportunity to review the program in support of a future update of the credit and fund.

The purpose of the study is to understand the contribution of carshare to transportation sustainability on campus in support of an update to the community carshare credit. This study's goals are:

- to research and explore instances of sustainable transportation financing projects, such as electrification of community access and charging;
- to survey project stakeholders and community members; and
- to develop recommendations for the community carshare credit and associated carshare fund.

In reviewing the conversations held with each project stakeholder, seven themes were broadly drawn from the scoping meetings, including: affordability, community impact, parking, partnerships, program effectiveness, intermodality, and sustainability. Several university and regional policies exist that apply to the community carshare credit.

The information gathered for the literature review consists of both academic and grey sources. The literature has been organized into categories that correspond with the study's objectives, including: the benefits of carshare, the differences between carshare systems, electric vehicles, and parking regulations.

Several academics have written of the benefits of carshare. Carshare provides significant potential for emissions reductions when compared to private vehicle ownership. Membership with a carshare organization is shown to reduce the use of private vehicles by individuals. The effect carshare has upon vehicle kilometers traveled is inconclusive. Financial benefits can result from carshare. Carshare works to supplement and benefit existing transportation systems.

It is important to distinguish between one-way and two-way carshare systems as each option is best suited for a particular purpose. The two forms of carshare differ in terms of key demographics. An individual's rationale for using a carshare service varies between the two systems. There are distinct differences in trip purposes between the two groups. The travel patterns between members of the two carshare systems differ considerably. Two-way carshare provides higher rates of users relinquishing ownership of their personal vehicle in comparison to one-way carshare.

There are several different forms of electric vehicles currently available on the market. Academic studies have demonstrated the potential for emissions reductions resulting from electric vehicles.

Supportive public policy pertaining to parking regulations is critical to the expansion and success of carshare. An overabundance in parking supply creates financial burdens on developers and the community. Carsharing is unlikely to succeed without supportive local governments.

To gain a better sense of the transportation preferences of residents living within the Neighbourhood Housing Areas, a survey was developed by the project stakeholders and disseminated to the public. Officially titled the *UNA Carshare Survey*, the survey was active between March 1 and March 31. The survey consisted of 26 questions and focused upon population demographics, existing transportation habits, and knowledge and use of carshare.

The survey targeted residents living within the Neighbourhood Housing Areas. In total, the survey received 270 unique responses. Of those responses,

203 surveys were completed in full, 33 were partially completed, and 34 provided no response. Based upon the survey responses, the following inferences can be made about survey respondents.

The average survey respondent is: between 31 and 50 years of age; lives with 2 to 3 adults, 2 children, and 1 to 2 seniors at home; earns a cumulative household salary of $100,000 per year or more; has some form of professional affiliation with UBC; considers their household to be their permeant residence; is renting; and live either at Wesbrook Village or Hawthorn Place.

The average survey respondent has the following transportation preferences: does not own a vehicle at their residence; has access to some form of underground parking; owns or rents a parking stall; travels to Vancouver's Westside, Downtown Vancouver, and East Vancouver/Burnaby; would not pay more than $120 for an on-street parking permit; and uses a private vehicle for travel.

The average survey respondent has the following knowledge of and preferences towards carshare: is very comfortable with their knowledge of carshare; is a carshare member; uses carshare either once per week, 2-3 times per week, or once per month; can afford to buy and run a vehicle (or another) but chooses to use carshare instead; uses carshare to run errands and for pleasure; did not shed a private vehicle as a result of carshare; considers convenience to be the most important factor in using carshare; enjoys the ability to get stuff done with carshare; and is interested in using electric carshare vehicles.

Having reviewed the existing literature and analyzed the survey data, several important findings become apparent. The community carshare credit within the *Residential Environment Assessment Program* has been a successful tool for advancing sustainability and transportation initiatives on campus. The program's primary successes have been in expanding the knowledge and use of carshare, increasing the availability of carshare vehicles, and reducing the number of private vehicles within the Neighbourhood Housing Areas. As it currently exists, the partnership between Campus + Community Planning, The University Neighbourhoods Association, UBC Properties Trust and Modo has been of great benefit for all organizations. For the continued success of the program, it is imperative that this partnership remain strong provided that each organization has an important role to play in the credit's functioning.

With these successes in mind, there are areas within the credit that are in need of revitalization. Accordingly, several recommendations have been provided that, if implemented, could make the credit more effective. These updates will allow the community carshare credit to branch into exciting new avenues for the program's continued growth and success in future. It is intended that these recommendations be worked upon jointly between the different organizations to ensure policy continuity and to strengthen collaboration.

In summary, the following twelve recommendations have been made:

1. Partner with carshare operators and developers to finance carshare memberships through the community carshare credit that target low-income categories.
2. Permit developers to provide dedicated carshare parking stalls in exchange for reduced on-site parking requirements.
3. Continue to utilize the community carshare credit funding for two-way carshare only.
4. Consider adopting Points 1, 2, 3, 4 & 5 from Lempert's (2018b) best practices into carshare and parking policy within the Neighbourhood Housing Areas.
5. Coordinate parking policies between The University Neighbourhoods Association and UBC to ensure parking policy continuity.
6. Continue the partnership between Campus + Community Planning, The University Neighbourhoods Association, UBC Properties Trust and Modo.
7. Enhance marketing efforts to educate residents on carsharing and demonstrate its benefits.
8. Conduct a statistically valid follow-up study to explore how carshare can better meet the needs of residents within the Neighbourhood Housing Areas.
9. Conduct a follow-up study to analyze the usage patterns of carshare vehicles on campus.
10. Evaluate the placement of carshare vehicles on an annual basis and reallocate accordingly.
11. Conduct an electric vehicle pilot study within the Neighbourhood Housing Areas.
12. Permit the community carshare credit for financing electric vehicle charging infrastructure within the Neighbourhood Housing Areas.

Introduction

Context

In 2004, Campus + Community Planning, The University Neighbourhoods Association and UBC Properties Trust brought carsharing to The University of British Columbia (UBC) residential neighbourhoods through a partnership with local carshare operator Modo. At the time, Modo was chosen as the project partner given its fleet size and established membership base. The agreement between the organizations specified that carshare vehicles would be purchased by UBC Properties Trust and operated in-full by Modo. The agreement also included a guarantee that purchased vehicles would remain on campus for a pre-determined duration of time. This clause was established due to the university's geographical isolation and smaller population size, necessitating a measure to ensure that purchased vehicles would remain on campus irrespective of their financial performance.

Carshare vehicles are financed through a mandatory community carshare credit within *The Residential Environmental Assessment Program* (REAP), which is administered by Campus + Community Planning. This credit applies a fee of $200 per unit for new developments within the Neighbourhood Housing Areas (NHAs). Vehicles are provided at a ratio of 1 vehicle per 125 units and dispersed throughout the NHAs, with The University Neighbourhoods Association allocating on-street parking for the vehicles. As of April 2019, fifteen Modo vehicles have been purchased through this program and five more are scheduled to arrive. Additional past program expenditures include financing for carshare signage and the installation of a level three electric vehicle charging station in Wesbrook Village.

While the community carshare program is generally thought to be a success, it has not been reviewed since its inception. *The Residential Environmental Assessment Program Community Carshare Credit Exploratory Study* (the study) provides an opportunity to review the program in support of a future update of the credit and fund. There is also an opportunity for future fleet expansion to include a greater diversity of vehicles, including electric vehicles.

Purpose

The purpose of the study is to understand the contribution of carshare to transportation sustainability on campus in support of an update to the REAP community carshare credit.

The study's goals are:

- to research and explore instances of sustainable transportation financing projects, such as electrification of community access and charging;
- to survey project stakeholders and community members; and
- to develop recommendations for the community carshare credit and associated carshare fund.

Rationale

UBC aims to reduce single-occupancy vehicles traveling to and from campus, a policy that can be attributed to both the *20-Year Sustainability Strategy* as well as the *2014 UBC Transportation Plan* (UBC, 2014a; UBC, 2014b). Several policy gaps for driving to and from campus were outlined within the *2014 UBC Transportation Plan*, including limited policies and programs in relation to carsharing on campus (UBC, 2014b). While the number of carshare operators on campus has increased in recent years, the knowledge gap between carshare performance and the program's use remains unclear. Furthermore, the project stakeholders are interested in exploring how the community carshare credit and it's associated funding can also be used to advance sustainability efforts on campus, including the electrification of carshare on campus and providing publicly accessible electric vehicle charging stations. Finally, the reduction in single-occupancy vehicle travel is also of interest to the project stakeholders. This in turn would allow the university to remove parking lots and repurpose land for other purposes including housing, academic spaces, and green spaces.

Scope

The project stakeholders have identified five key deliverables for the study:

1. Conduct a literature review for best practices of sustainable modes of transportation including electric vehicles and carshare.
2. Research current needs and opportunities for advancing sustainable transportation options.
3. Meet and interview with key stakeholders to understand and analyze the current credit model, spending, best practices, and community feedback to inform future funding opportunities to advance sustainable transportation.
4. Design and administer a survey for the NHAs to better understand resident needs.
5. Review final report with project stakeholders.

Methodology

Following an initial meeting in early-August to discuss the study's scope, the project stakeholders – being Campus + Community Planning, UBC Properties Trust, and the University Neighbourhood Association – reconvened for a second meeting in mid-September to finalize details and kick-off the study. In the time between mid-September and April, the following data sources were collected and analyzed.

Stakeholder Engagement – Project stakeholders were interviewed individually to gain a sense of their specific interests in relation to the study. This was done to ensure that each organization's interests are represented within the scope of the study.

Literature Review – As a result of the scoping interviews, several articles and documents were provided by the project stakeholders for the literature review. Additional documents were collected through academic databases and government websites. The research focused upon the benefits of carshare, the differences between carshare systems, electric vehicles, and parking regulations. A policy analysis was also conducted, reviewing the relevant policies from the university and regional government.

Data Analysis – A survey was developed and distributed to residents of the NHAs. This information was analyzed to gain a sense of the transportation patterns occurring within the NHAs, who is utilizing carshares, and what are the barriers preventing individuals from using carshare.

Background

REAP

REAP is a framework for mandating and measuring sustainable building practices for market-based and staff, faculty and student residential developments located within the NHAs at UBC's Vancouver campus (UBC, 2018a). Developed specific to the university's context, REAP is integrated into the community planning and development approval process, playing a key role in the build out of the NHAs (UBC, 2018a). REAP is uniquely designed for application to multi-family residential buildings (UBC, 2018a).

REAP evaluates a building's performance across seven categories. The system is a credit-based certification system, with credits being either mandatory or optional to complete. For a developer to be permitted to build on campus, the project must meet all the mandatory credits and a certain number of the optional credits across seven categories (UBC, 2018a).

Four levels of certification can be achieved through REAP. The minimum development standard is Gold followed by Gold Plus, Platinum, and Platinum Plus (UBC, 2018a). While going beyond the minimum certification is not required of developers, seeking higher REAP ratings is encouraged and may help attract prospective buyers by differentiating a development in the marketplace.

The specific credit that is of interest to this study is Credit M4 - Contribution to Community Car Sharing. Figure 2 provides the specific details of this credit.

Beyond the aspirational goals detailed above, the wider objectives for establishing REAP are to ensure that multi-family residential projects built in the NHAs are of higher quality and have lower environmental impacts than standard construction in the Lower Mainland, benefiting both individual consumers and the wider university community (UBC, 2018a).

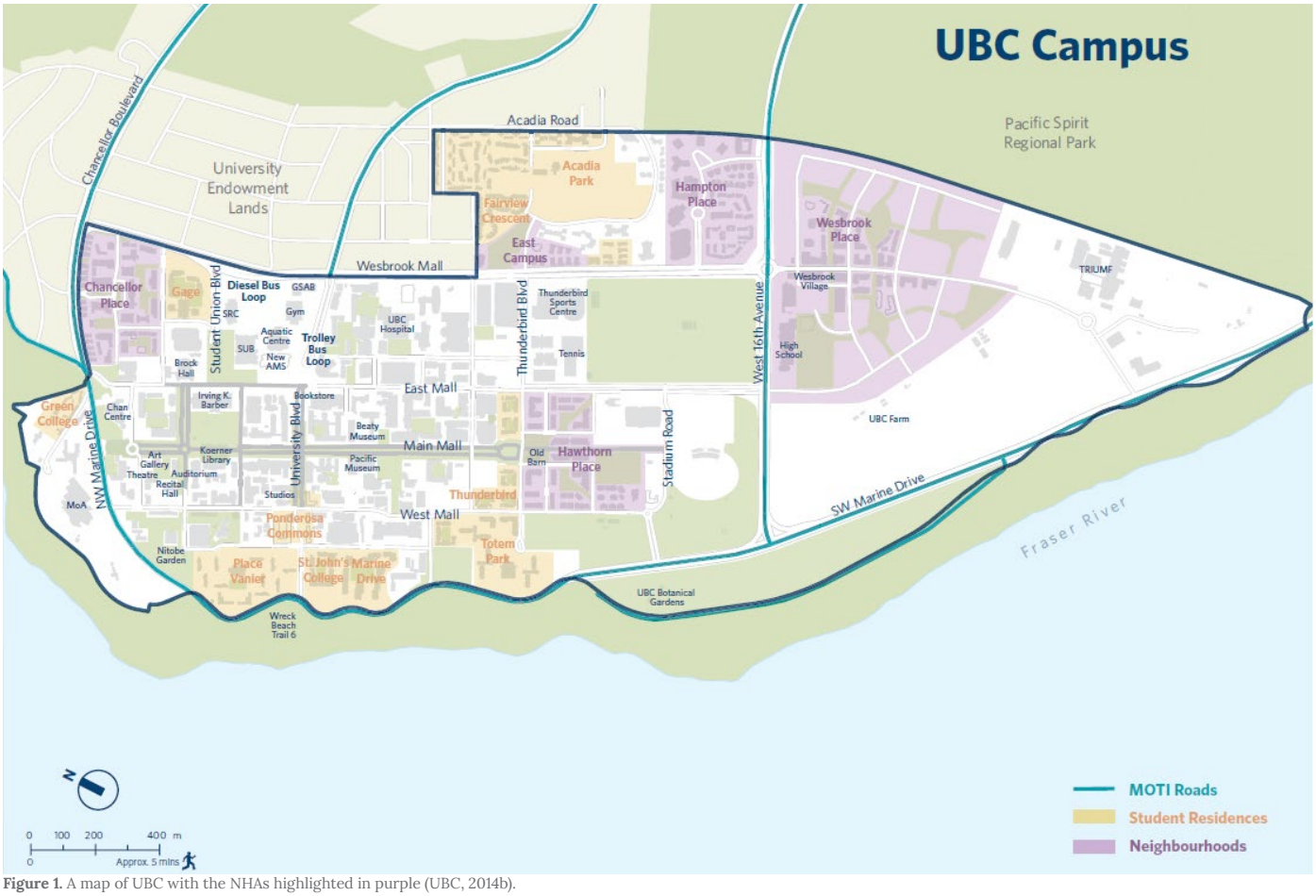

Figure 1. A map of UBC with the NHAs highlighted in purple (UBC, 2014b).

SS MANDATORY

SS Credit M4: Contribution to Community Car Sharing **Mandatory**

Requirement

Contribute to the development of a community car-sharing network by funding the equivalent of one community vehicle per 100 residential units.

Intent

To reduce environmental impacts associated with private automobile use.

Rationale

Car sharing makes public transportation a viable option by providing a cost-effective alternative for special trips. The World Car-Share Online Inventory reports that in 2006, there are more than 1,000 cities in the world with active car-sharing networks.

Definitions

- *Community car-sharing network*: An organization that provides access to shared automobiles for its members as an alternative to private ownership.

Strategies

- Consult with UBC Properties Trust to make arrangements for the required contribution.
- Provide information to homebuyers on the community car-sharing program

Resources

- *Victoria Transport Policy Institute (VTPI):* The VTPI in an excellent resource for information on a variety of sustainable mobility resources.

  Site: http://www.vtpi.org/
- *Wikipedia:* See the Wikipedia online encyclopaedia entry on Car Sharing for a comprehensive overview of car sharing networks worldwide.

  Site: http://en.wikipedia.org/wiki/Carsharing
- *Modo, the Car Co-op* is a Vancouver-based not-for-profit co-operative venture incorporated to foster car sharing as an alternative to the privately owned automobiles.

  Site: http://www.modo.coop/
- *CarSharing.net* is a non-profit educational and promotional site, supporting the car sharing industry in North America.

  Site: http://www.carsharing.net

Documentation: *Submit at the Occupancy Permit phase*

- Letter signed by Developer declaring that the requirements have been met.
- Number of residential units and documentation confirming the amount contributed to car-sharing network.

Figure 2. Credit M4 – Contribution to Community Car Sharing from REAP (UBC, 2018a).

History of Carshare

The first carsharing initiative was established in Switzerland in the late 1940s. As it rose in popularity, carsharing was quick to spread into new markets, expanding throughout Europe in the late 1980s, into North America in the late 1990s and eventually Asia in the early 2000s (Shaheen et al., 1999). Due to technological limitations, carsharing was initially limited to a two-way system where members were restricted to picking up and dropping off their vehicle at the same location (Shaheen et al., 1999). Advances in information and communications technology in the late 2000s allowed for one-way carsharing to exist, which is distinguished by a user's ability to pick up and drop off vehicles anywhere within a designated service area (Shaheen et al., 1999). Smartphones further lowered the transactional costs associated with carsharing, making services more convenient and affordable (Lempert et al., 2019).

In a relatively short timeframe, one-way carsharing has accumulated nearly 5 million members and two-way carsharing has over 10 million members, both of which continue to grow (Lempert et al., 2019). car2go is the most popular global one-way carsharing service with over 2.5 million members and Zipcar is the most popular two-way service with 750,000 members (Lempert et al., 2019). Starting in 2007, North America carsharing has grown at a rate of 23% per year, going from 200,000 members to nearly 2 million members at present (Lempert et al., 2019).

Carshare has existed in Vancouver since 1996 with the founding of the Cooperative Auto Network, which was later rebranded as Modo (Lempert, 2018a). At present, Vancouver has four carshare operators operating within the city: car2go, Evo, Modo and Zipcar. While only about 0.5% of registered vehicles in Vancouver, Burnaby, New Westminster, and North Vancouver are carshare vehicles, their greater use means they make up 1.1% of all vehicles in motion (Vancity, 2018). The percentages rise significantly in Vancouver where carshare concentrations are higher: 0.7% of all vehicles are carshare vehicles, totalling 1.65% of all moving vehicles at any given moment (Vancity, 2018). A recent report by Vancity notes that Vancouver has the largest number of carshare vehicles per capita of any North American city, with 4.22 carshare vehicles per 1000 people (Vancity, 2018). The region's carsharing fleet of approximately 3,000 vehicles is the largest in Canada and is larger than the fleets in cities such as Seattle, Portland, and San Francisco (Vancity, 2018).

What are the factors that have led to the success of carshare in Metro Vancouver? A key ingredient in carshare's success has been the region's high urban population density (Vancity, 2018). Other suggested factors include a limited supply of taxis, an absence of ride-hailing services, a short supply of affordable housing and parking, a larger contingent of environmentally conscious residents, an urban population that prioritizes urban lifestyle over car ownership, and a large immigrant population (Vancity, 2018).

The University of British Columbia

The daytime campus population – including students, staff and faculty – has grown by 51% from 1997 to 2012 (UBC, 2014b). This includes a population of 8,850 residents living within the NHAs as of 2016 (Statistics Canada, 2016). This growth is projected to continue well into the future, with estimates of approximately 22,500 residents living within the NHAs by 2021 (UBC, 2014b). Student enrolment is also expected to continue growing during this timeframe, reaching 60,000 full time equivalents by 2041 (UBC, 2014b). At full community build out, the total population of the NHAs is projected to be 24,000 people by 2041 (UBC, 2014b).

In recent years, travel to and from the university has witnessed several shifts in modal preferences. As an example, the time period between 1997 and 2012 saw transit mode share increase significantly with the commencement of the U-Pass BC program and its subsequent uptake (UBC, 2019). At the same time, single and high occupancy vehicles experienced a slight reduction in mode share with all other transportation methods remaining steady (UBC, 2019).

The university has only recently begun collecting and analyzing carshare data in its annual census. In the UBC Vancouver Transportation Status Report – Fall 2018, a steady increase of carshare trips is noted, increasing from 349 trips in 2015 to 553 trips in 2018 (UBC, 2019). This amounts to an impressive 58.45% increase between the two periods. While one-person vehicle trips continue to see growth yearafter year, two-person and three-person trips have seen a decline since 2017.

The report also found that both car2go and Evo were the top two carshare providers for university residents (UBC, 2019). Survey respondents provided detail on the top three reasons why they choose to use carshare: to run errands and shopping, when the weather is poor, and for commuting to school and work (UBC, 2019). The university facilitates carshare on campus by providing 157 dedicated parking stalls to carshare operators in addition to rooftop overflow parking on parkades for one-way carshare vehicles (UBC, 2019).

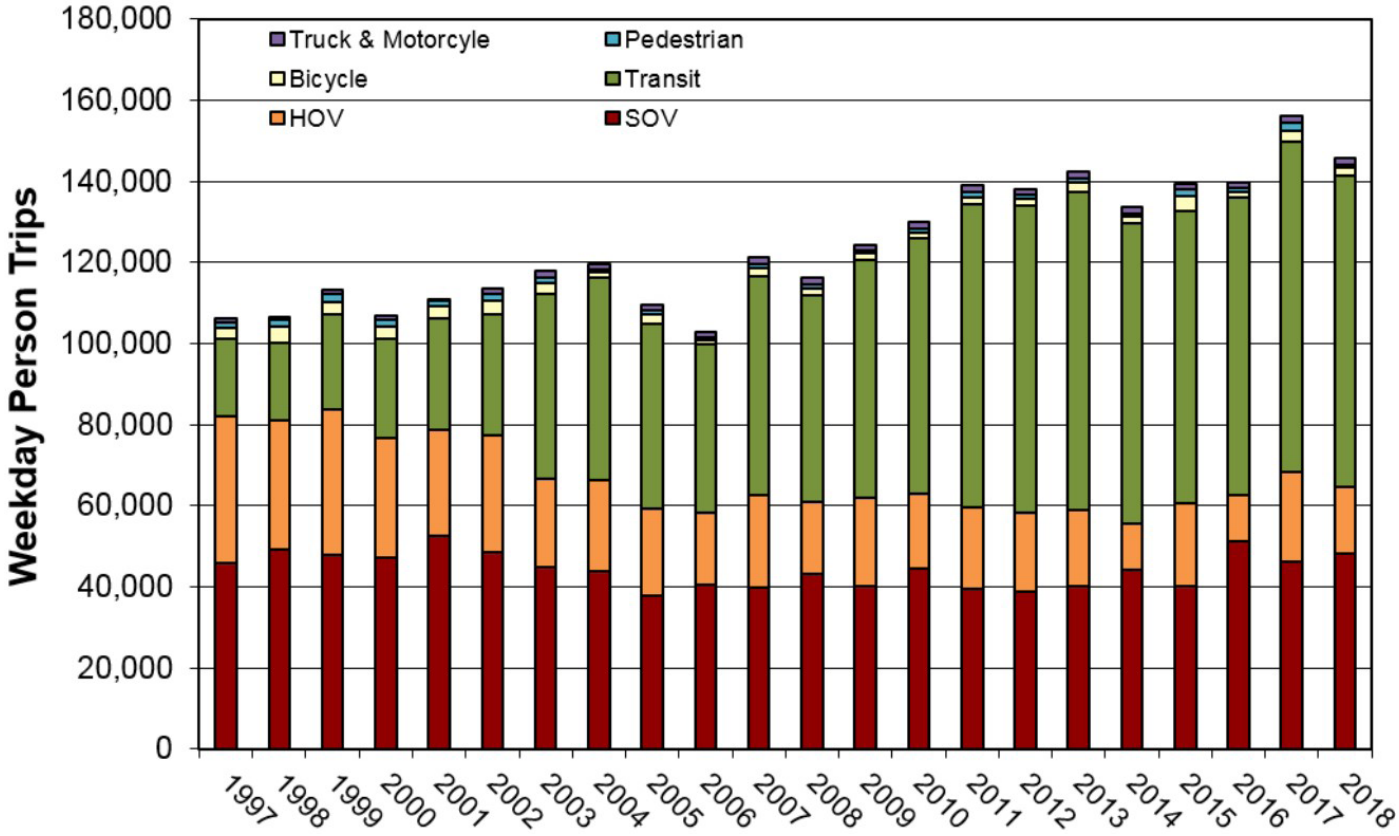

Figure 3. Daily person trips to and from UBC by mode (UBC, 2017).

Table 1. Summary of carshare trips to and from the university (UBC, 2019).

Car-Share Vehicle Trips	Fall 2015	Fall 2016	Fall 2017	Fall 2018
1-Person Trips	299	388	408	503
2-Person Trips	45	41	73	41
3+ Person Trips	5	7	39	9
Totals	**349**	**436**	**520**	**553**

Stakeholder Engagement

Each project stakeholder was interviewed to discuss the study in relation to their specific organization. The goal of these sessions was to discern each stakeholder's interest in the research and to assist in further scoping the study. Questions asked during these sessions include:

1. What aspect of this research is most interesting or important to your organization?
2. Identify the key stakeholders and partners that are important for this project.
3. Is there any media or research that your organization has created that would help inform this project?
4. Are there any resources that I can use from your organization?
5. What would you like to see in the final outcome? What are your expectations for the project?
6. Any additional items that I should be made aware of?

In reviewing the conversations held with each project stakeholder, seven themes were broadly drawn from the scoping meetings.

Affordability – Aim to increase affordability for residents on campus through transportation cost savings. Focus on how carshare and electric vehicles can help address affordability on campus. Consider decoupling parking from the purchase/rental cost of rentals and condos on campus to disincentivize single occupancy vehicles and increase affordability.

Community Impact – Modo is interested in how this research may impact their users, including providing a clear scientific justification for the benefits of the program. Research should be conducted to identify what the impact of carshare is on residences. Look for a better understanding of usage patterns amongst residents and patrons of the neighbourhood. Aim to apply the project's recommendations to new neighbourhoods including the upcoming Stadium District.

Parking – Strive to reduce the number of cars and parking spots found at UBC. This project should work to address the concern of parking amongst residents knowing that there is already limited street parking in the NHAs and that there is a lot of stress placed upon this parking by outside users. As it currently stands, there is no ticketing within the neighbourhoods as The University Neighbourhoods Association does not have the authority to do so. As a result, vehicles that are improperly parked in the university neighbourhoods are immediately towed at the owner's expense. Carshares have resulted in a spillover effect, where carshare vehicles are occupying spots not designated for them and limiting the parking offered to residents. If implemented properly, carshares can help to reduce the need for private parking and private automobiles in the NHAs.

Partnerships – Focus on working with developers to utilize and promote the carshare credit as they are somewhat resistant currently. Modo is interested in partnering with UBC Properties Trust to finance a number of memberships through a form of community contribution. Look to the potential of developers providing marketing collateral for Modo. Consider expanding the program to include other service providers and services.

Program Effectiveness – Consider how successful the carshare credit has been to date in reducing vehicle emissions and the usage of single occupancy vehicles on campus. Explore if there been any environmental assessments conducted to date. It is important to understand that visibility is key for carshares to be effective, preferring to be in central locations with high traffic volumes. Focus on practical results that are easy to implement.

Intermodality – Strive to assist in the transformation of the transportation market. Reduce the number of single occupancy vehicles on the road. Offer additional options for mobility to neighbourhood residents provided that public transit is not always readily available to them, especially after working hours and on weekends. Consider what modes of transportation carshare users are switching over from. Look to further diversify transportation options by promoting carshare and expanding intermodal usage. Work to develop carshare as a more prominent mode share for travel to and from the university. Note the difference between one-way and two-way carshare.

Sustainability – Examine broader sustainability elements, such as lowering negative externalities and considering product life cycles. There is an interest in delivering the best environmental practices to the university. The project should link to the university's climate change and sustainability mandates. Lower the overall emissions of users transiting to campus by reducing the number of single occupancy vehicles and promoting the use of carshare. Explore the notion of what an electric vehicle pilot study would look like. Analyze the feasibility of a large charging network for electric vehicles to employ.

The full results from these scoping meetings can be found in Appendix A.

Policy Context

Provided that this study exists within a network of preexisting university policies, it is important to understand the context by which REAP is situated within to give credence to the study and provide guidance as to future strategic direction. Below is a compilation of the university and regional policies that apply to REAP.

University Policies

The Strategic Plan 2018-2022 establishes the collective vision, purpose, goals and strategies for the university in the years ahead, providing direction on decisions and actions for students, faculty, staff, alumni and community partners (UBC, 2018b). Strategy 3: Thriving Communities looks to support the ongoing development of sustainable, healthy and connected campuses and communities (UBC, 2018b). It is focused on advancing sustainability and wellbeing on campus through the renewal and innovation in learning environments, operations and infrastructure. This strategy also speaks to the university acting as a living laboratory, a model which looks to addresses social and environmental issues beyond the campus by integrating research and learning into the university's operations, in addition to bridging the divide between students, faculty, staff, and community partners to work collaboratively on community initiatives (UBC, 2018b).

The Land Use Plan discusses the goal of the university utilizing its land resources to support academic activities and build an endowment through the development of an integrated community that is environmentally-friendly and consistent with regional objectives (UBC, 2015). Further, the document's vision outlines the balance between ecological health, economic viability, and community at the university, with each component being equally valued (UBC, 2015).

The University of British Columbia Transportation Plan (The Transportation Plan) lays out the vision and long-term strategic plan for the transportation future of the Vancouver campus. It begins by stating that the university is dedicated to promoting sustainable transportation options for the university community (UBC, 2014b). Several of the document's policies seek to reduce single occupant vehicles commuting to and from the campus. Target 2 looks to reduce single occupant vehicle travel to and from the campus by 20% from 1996 levels (UBC, 2014b). Target 3 speaks to the goal of maintaining daily private automobile traffic at or less than 1997 levels (UBC, 2014b). The university has already accomplished Target 2 on an annual per person basis and is continuing to work on achieving it in terms of total trips (UBC, 2014b).

The Transportation Plan discusses the impact of parking at the university, detailing how effective land use planning and policies can contribute to restrained vehicle use on campus. Parking availability and pricing is one of the biggest influences on driving mode share to and from campus (UBC, 2014b). The Vancouver campus has a relatively constrained parking supply that will decrease in coming years as surface parking lots continue to be converted to new academic and housing facilities (UBC, 2014b). As a result, parking prices will continue to be used to influence parking demand and thus favour alternative modes of transportation (UBC, 2014b).

The Transportation Plan also has a section dedicated to carsharing and electric vehicles. The plan states that carsharing provides convenient, cost-effective vehicle access and frees up road and parking space for other users (UBC, 2014b). Expanding electric vehicle charging stations through the university's parking facilities and neighbourhood development would provide an alternative to traditional single occupancy vehicles on campus (UBC, 2014b). Carshare is described within the plan as a relatively new area for transportation planning but one where there are considerable opportunities for success. The limited policies and programs in relation to carsharing on campus is identified within the Transportation Plan as a policy gap for the university to address in future (UBC, 2014b).

The university already has several policies and actions that relate to carshare on campus, including:

- D1.1 – Restrain automobile use on campus, especially single occupancy vehicles.
    - ◊ D1.1.1 – Encourage single occupancy vehicle commuters to shift to carpooling and vanpooling.
    - ◊ D1.1.7 – Collaborate with UBC Properties Trust, developers, realtors and other stakeholders to communicate UBC's land use and transportation visions.
- D2.1 – Use parking costs and measures to support reduced single occupancy vehicle usage.
    - ◊ D2.1.5 – Continue to reduce the amount of commuter parking.

- ◊ D2.1.6 – Discontinue the use of surface parking lots over time by converting them to future academic building sites or other interim uses, such as recreational areas. The loss of approximately 500 surface stalls can be accommodated by existing parkades.
- ◊ D2.1.8 – Discourage off campus, on-street parking in adjacent university neighbourhoods by collaborating with partner organizations and sharing information online and through social media channels.
- ◊ D2.1.9 – Collaborate with The University Neighbourhoods Association to harmonize campus parking regulations and reduce incentives to drive.

- D3.1 – Support car sharing and electric vehicles as alternatives to conventional single occupancy vehicles.
  - ◊ D3.1.1 – Expand car sharing parking locations across campus to meet demand.
  - ◊ D3.1.2 – Expand electric vehicle charging stations in academic and residential areas (UBC, 2014b).

The UBC Vancouver Transportation Status Report - Fall 2018 details the university's goal of reducing automobile trips to and from campus and encouraging the use of other modes of transportation, including transit, carpooling, cycling and walking (UBC, 2019). The report also indicates that more research is required to determine the overall benefits of carshare at the university (UBC, 2019). It is not currently known what mode share is being replaced by carshare and how many times do the vehicles that are driven to campus move each day (UBC, 2019).

Strategy 5 by the UBC Board of Governors pertains to sustainable development on campus. It details how the university is to assume a leadership role in sustainable development by practicing and instilling sustainable values in its graduates and employees, through research, teaching, and operations (UBC, 2005). Further, the strategy works to ensure the integration of ecological, economic and social considerations at all levels of strategic planning and operations within the university (UBC, 2005). The purpose of the strategy is to develop an environmentally responsible campus communities that are economically viable and reflects the values of the members of its campus communities (UBC, 2005).

Regional Policies

One of the key policy documents for Metro Vancouver is the regional growth strategy, *Metro Vancouver 2040: Shaping our Future* (Metro 2040). Acknowledging that much of the region exists within a physically constrained land base, Metro 2040's priorities focus on growth management. This includes goals to make efficient use of lands, promote a greater range of transportation choices, and to lessen the region's contribution to air contaminants and emissions (Metro Vancouver, 2010). Metro 2040 also places a high priority on reducing the number of private vehicles used to help mitigate the negative health effects associated with pollution (Metro Vancouver, 2010). This includes the goal of supporting sustainable transportation choices throughout the region (Metro Vancouver, 2010).

Metro Vancouver's *Integrated Air Quality and Greenhouse Gas Management Plan* further recognizes the opportunity carshare provides in offering a low carbon transportation choice in future (Metro Vancouver, 2014a). The plan contains a commitment to work with municipalities and TransLink to develop model bylaws that facilitate low carbon transportation choices, such as carsharing (Metro Vancouver, 2014a).

The Metro Vancouver Carshare Study: Technical Report states that there exists an opportunity in the upcoming five-year review of Metro 2040 to consider elevating the role of carsharing as a sustainable transportation choice (Metro Vancouver, 2014b). If carshare is to be promoted as a growth management tactic, however, Metro Vancouver believes that a better understanding of carsharing is needed (Metro Vancouver, 2014b). The report's authors note that acknowledgement of carshare in any future regional policy would be contingent on providing demonstratable evidence that carshare is helping to address regional interests around land use, transportation, affordability, and the environment (Metro Vancouver, 2014b). If the link between transportation, land use, and housing affordability can be established, carshare would likely be considered for future inclusion in regional policy as a distinctive form of sustainable transportation choice (Metro Vancouver, 2014b).

TransLink's *Regional Transportation Strategy: Strategic Framework* includes a policy supporting carshare and a performance target to reduce driving by one-third (TransLink, 2013). The framework also provides a clear indication of support for carshare by committing TransLink to supporting carsharing initiatives across the region (TransLink, 2013).

Literature Review

Academic research on the topic of carshare has becoming increasingly prevalent in recent years, corresponding to the technology's maturity and rise in popularity. In the context of this study, it is important to consider existing literature as it provides a solid academic foundation to base the recommendations upon. The information gathered for this literature review consists of both academic and grey sources. Relevant research was identified by searching academic databases and government websites, in addition to literature provided by the project stakeholders. The literature has been organized into categories that correspond with the study's objectives, including: the benefits of carshare, the differences between carshare systems, electric vehicles, and parking regulations.

Benefits of Carshare

Several academics have written of the benefits of carshare. Authors have discussed carshare in relation to vehicle emissions, private vehicle ownership, vehicle kilometers travelled, personal finance, and transportation systems. In the regional context, two noteworthy studies have been conducted by Vancity and Metro Vancouver. Vancity commissioned a study to investigate the habits of individuals who choose to utilize carshare, titled *Changing Gears: Exploring the Carsharing Shift in Metro Vancouver*. Metro Vancouver led a technical study on carshares within the region, titled *Metro Vancouver Carshare Study: Technical Report.*

Carshare provides significant potential for emissions reductions when compared to private vehicle ownership. Namazu & Dowlatabadi (2015) developed a model to quantify the impact of carsharing on vehicle emissions, taking into consideration the different types of households and associated trip characteristics. Of the five factors analyzed – being transportation mode change, fleet vintage, vehicle optimization, drive train efficiency, and trip aggregation – the first three factors led to significant reductions in vehicle emissions, with transportation mode change having the highest emission reduction potential (Namazu & Dowlatabadi, 2015). The age of a vehicle also plays a significant role in reducing emissions, with newer vehicles experiencing up to a 20% reduction in emissions when compared to older vehicles (Namazu & Dowlatabadi, 2015). Carshare allows for individuals to select a vehicle size and feature set that are optimized to suit their trip purposes, resulting in emissions reductions of up to 45–55% per household (Namazu & Dowlatabadi, 2015; Vancity, 2018). This phenomenon is known as vehicle right-sizing. By analyzing Modo's fleet in Metro Vancouver, Vancity was able to conclude that newer, right-sized carshare vehicles reduced vehicle emissions by approximately 30% over private vehicles (Vancity, 2018). Finally, shared vehicles have the benefit of having a much higher utilization rate, reducing the environmental impacts of these vehicles over the long term (Namazu et al., 2018).

Membership with a carshare organization is shown to reduce the use of private vehicles by individuals. Research indicates that access to carsharing has led users to relinquish ownership of their personal vehicle, referred to as vehicle shedding in the literature (Millard-Ball, 2005; Namazu & Dowlatabadi, 2015; Vancity, 2018). An average of up to three personal vehicles are shed per carshare vehicle (Metro Vancouver, 2014b). Carsharing also reduces a household's likelihood of purchasing additional vehicles in future (Meijkamp, 1998; Vancity, 2018). When accounting for the avoidance of future private vehicle purchases, each carshare vehicle can remove between 5 and 11 private vehicles from use (Metro Vancouver, 2014b). In a survey conducted by Vancity, 40% of survey respondents indicated that they would have bought or acquired a vehicle had carsharing not been made available to them (Vancity, 2018). In their annual survey, Modo reported similar findings with over 47% of survey respondents stating their carshare membership either encouraged them to shed a vehicle or prevented them from otherwise purchasing a new vehicle (Modo, 2018). Households that dispose of private vehicles are also more likely to consolidate trips and drive less (Vancity, 2018).

Namazu & Dowlatabadi (2018) produced a summary table demonstrating the relative vehicle reduction of global cities after implementing carshare. This summary is reproduced in Table 3. In general, cities where carshare is available report reduced private vehicle ownership (Namazu & Dowlatabadi, 2018).

The effect carshare has upon vehicle kilometers traveled is inconclusive in the literature. Meijkamp (1998) and Firnkorn & Shaheen (2015) both detail a significant reduction in vehicle kilometers travelled resulting from carshare. In contrast, Namazu & Dowlatabadi (2015) conclude that there is no significant reduction in vehicle kilometers traveled because of carshare. In a review of existing literature, Vancity provides a more nuanced conclusion, stating that some, but not all forms of carshare do reduce vehicle kilometers travelled (Vancity, 2018). In their survey of Metro Vancouver households, the regional government noted that the amount of vehicle kilometers travelled either increased or decreased depending on the household's prior access to vehicles. One-half

Table 2. Comparison of household vehicle holdings before and after joining carshare (Metro Vancouver, 2014b).

Before Joining Car Share \ After Joining Car Share	Zero Vehicle Household	1-Vehicle Household	2-Vehicle Household	3 Plus Vehicle Household	Total
Zero Vehicle Household	984	80	1	1	1,066 (38%)
1-Vehicle Household	323	905	15	0	1,243 (45%)
2-Vehicle Household	18	121	242	6	387 (14%)
3 Plus Vehicle Household	0	2	11	71	84 (3%)
Total	1,325 (48%)	1,108 (40%)	269 (10%)	78 (3%)	2,780

Table 3. Summary table of relative vehicle reduction for cities following carshare implementation (Namazu & Dowlatabadi, 2018).

Area/Country	Survey year	Target CS (Round-trip or One-way)	Vehicle ownership reduction	Reference
US (Portland)	Around 1999	Round-trip	Among CS survey respondents, 26% of them sold their personal vehicle, and 53% of them forgone purchasing a car.	(Katzev, 2003)
US (San Francisco)	2002	Round-trip	Among CS members, 29.1% of them reduced car ownership, and 67.5% of them foregone the purchase of a vehicle	(Cervero and Tsai, 2004)
US (Philadelphia)	2003	Round-trip	A carsharing vehicle removed an average of 22.8 cars from the roads (10.8 cars removed by vehicle ownership reduction, and 12.0 cars removed by deferring purchase of a car)	(Lane, 2005)
North America (multiple cities)	2004	Round-trip	About 20% of CS users reduced their private car ownership. One carsharing vehicle replaced five to six privately owned cars.	(Millard-Ball et al., 2005)
US (San Francisco)	2005	Round-trip	Among CS survey respondents, 2% of them reduced multiple cars, and 22% of them reduced a car	(Cervero et al., 2007)
North America (multiple cities)	2008	Round-trip	The average vehicle ownership reduced from 0.47 vehicle/household to 0.24 vehicle/household. A carsharing vehicle removed four to six private vehicles from the road.	(Martin et al., 2010)
Canada (Toronto)	2009	Round-trip	29% of CS users gave up a vehicle after becoming a CS member. 55% of CS users forgone purchasing a car as a result of CS participation.	(Engel-Yan and Passmore, 2013)
Europe	Around 2009	Round-trip	CS users who got rid of cars: Belgium: 15.7%, Switzerland: 31.6%, Germany: 16%. CS users who decided against a planned vehicle purchase: Belgium: 35%, Germany: 33%	(Loose, 2010)
US (Ithaca)	2011	Round-trip	A carsharing vehicle reduced roughly 15.3 personal vehicles.	(Stasko et al., 2013)
France (Paris)	2013	One-way (station-based) & Round-trip	23% reduction in the number of private vehicles owned by one-way (station-based) users after their subscription while 67% reduction in the number of private vehicles owned by round-trip users after their subscription.	(6t-bereau de recherché, 2014)
UK (England&Wales excl. London)	2014–15	Round-trip	One carsharing vehicle removed 4 private cars from the road, and differed the purchase of over 9 cars	(Steer Davies Gleave, 2015a)
UK (London)	2014–15	Round-trip	One carsharing vehicle removed 8.6 private cars from the road, and deferred the purchase of 19.8 cars	(Steer Davies Gleave, 2015b)
UK (Scotland)	2014–15	Round-trip	One carsharing vehicle removed 3.5 private cars from the road, and deferred the purchase of 9.3 cars	(Steer Davies Gleave, 2015c)
Canada (Montreal)	2014	Round-trip	Regression models results show that the number of shared vehicles in 500 m radius is negatively correlated with car ownership.	(Klincevicius et al., 2014)
North America (multiple cities)	2014–15	One-way (free-floating)	One carsharing vehicle removed 1– 3 private cars from the road, and deferred the purchase of 4–9 cars.	(Martin and Shaheen, 2016)

of carshare households with no vehicles prior to joining carshare reported driving more after joining a service (Metro Vancouver, 2014b). In contrast, one-third of carshare households with vehicles prior to joining a carshare program reported reductions in driving after joining (Metro Vancouver, 2014b). Over two-thirds of carshare households that shed one or more vehicles also reduced their vehicle kilometers travelled (Metro Vancouver, 2014b).

Financial benefits can result from carshare. Carshare provides direct affordability benefits to member households that may also provide residual benefit to neighbouring households. The first set of affordability benefits are achieved when personal vehicles are shed and payments for fixed costs – including vehicle purchase, insurance, depreciation, and financing expenses – and variable costs – including gasoline and maintenance costs – are eliminated (Metro Vancouver, 2014b). The second set of affordability benefits result from cost savings to the developer. This occurs when municipal parking regulations allow a developer to not build the full complement of residential parking stalls that would otherwise be required in exchange for dedicated carshare space (Metro Vancouver, 2014b). It should be noted that this benefit is only achieved if the cost savings are passed on from the developer to the consumer in the form of purchase or rent reductions, or to the municipalities for reinvestment in expanded mobility options or housing affordability initiatives (Metro Vancouver, 2014b).

Carshare works to supplement and benefit existing transportation systems. Carsharing can strengthen multi-modal travel by providing a more sustainable transportation choice to private vehicles (Vancity, 2018). It is also often used to supplement other services, such as walking or public transit (Modo, 2018). Carsharing results in an increased parking efficiency, as carshare vehicles leave parking spots quicker than private vehicles and thus reduces the overall demand for parking space (Vancity, 2018).

Difference Between Carshare Systems

It is important to distinguish between one-way and two-way carshare systems as each option is best suited for a particular purpose. This section will highlight differences in technical aspects, demographics, member rationale, travel patterns and vehicle shedding.

The technical differences between carshare systems are easily identifiable. One-way carshare systems allow individuals to pick up and drop off vehicles at different locations within a designated area. Operators of one-way carshare in Metro Vancouver include car2go and Evo. Two-way carshare systems require individuals to both pick up and drop off their vehicle at the same location. Operators of two-way carshare in Metro Vancouver include Modo and Zipcar. Table 4 provides further detail about the technical aspects of both carshare systems.

The two forms of carshare differ in terms of key demographics, including age and household finances. In general, one-way carshare is preferred by younger individuals while older individuals prefer to use either two-way carshare exclusively or both systems (Vancity, 2018). Two-way member households report a higher level of affordability overall compared to one-way member households (Lempert et al., 2019).

An individual's rationale for using a carshare service varies considerably between the two systems. In a survey of over four-thousand carshare members, Lempert et al. (2019) note two important findings. First, one-way members emphasized the added convenience provided by carshare and are much more likely to see carsharing as a replacement for taxi or ride-hailing services (Lempert et al., 2019). Second, two-way members view carsharing as a way to live efficiently, save money, be more sustainable and reduce their dependence on car ownership (Lempert et al., 2019). This point is further exemplified by Vancity's findings, with one-way members expressing interest in the convenience of carshare and two-way members preference for carshare.

Further to the point of a member's rationale are the distinct differences in trip purposes between the two groups. The top reasons for a one-way member to use carshare include: restaurant/bar, shopping, visiting friends and family, to and from work, and recreation (Metro Vancouver, 2014b). This contrasts with the top reasons for a two-way member to use carshare, being: shopping, recreation, visiting

friends and family, vacation and medical (Metro Vancouver, 2014b).

The travel patterns between members of the two carshare systems differ considerably. One-way members take three times as many trips by private vehicle and twice as many trips by carshare vehicle compared to two-way members (Lempert et al., 2019). These trends are consistent across multiple dimensions, including age, gender, income, and geography (Lempert et al., 2019). One-way members are more likely to use carshare as an additional mode of transportation while two-way carshare members are more likely to use walking and biking to supplement carshare (Lempert et al., 2019; Vancity, 2018).

Another important difference between the two forms of carshare is in regard to vehicle shedding. In their analysis of 3,405 carshare members in Vancouver, Namazu & Dowlatabadi (2018) found that users of both car2go and Modo reported reduced vehicle ownership after joining a carsharing service but differ in the number of vehicles they owned prior to joining and how many vehicles they shed afterwards. Households that joined car2go reported average car ownership rates of 1.08 prior to joining and 0.98 afterwards (Namazu & Dowlatabadi, 2018). In comparison, households that joined Modo reduced their ownership levels from an average of 0.68 to 0.36 vehicles (Namazu & Dowlatabadi, 2018). Modo members were also five times more likely to reduce car ownership when compared to car2go users (Namazu & Dowlatabadi, 2018).

In understanding the differences between carshare systems, jurisdictions can look to leverage carshare policy to target specific demographics and households (Lempert et al., 2019). Overall, two-way carsharing provides a better substitute for private car ownership while one-way carsharing is best suited to supplement other modes of transportation (Lempert et al., 2019). Neighbourhood characteristics can be extrapolated to better inform future carshare policy and enhance the recruitment of either one-way or two-way carshare members (Lempert et al., 2019).

Table 4. One-way and two-way carshare compared against six different metrics (Modo, 2018).

	2-Way *aka* Station-based	1-Way *aka* Free-floating
Usage	Pick-up and drop-off from the same location	Pick-up and drop-off anywhere in permitted zone
Booking	15 minute blocks – weeks in advance	Limited to 30 minutes in advance
Payment	By time and distance	By minute increments
Operating costs	User fees	User fees
Capital costs	Mostly from membership dues	Mostly from holding corporation
Established	1970s	2000s

Electric Vehicles

There are several different forms of electric vehicles currently available on the market. For this study, the two primary types of electric vehicle were considered: battery electric vehicles and plug-in hybrids. Battery electric vehicles are powered entirely by electricity from an internal battery, are charged by an external source – either a household electrical outlet or a charging station – and utilize an electric motor for the vehicle's movement and onboard electronics (Plug in BC, n.d.). Plug-in hybrid electric vehicles use a combination of an internal combustion engine and an electric motor to propel the vehicle forward (Plug in BC, n.d.). These vehicles differ from battery electric vehicles by having a smaller battery, are recharged from a standard electrical outlet, and can remain functional in the event of full battery depletion using the internal combustion engine (Plug in BC, n.d.).

Academic studies have demonstrated the potential for emissions reductions resulting from electric vehicles. Kukreja (2018) discussed the lower emissions and energy consumption per kilometer of electric vehicles in comparison to an equivalent internal combustion engine vehicle. When a life cycle assessment of electric and internal combustion engine vehicles was analyzed, the subsequent analysis revealed that electric vehicles have a markedly lower environmental impacts in terms of energy use and vehicle emissions, especially in regions with clean power sources (Kukreja, 2018). The results remain consistent even when the higher environmental burden of raw material production and decommissioning electric vehicles is taken into account (Kukreja, 2018).

Currently, Modo has five electric vehicles in its fleet, three of which reside in Vancouver (Modo, 2018). Four of these vehicles are battery electric vehicles and one is a plug-in hybrid vehicle.

Parking Regulations

Public policies that support carshare are critical to its expansion and success, especially those pertaining to parking regulations. Abbott (2015) examined the parking regulations used to reduce automobile dependence and promote carsharing in several municipalities. In the majority of North American cities, land allocated for the storage and movement of vehicles occupies the largest percentage of city space for any single purpose (Abbott, 2015). As much of this land is dedicated to the storage of private vehicles, the space is rarely utilized to its full potential (Abbott, 2015). Excess parking has the further disadvantages of encouraging individuals to drive to their destinations and influencing the built environment's design to promote private vehicle usage (Abbott, 2015). Ultimately, these land use decisions work to dissuade individuals from using other forms of transportation by making walking, cycling, and public transportation less accessible. In these environments, the right of way is primarily focused upon vehicular flow rather than other considerations such as pedestrian safety and modal connectivity.

An overabundance in parking supply also creates financial burdens on developers and the community through direct construction costs, lost opportunity costs, impacts on regional housing affordability, and negative health implications (Abbott, 2015). The cost of constructing on-site parking in Metro Vancouver can range from $20,000 to $45,000 per stall, not including annualized maintenance and operation costs (Abbott, 2015). These high costs can be further exacerbated in municipalities where parking is required to be built underground and the price of land is at a premium, as is the case in many Metro Vancouver municipalities.

Carsharing is unlikely to succeed without supportive local governments. In municipalities where restrictive parking regulations have been enforced, carsharing has been slow to develop (Vancity, 2018). The City of Vancouver has encouraged carsharing in new developments through several building policies, including reducing the number of required parking stalls for new developments if a carsharing service is incorporated into the building's design (Vancity, 2018). Carsharing tends to do best in communities where all residents have access to carshare vehicles and not just residents of a particular building (Vancity, 2018).

In Metro Vancouver, parking in strata properties has a vacancy rate ranging from 20-40% (Abbott, 2015). Provided this, Metro Vancouver recommends using carshare as a tool for negotiating variances to parking supply and to unbundle the cost of parking from the purchase price or rental price of an apartment unit (Metro Vancouver, 2014b). This arrangement also establishes early and potentially sustained demand for carshare and improves the financial viability for operators (Metro Vancouver, 2014b). Tenants who choose to purchase or rent a unit without an assigned parking stall are more likely to use carshare and transit (Metro Vancouver, 2014b).

Lempert (2018b) spoke of several emerging best practices regarding municipal parking regulations that can be used to promote carshare. This includes five goals for municipal carshare policy:

1. Equitably facilitate access to carshare services for all residents.
2. Allow ease of parking for carshare members to facilitate the use of carsharing.
3. Treat carshare operators equitably while acknowledging the differences between one-way and two-way carshare services.
4. Effectively manage low turn-over and clustering of carshare vehicles in congested parking areas.
5. Allow portions of existing or new parking spaces to be dedicated to carshare parking in commercial and residential areas (Lempert, 2018b).

To achieve these five goals, Lempert proposed five solutions for successful carshare policy. These parking regulation best practices are as follows:

1. Allow carshare vehicles to end trips at parking meters. To account for the loss in revenue to the City, carshare operators should pay for the time associated with metered parking. This information can be tracked and gathered through the use of the carshare operator's booking application. Some municipalities may also consider subsidizing metered carshare parking.
2. Charge an annual fee that enables carshare vehicles to park in residential parking zones. With the introduction of carshare vehicles to a neighborhood, some residents may choose to dispose of their private vehicles, which in turn will open up additional neighborhood parking spots.
3. Allow carshare operators to apply for designated on-street parking spaces through a tiered geographic payment system, with higher density zones requiring higher annual fees. This incentivizes carshare operators to place vehicles in areas less likely served by public transportation. As one-way and two-way carshare serve different purposes, each should be treated differently when applying for designated spaces.
4. Clustering of one-way vehicles should be managed either on an ad hoc basis or through enforcement averaged on a weekly or monthly time frame.
5. Work with carshare operators toward creating equitable carshare policy that allows underserved or low-income community members access to carshare (Lempert, 2018b).

Data Analysis

To gain a better sense of the transportation preferences of residents living within the NHAs, a survey was developed by the project stakeholders and disseminated to the public. Officially titled the *UNA Carshare Survey*, the survey was active between March 1 and March 31. The survey consisted of 26 questions and focused upon population demographics, existing transportation habits, and knowledge and use of carshare. To conduct the survey, UBC's survey tool Qualtrics was employed. Qualtrics is a top-tier survey platform that offers a wide range of features and complies with the *BC Freedom of Information and Protection of Privacy Act*.

Promotion for the survey was jointly administered by The University Neighbourhoods Association and Modo through their official media channels. This included distribution through email, community newsletters, physical media and by word of mouth. Individuals could access the survey either by clicking on a weblink or scanning a QR code.

The survey targeted residents living within the NHAs. Postal codes were used to identify residents living at the university. Individuals were encouraged to respond to the survey via a prize draw that included five gift cards provided by the project stakeholders. In total, the survey received 270 unique responses. Of those responses, 203 surveys were completed in full, 33 were partially completed, and 34 provided no response. This amounts to a response rate of 2.26% of residents living within the NHAs, being 236 respondents of 8,850 residents.

The introduction to the survey begins as follows.

"Carsharing has become an increasingly popular mode of transportation for travel to and from campus. As such, Campus + Community Planning, The University Neighbourhoods Association, UBC Properties Trust and Modo are interested in studying the travel habits of residents living in the university neighbourhoods, with emphasis placed on residents' use of carshare vehicles. The results of this survey will be used to inform future parking and carshare decisions on campus.

The survey consists of twenty-five questions and should take at most 10 minutes to complete. All individuals who complete the survey will be entered to win one of five $50 gift certificates."

Based upon the survey responses, the following inferences can be made about survey respondents. The responses have been grouped into three categories: general demographics, transportation preferences, and carshare knowledge and preferences.

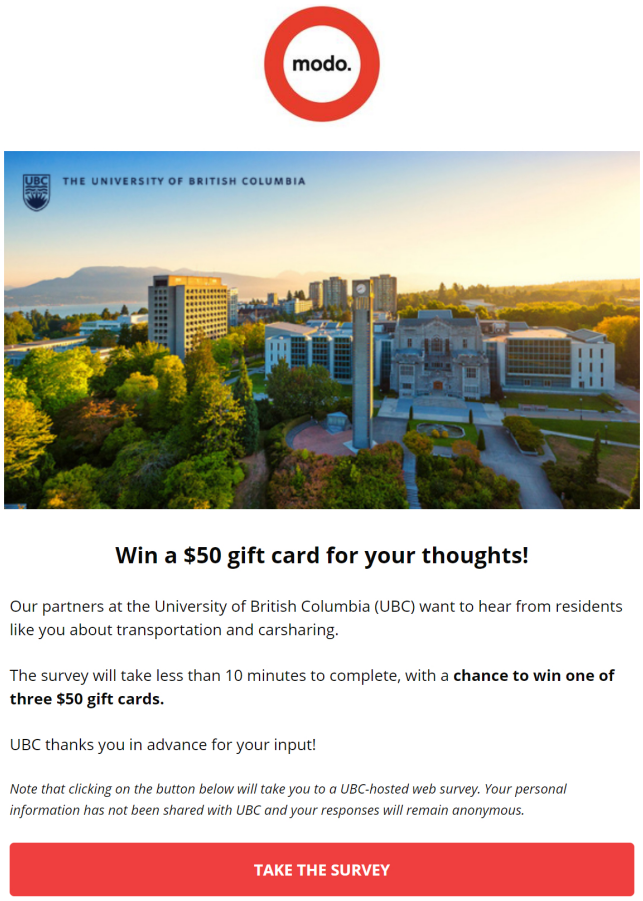

Figure 4. Email notice delivered to Modo members.

Figure 5. Postcard used to market the survey by UNA.

General Demographics

This section will detail the general demographics of survey respondents living within the NHAs, including personal and household characteristics.

The majority of survey respondents were between the ages of 31 and 50 years old, with 29.61% of respondents between the ages of 31 and 40 and 27.90% of respondents between the ages of 41 and 50. While middle-aged individuals were the largest response group, both young adults and the elderly were also represented, corresponding to 16.31% and 14.61% respectively of all respondents.

On average, households consist of 2.02 children, 2.8 adults, and 1.67 seniors. Of 230 survey respondents, a total of 135 residents indicated that they live with two adults in their home.

The majority of survey respondents indicated a household wealth of $150,000 or more, with 31.22% of residents indicating this. The second and third most popular categories were $100,000 to $149,999 and $75,000 to $99,999, with each receiving 19.46% and 17.65% of the responses respectively. The mean household wealth for respondents is $80,500.

Of 240 responses, 65.41% of survey respondents indicated having some form of affiliation with UBC either as a faculty member, staff, or student. The percentage for each group is near-even, being 23.75%, 22.08% and 19.58% respectively. 34.58% of residents specified no affiliation with UBC.

78.97% of survey respondents indicated they live in one of the NHAs for more than six months per year. Six months was chosen as a proxy indicator for whether a household is considered to be a permeant residence.

The majority of survey respondents are renting as opposed to owning their residence, accounting for 62.07% and 37.93% of residents respectively.

Survey respondents were most likely to live within Wesbrook Village and Hawthorn Place, accounting for a total of 40.00% and 39.49% of respondents.

In summary, the average survey respondent is:

- between 31 and 50 years of age;
- lives with 2 to 3 adults, 2 children, and 1 to 2 seniors at home;
- earns a cumulative household salary of $100,000 or more;
- has some form of professional affiliation with UBC;
- considers their household to be their permeant residence;
- is renting; and
- live either at Wesbrook Village or Hawthorn Place.

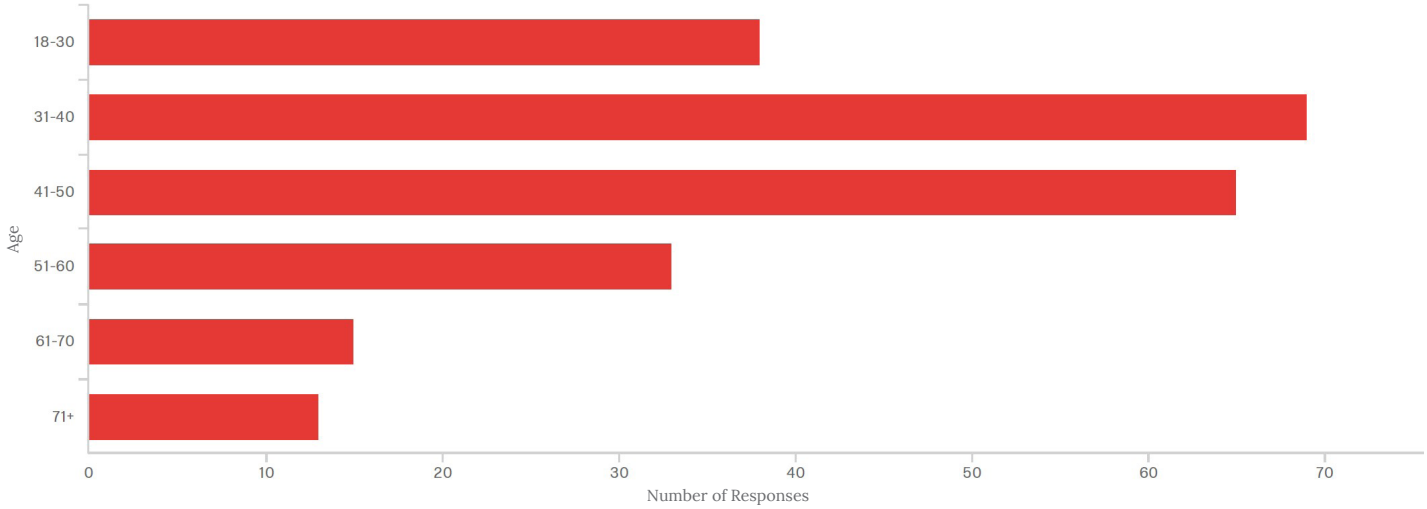

Figure 6. Age breakup of survey respondents. Total number of responses is 233.

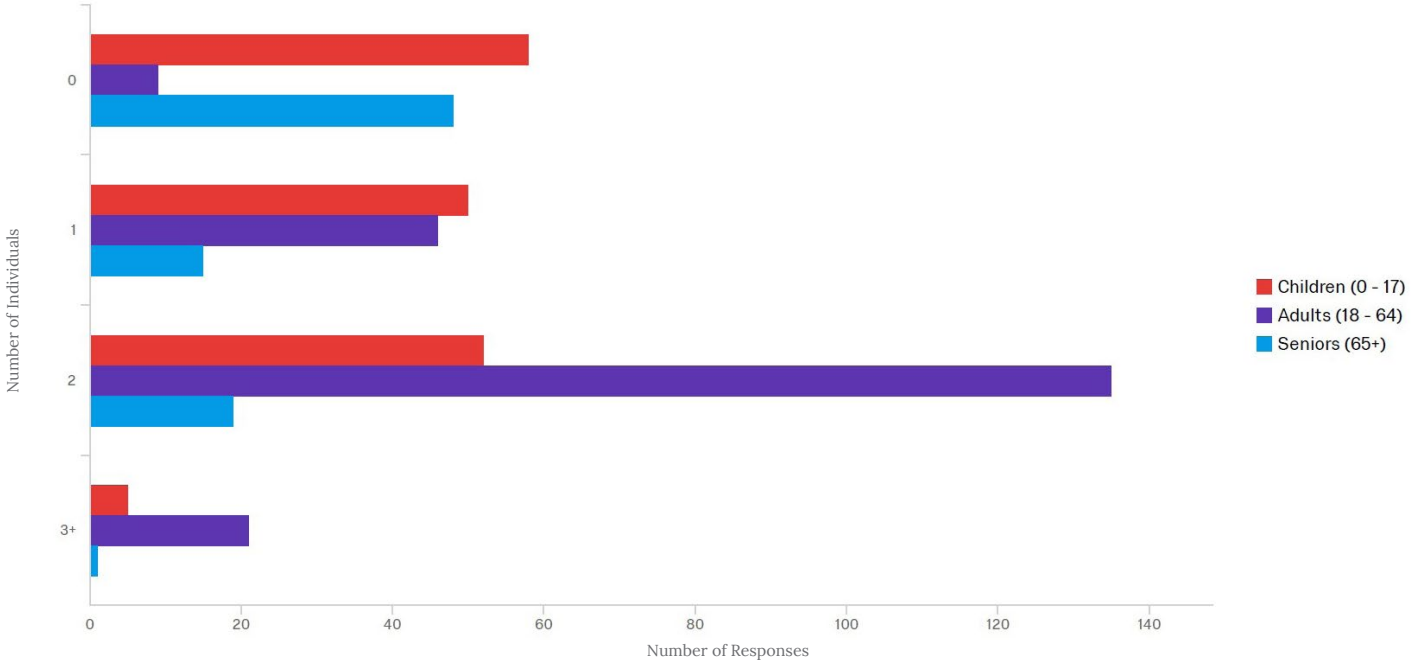

Figure 7. Household composition of survey respondents. Total number of responses is 236.

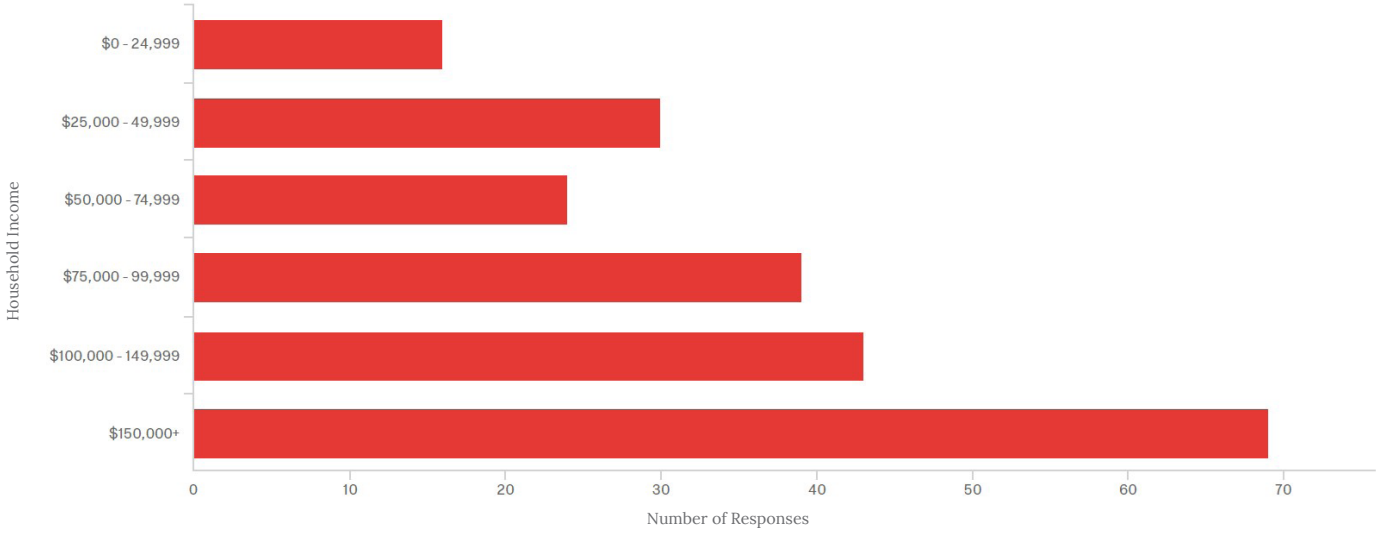

Figure 8. Household cumulative salary of survey respondents. Total number of responses is 221.

Transportation Preferences

This section will detail the transportation preferences of survey respondents living within the NHAs, including vehicle holdings, parking allocation, and travel habits.

The majority of survey respondents indicate no vehicle holdings at their place of residence, with 48.20% of residents indicating this. Of the 115 respondents that do own a vehicle, 90 individuals said they own one vehicle and 24 individuals said they own two vehicles. The household average is 0.64 vehicles.

75.23% survey respondents have access to some form of underground parking at their residence, with 24.77% of residents indicating no access.

Of the survey respondents who answered yes to having access to underground parking, the majority indicated owning or renting a parking stall at their residence, totalling 115 residents or 71.43%.

When residents choose to leave UBC, they have several options for where to travel. The most popular destination is Vancouver's Westside - including Dunbar, Kitsilano, and Point Grey – with an average of 2.95 trips per week. The second and third most popular locations are Downtown Vancouver and East Vancouver/Burnaby, with an average of 1.26 and 0.67 trips per week respectively. One survey respondent's answer was removed from the dataset as the values were well-beyond what was to be expected from a normally distributed population. This was confirmed using Grubbs' Test for Outliers. Several other respondents indicated higher then expected trip numbers to locations, including 14 respondents travelling to Vancouver's Westside more than 10 times per week and 5 respondents for Downtown Vancouver, but their responses were ultimately left within the results. The 'Other' category included two people travelling once per week to Mount Baker and Whistler.

The vast majority of survey respondents indicated that they would not pay more than the current price of $120 per year for on-street parking, totaling 74.30%. 16.20% of residents indicated they would be willing to pay up to $200 for on-street parking. The average willingness to pay for all respondents was calculated to be $156.

The most common method of getting around for survey respondents is by private vehicle with a 30.76% mode share. Walking and biking are a close second with 29.92% mode share, followed by public transit at 23.34% mode share, and finally carshare at 15.75% mode share.

In summary, the average survey respondent has the following transportation preferences:

- does not own a vehicle at their residence;
- has access to some form of underground parking;
- owns or rents a parking stall;
- travels to Vancouver's Westside, Downtown Vancouver, and East Vancouver/Burnaby;
- would not pay more than $120 for an on-street parking permit; and
- uses a private vehicle for travel.

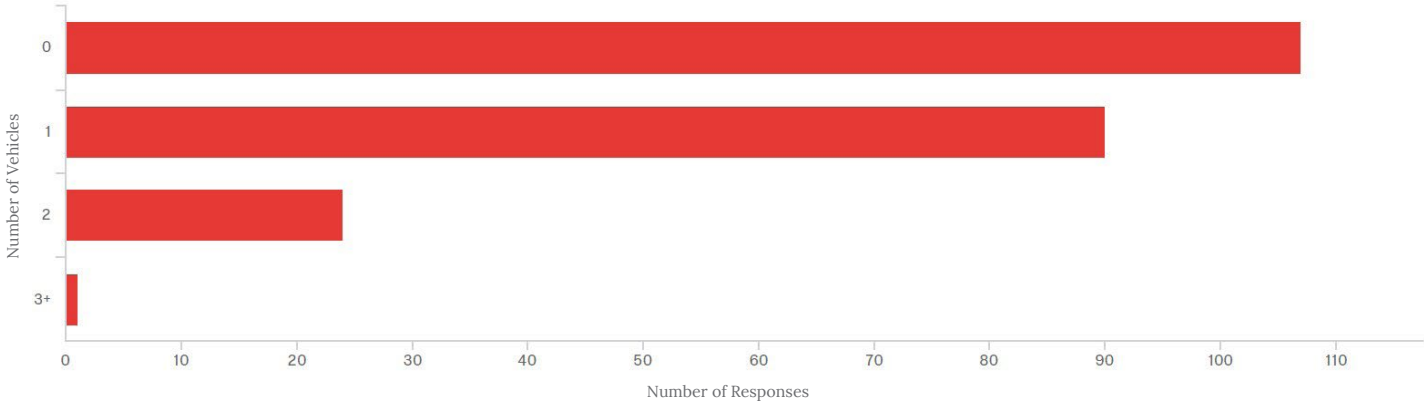

Figure 9. Number of vehicles owned in the UNA by survey respondents. Total number of responses is 222.

#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Downtown Vancouver	0.00	17.00	1.26	2.22	4.94	205
2	Vancouver's Westside (Dunbar, Kitsilano, Point Grey, etc.)	0.00	16.00	2.95	3.06	9.37	204
3	East Vancouver / Burnaby	0.00	8.00	0.67	1.37	1.89	205
4	Richmond	0.00	10.00	0.60	1.38	1.89	205
5	The North Shore	0.00	5.00	0.21	0.66	0.43	205
6	South of the Fraser (Surrey, Delta, Langley, etc.)	0.00	2.00	0.09	0.32	0.10	205
7	Northeast Sector (Coquitlam, Port Moody, etc.)	0.00	2.00	0.06	0.28	0.08	205
8	Other	0.00	20.00	0.23	1.53	2.35	203

Figure 10. Destination preferences of survey respondents when traveling from UBC. Total number of responses is 206. Note: Respondents could select more than one option.

Carshare Knowledge and Preferences

This section will detail the knowledge and preferences of survey respondents living within the NHAs regarding carshare, including usage, travel patterns, and rationale.

50.00% of all survey respondents felt extremely familiar with their knowledge of carshare, followed by 25.98% being very familiar and 13.78% being moderately familiar. The number of residents that are somewhat familiar or not familiar with carshare are 7.84% and 2.45% respectively.

The majority of survey respondents are carshare members: 89.30% of residents indicate membership with at least one carshare operator. The most popular one-way carshare operator was Evo with 30.14% of total memberships followed by car2go with 27.61%. The most popular two-way carshare operator is Modo with 29.01% of total memberships followed by Zipcar with 2.54%. The majority of respondents had two or more carshare memberships, with the most popular combination being car2go/Evo/Modo with 19.00% of total respondents followed by car2go/Evo with 16.50%. Modo had the greatest number of exclusive members in comparison to other carshare operators with 16.00% of total respondents. 10.70% of residents indicated that they do not have a carshare membership.

Of the survey respondents who indicated having no carshare memberships, the main barriers preventing them from utilizing carshare include already owning a vehicle at 52.73% and carshare not matching their needs at 30.91%. The other three factors were found to have negligible impacts on a resident's decision to use carshare, including 7.27% for a lack of familiarity, 7.27% for cost of using carshare, and 1.82% for cost of membership. Survey respondents who answered this question were immediately brought to the end of the survey to avoid recording invalid responses.

27.88% of survey respondents indicated they use carshare primarily once per week. Equal numbers of residents indicated using carshare 2-3 times per week and once per month, both being 21.21%. 18.79% of residents indicated rarely or never using their carshare membership while 10.91% used carshare either daily or 4-6 times per week.

Examining survey respondents' financial situation, 35.80% of residents could comfortably afford to buy and run a vehicle (or another) but choose to use carshare instead. 26.54% of respondents indicate they already own a vehicle but choose to use carshare for convenience at 26.54%. 18.52% of respondents indicated that they would like to own a vehicle (or another) and could just about afford one but would rather use their money elsewhere. 11.11% of respondents indicated being unable to afford a vehicle (or another), but even when provided the option, would still prefer to use carshare. Finally, 8.02% of respondents indicated a preference to purchasing a vehicle (or another) but currently cannot afford one.

When survey respondents utilize carshare, they are doing so for several purposes. The most common reason is to run errands at 38.95% of residents, followed by for pleasure at 26.12%, commuting to and from school at 14.90%, and travel at 9.42%.

When asked if the survey respondent's household had shed a private vehicle because of carsharing, most residents indicated no with 64.63%. Of 164 individuals, 35.37% indicated they had shed a vehicle because of carshare.

For those that indicated they had shed a vehicle, they were asked if the availability of carshare services on campus had influenced their decision to do so: 85.96% of survey respondents indicated that carshare had influenced their decision.

An additional follow up question asked if the respondent would buy a vehicle if carsharing where no longer available on campus: 66.67% of respondents indicated they would purchase another vehicle if carshare were removed.

In a ranking of six factors relating to carshare, respondents indicated the most important factor to be convenience. This is followed by the financial savings compared to owning a vehicle, environmental considerations, for 'just in case' scenarios, the unavailability of ride-hailing services, and that carshare is safer than transit.

Asked whether carshare benefits survey respondents in eight functions, the ability to get stuff done was the most prominent response, which had a response between mostly and sometimes. This is followed by the ability to go more places in the city, which had a response of sometimes. The other six factors – being the ability to go more places outside the city, ability to not own a personal vehicle, expanding options for travel, ease of meeting up with family and friends, peace of mind, and sense of personal freedom – are negligible in their effect as the responses varied between sometimes and rarely.

A strong majority of survey respondents at 92.51% indicated an interest in accessing electric vehicles if they were made available through carshare.

In summary, the average survey respondent has the following knowledge of and preferences towards carshare:

- is very comfortable with their knowledge of carshare;
- is a carshare member;
- uses carshare either once per week, 2-3 times per week, or once per month;
- can afford to buy and run a vehicle (or another) but chooses to use carshare instead;
- uses carshare to run errands and for pleasure;
- did not shed a private vehicle as a result of carshare;
- considers convenience to be the most important factor in using carshare;
- enjoys the ability to get stuff done with carshare; and
- is interested in using electric carshare vehicles.

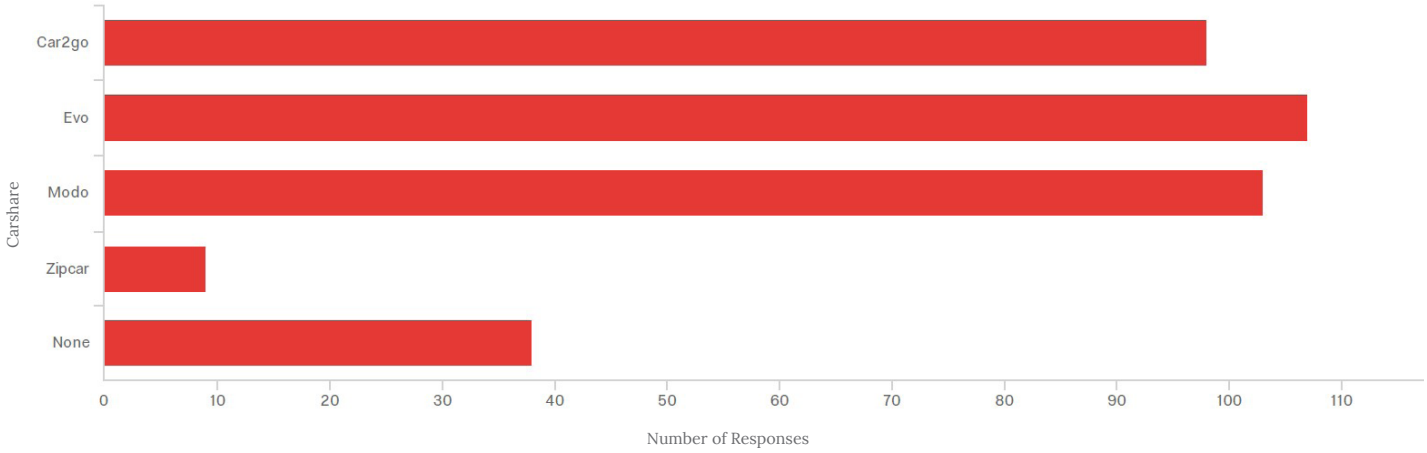

Figure 11. Carshare memberships of survey respondents. Total number of responses is 200. Note: Respondents could select more than one option.

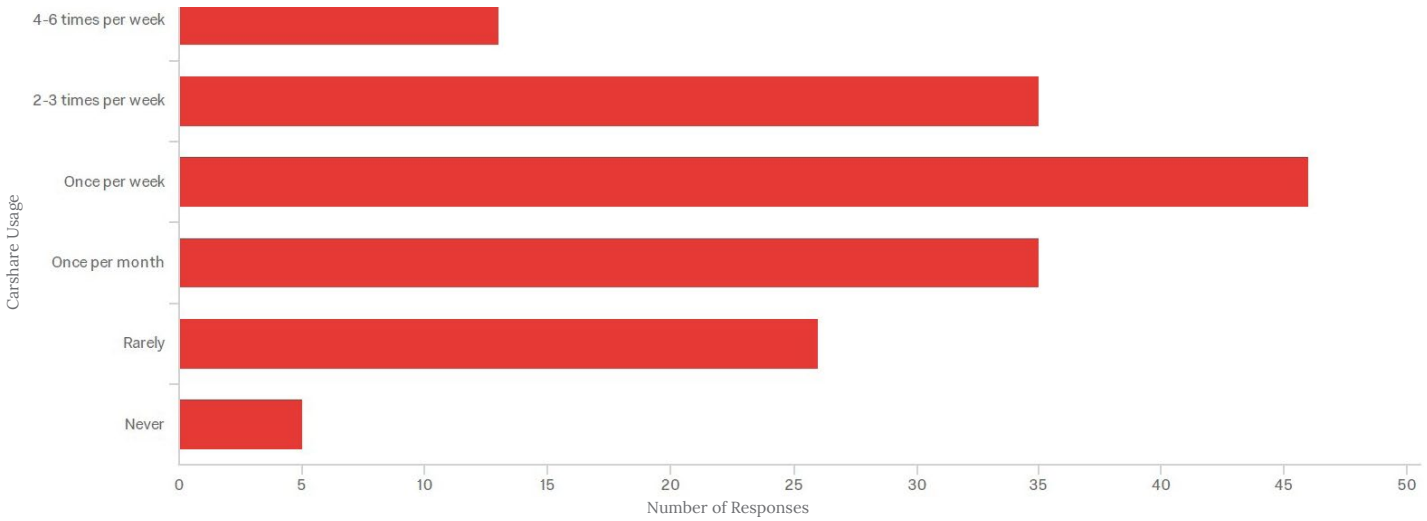

Figure 12. Frequency of survey respondents using carshare. Total number of responses is 164.

Discussion

As a reminder, the purpose of this study was to understand the contribution of community carshare to transportation sustainability on campus in support of an update to the REAP community carshare credit. Having reviewed the existing literature and analyzed the survey data, several important findings become apparent. These insights have been organized according to the themes first identified within the scoping interviews.

Affordability

The project stakeholders identified within the The project stakeholders identified within the scoping interviews a focus of increasing affordability for residents on campus through transportation cost savings resulting from carshare and electric vehicles. The literature supports the notion that carshare does provide affordability benefits to individuals. Carshare provides two primary benefits to members: it reduces fixed and variable costs when compared to private vehicle ownership and it provides potential cost savings to homeowners if passed on by the developers (Metro Vancouver, 2014b).

In general, two-way carshare members reported a higher level of overall affordability compared to one-way carshare members (Lempert et al., 2019). While two-way carshare exhibits affordability benefits, there are equity concerns surrounding the current two-way carshare model as high membership costs can limit access to the service for the lowest income categories (Lempert et al., 2019). To alleviate this issue, Namazu et al. (2018) recommends waiving membership fees for the lowest income categories of non-vehicle owners. This recommendation is in line with solutions provided by Lempert (2018b), who recommends working with carshare operators to create equitable carshare policy that allows underserved or low-income community members access to carshare.

Recommendation: Partner with carshare operators and developers to finance carshare memberships through the community carshare credit that target low-income categories.

The scoping interviews also brought forward an interest in decoupling parking from the cost of renting or owning a home on campus as a means of disincentivizing private vehicle ownership and increasing affordability. The literature demonstrated that an overabundance in parking supply creates financial burdens on developers and the community through direct construction costs, lost opportunity costs, impacts on regional housing affordability, and negative health implications (Abbott, 2015). The high cost of constructing on-site parking in the university further inflates the cost of home ownership and renting within the NHAs. Developers that offer carshare as an alternative to private vehicle usage should be granted leniency on the number of on-site parking stalls required for development.

Recommendation: Permit developers to provide dedicated carshare parking stalls in exchange for reduced on-site parking requirements.

Looking to the survey data, it becomes clear that there is a wide-variety of income categories living within the NHAs. While the household average is calculated to be $80,500 per year, there is a considerable discrepancy between those living in the top and bottom brackets. Affordability may not be of great concern for the 68.34% of survey respondents that earn above $75,000 per year, but for the 31.66% of individuals who earn below $75,000 per year they may well struggle to afford living expenses such as a private vehicle. These individuals would be well-suited to carshare provided its affordability benefits, especially those in the lowest income brackets. This includes the 13.57% of survey respondents that earn $25,000 to $49,999 per year and the 7.24% of residents that earn below $25,000 per year.

While an individual's financial situation is an important part of why they decide to join carshare, there are several other factors that contribute to this decision. 35.80% of survey respondents who can afford to buy and run a vehicle instead choose to use carshare. This is in addition to the 26.54% of individuals who already own a vehicle but choose to use carshare for the added convenience. This is an important consideration when looking to promote carshare in future amongst higher-income categories as these households will not be as readily influenced by the affordability of carshare. These groups will instead be motivated by different rationales if they are to join carshare, such as the added convenience over private vehicles or for environmental purposes.

For the remainder of survey respondents, personal finances played an important role in choosing to use carshare. This includes the 18.52% of respondents who would rather spend their money elsewhere then on a private vehicle, the 11.11% who are unable to afford a vehicle and prefer carshare, and the 8.02% of residents who would like to purchase a vehicle but currently cannot afford one. For this 37.65% of residents, the affordability aspect of carshare is significant and should be emphasized in future promotion.

Community Impact

The project stakeholders were interested in studying the impact of carshare on the residences, with emphasis placed upon understanding the carshare usage patterns amongst residents. Research suggests it may be difficult to extrapolate the behaviour and transportation choices of future carshare households without first understanding the role that personal beliefs and household circumstances play in travel behaviour (Metro Vancouver, 2014b). Transportation-related decisions are complex and often influenced by a number of interrelated factors. Provided this, a better understanding of these factors is necessitated prior to making any future strategic policy decisions around carshare (Metro Vancouver, 2014b).

The survey provides important demographic and behavioural informational of residents living within the NHA. This data also allows for a generalized profile of NHA residents to be constructed. The average resident living within the NHA: is between the ages of 31 and 50 years old; lives in a household with 2.02 children, 2.8 adults, and 1.67 seniors; is likely affiliated with UBC; rents their residence; does not own a vehicle; and considers their home within the NHAs as their permanent residence. When a resident utilizes carshare, they are doing so to run errands, for pleasure, and for commuting to and from school in Vancouver's Westside, Downtown Vancouver, and East Vancouver/Burnaby. Residents indicate that the most important factor of carshare is convenience followed by the financial savings and environmental considerations. The barriers preventing residents from using carshare include already owning a vehicle and that carshare does not match their current needs.

Neighbourhood characteristics can be extrapolated to inform carshare policy and enhance the recruitment of carshare members (Lempert et al., 2019). Having established a basic profile of the average resident, an understanding of community preferences becomes evident. Looking to the two carshare systems available, two-way carshare is best suited to the preferences of residents provided its technical characteristics, including the ability to book in advance and its permeance within a community. The literature supports this finding as two-way carshare is deemed a more suitable alternative to private car ownership in comparison to one-way carsharing, which is best suited to supplement other modes of transportation. Additional benefits of two-way carshare include reducing traffic congestion, alleviating parking constraints, and lessening the spillover of one-way carshare into on-street parking.

Recommendation: Continue to utilize the community carshare credit funding for two-way carshare only.

Parking

Initial stakeholder interviews identified parking as a significant concern amongst residents living within the NHAs. While The University Neighbourhoods Association does have sole authority over on-street parking management within the NHAs, they do not currently have the authority to ticket improperly parked vehicles. This issue is resolved through the immediate towing of vehicles at the owner's expense. While this stopgap measure has been effective in curtailing improperly parked vehicles in past, neighbourhoods are beginning to see an inundation of one-way carshare vehicles improperly parking within the NHAs. This has resulted in a spillover of one-way carshare vehicles occupying an increasing number of residential parking spots, thus limiting access to parking for residents.

Parking availability and pricing is one of the biggest influences on driving mode share to and from the university (UBC, 2014b). UBC has a relatively constrained parking supply that will be further exacerbated with the conversion of surface parking lots to new academic and housing facilities in the near future (UBC, 2014b). As a result, mitigation techniques – such as parking pricing and the promotion of carshare – have been employed to influence parking demand to varying degrees of success (UBC, 2014b).

The literature spoke to the importance of supportive parking regulations as being critical to the expansion and success of carshare. In municipalities where restrictive parking regulations have been enforced, carsharing has been slow to develop (Vancity, 2018). Looking to The Transportation Plan, several policies and actions have been identified that favour carshare, including:

- D2.1 – Use parking costs and measures to support reduced single occupancy vehicle usage.
    - ◊ D2.1.5 – Continue to reduce the amount of commuter parking.
    - ◊ D2.1.6 – Discontinue the use of surface parking lots over time by converting them to future academic building sites or other interim uses, such as recreational areas. The loss of approximately 500 surface stalls can be accommodated by existing parkades.

- ◊ D2.1.8 – Discourage off campus, on-street parking in adjacent university neighbourhoods by collaborating with partner organizations and sharing information online and through social media channels.

- ◊ D2.1.9 – Collaborate with The University Neighbourhoods Association to harmonize campus parking regulations and reduce incentives to drive.

While these policies and actions have been somewhat successful, they have proven to be also insufficient in alleviating the strain placed upon residential parking from one-way carshare. Two-way carsharing can help to alleviate this problem while also reducing the number of private vehicles and need for additional parking, but only if implemented properly. Referring to the literature, Lempert's (2018b) parking regulation best practices would be well-suited for use in promoting two-way carshare within the NHAs, including:

1. Allow carshare vehicles to end trips at parking meters. To account for the loss in revenue to the City, carshare operators should pay for the time associated with metered parking. This information can be tracked and gathered through the use of the carshare operator's booking application. Some municipalities may also consider subsidizing metered carshare parking.

2. Charge an annual fee that enables carshare vehicles to park in residential parking zones. With the introduction of carshare vehicles to a neighborhood, some residents may choose to dispose of their private vehicles, which in turn will open up additional neighborhood parking spots.

3. Allow carshare operators to apply for designated on-street parking spaces through a tiered geographic payment system, with higher density zones requiring higher annual fees. This incentivizes carshare operators to place vehicles in areas less likely served by public transportation. As one-way and two-way carshare serve different purposes, each should be treated differently when applying for designated spaces.

4. Clustering of one-way vehicles should be managed either on an ad hoc basis or through enforcement averaged on a weekly or monthly time frame.

5. Work with carshare operators toward creating equitable carshare policy that allows underserved or low-income community members access to carshare (Lempert, 2018b).

If implemented in full, these points would help to address residents' concerns and alleviate the pressure placed upon parking within the NHAs.

Recommendation: Consider adopting Points 1, 2, 3, 4 & 5 from Lempert's (2018b) parking regulation best practices within the Neighbourhood Housing Areas

Further, it is important that The University Neighbourhoods Association and UBC continue to coordinate on parking policy to ensure harmony amongst campus parking regulations.

Recommendation: Coordinate parking policies between The University Neighbourhoods Association and UBC to ensure parking policy continuity.

Partnerships

As it currently exists, the partnership between Campus + Community Planning, The University Neighbourhoods Association, UBC Properties Trust and Modo has been advantageous for all organizations. Campus + Community Planning has benefited from the assistance provided by the other three partners in administering the carshare credit. The University Neighbourhoods Association benefits in that carshare assists with regulating demand for on-street parking. UBC Properties Trust benefits from several environmental and transportation-related benefits that assist in achieving the university's strategic directives. Modo benefits in that they are not required to purchase the carshare vehicles initially and are provided a significant potential market for new carshare members in the residents living within the NHAs.

As was established in the introduction, the agreement between the two organizations specifies that carshare vehicles are purchased by UBC Properties Trust and operated in-full by Modo for a pre-determined duration of time. This time clause is important as it establishes a sustained pool of carshare vehicles that are available to residents. It is important to ensure that the availability of carshare vehicles remains stable over a long period of time to maintain gains in mobility, affordability, and environmental performance (Metro Vancouver, 2014b). If these levels were to fluctuate or decrease at some point, these benefits could potentially become reduced or disappear altogether (Metro Vancouver, 2014b).

The initial scoping meetings discussed the potential for opening the community carshare credit to other carshare operators. While this option is technically feasible, it is currently not recommended as it would result in the dividing of members amongst services. The further subdivision of funding between carshare operators would negatively impact the number of available carshare vehicles for any one service and reduce the perceived convenience of carshare overall. As the literature has demonstrated, one-way carshare is not considered to be an appropriate substitute for private vehicle usage and should thus not be considered for funding. These leaves two-way carshare operators as the primary beneficiary of the credit's funds. As was identified within the survey, the most popular two-way carshare operator is Modo with 29.01% of total memberships and 16.00% of exclusive memberships. Modo is far ahead of the other two-way carshare operator Zipcar, which amounts for only 2.54% of total carshare memberships for residents living within the NHAs. Provided this, Modo remains the preferred option for two-way carshare given its established membership base and existing vehicle presence on campus.

Recommendation: Continue the partnership between Campus + Community Planning, The University Neighbourhoods Association, UBC Properties Trust and Modo.

Program Effectiveness

For several of the project shareholders, the question For several of the project shareholders, the question of how successful the community carshare credit has been to date is important. While the literature does not provide much on this topic, it did detail the importance of up-to-date data collection, appropriate data analyses, interpretation and frequent regulation updates for policymakers in promoting and supporting carshare (Namazu et al., 2018). It also described how carsharing tends to do best in communities where all residents have access to carshare vehicles and not just residents of a particular building (Vancity, 2018).

Most information on the program's effectiveness can be derived from the survey data. It is now known that the majority of survey respondents feel either extremely familiar or very familiar with their knowledge of carshare, totalling 75.98%. A small number of residents feel either somewhat familiar or not familiar with carshare, being 7.84% and 2.45% respectively. Most survey respondents use carshare once per week at 27.88%, followed by equal number of residents using carshare 2-3 times per week and once per month at 21.21%. Only 18.79% of residents indicated rarely or never using their carshare membership.

Provided this, the program has been successful to some extent in expanding the knowledge and use of carshare on campus, but it is difficult to discern exactly how much of this can be attributed to the community carshare credit. Future expansion of carshare on campus should focus on those that are unfamiliar with carshare and are not current members. It should be acknowledged that while the knowledge aspect can be fully addressed through education efforts, some residents may never choose to sign up for carshare regardless of how incentivized the program is.

Recommendation: Enhance marketing efforts to educate residents on carsharing and demonstrate its benefits.

There are several reasons why individuals choose to not use carshare. Of the survey respondents who indicated having no carshare memberships, the main barriers preventing them from utilizing carshare include already owning a vehicle at 52.73% and carshare not matching their needs at 30.91%. The other three factors were found to have negligible impacts on a resident's decision to use carshare, including 7.27% for a lack of familiarity, 7.27% for cost of using carshare, and 1.82% for cost of membership.

Provided this, it can be said that a lack of familiarity and costs associated with carshare are not a significant factor in the avoidance of carshare. The greatest barrier to carshare – the owning of a private vehicle – is hard to mitigate given that it is a personal choice and difficult to influence. The best opportunity for adding additional people to the program is in the second barrier to carshare, being that carshare does not currently meet residents' needs. Additional study is required to conclude in what aspect carshare is not meeting residents' needs, be it convenience, accessibility, diversity of fleet, or other factors. Further, as the initial survey was an opt-in format instead of a random-sampling, it is difficult to extrapolate trend information beyond the survey respondents. Provided this, it would be worthwhile for future studies to use proper surveying techniques to ensure the validity of the results and allow for analysis of the general population.

Recommendation: Conduct a statistically valid follow-up study to explore how carshare can better meet the needs of residents within the Neighbourhood Housing Areas.

Looking to the program's effectiveness in terms of environmental considerations, one of the main indicators of this is vehicle shedding and avoidance. 35.37% of survey respondents indicate they have shed a private vehicle because of carsharing. Of these individuals, 85.96% indicated that carshare services on campus had influenced their decision to shed their vehicle. If carsharing where no longer available on campus, 66.67% of respondents indicated they would purchase another vehicle to compensate for the services removal.

Provided this, it can be said that the availability of carshare has been effective in reducing private vehicle ownership on campus. The shedding and avoidance of private vehicles resulting from the program is significant and an important indicator of the program's success.

Intermodality

Several of the university's policy directives set out to diversify transportation options on campus by expanding intermodal usage. The Transportation Plan seeks to reduce single occupant vehicles commuting to and from the campus but also acknowledges that there are limited carshare policies and programs in place (UBC, 2014b). The UBC Vancouver Transportation Status Report - Fall 2018 echoes this sentiment, detailing the university's goal of reducing automobile trips to and from campus and encouraging the use of other modes of transportation (UBC, 2019).

Regional policies place further credence on the importance of transportation diversification and carshare. Metro 2040 places a high priority on reducing the number of private vehicles and supports sustainable transportation choices including carshare (Metro Vancouver, 2010). The Regional Transportation Strategy: Strategic Framework provides a clear indication of support for carshare by committing TransLink to supporting carsharing initiatives across the region (TransLink, 2013).

Carshare works to supplement and benefit existing transportation systems. Carsharing can strengthen multi-modal travel by providing a more sustainable transportation choice to private vehicles (Vancity, 2018). It is also often used to supplement other services, such as walking or public transit (Modo, 2018).

Modal share is an important indicator for residents' travel patterns. For survey respondents, the most common method of getting around is by private vehicle, with an average 30.76% mode share. Walking and biking are a close second with 29.92% mode share, followed by public transit at 23.34% mode share, and finally carshare at 15.75% mode share. Of the residents that are using carshare, most are using it once per week, followed by 2-3 times per week and once per month.

At present, it is not known what mode share is being replaced by carshare and how many times a carshare vehicle moves each day on campus (UBC, 2019). Namazu et al. (2018) details the importance of up-to-date data collection, appropriate data analyses, interpretation and frequent regulation updates for policymakers in promoting and supporting carshare. Provided this, further research is required to establish usage patterns of carshare vehicles to better understand how they are being used. This information can then be extrapolated to inform carshare policies that better meet the needs of the residents living within the NHAs.

Recommendation: Conduct a follow-up study to analyze the usage patterns of carshare vehicles on campus.

The availability of carshare vehicles in a neighbourhood proved to be an important factor in the uptake of carshare services. The number of carshare vehicles within walking distance of an individual's home has a statistically significant relationship with the number of vehicles held by individual's living within apartments (Metro Vancouver, 2014b). It is important to consider this evidence when allocating vehicles for a neighbourhood, as ample availability of carshare vehicles is necessary to promote reductions in household vehicle holdings (Metro Vancouver, 2014b). Possible adjustments to parking supply may be necessary for new apartment developments as they are developed.

Recommendation: Evaluate the placement of carshare vehicles on an annual basis and reallocate accordingly.

Sustainability

The community carshare credit exists within and links to a network of university sustainability policies. *The Strategic Plan* 2018-2022 supports the ongoing development of sustainable, healthy and connected campuses and communities (UBC, 2018b). *The Land Use Plan* discusses the goal of the university developing land resources that are environmentally-friendly and consistent with regional objectives (UBC, 2015). The Transportation

Plan is interested in the benefits of carsharing and expanding electric vehicle charging stations throughout the university's parking facilities and neighbourhood developments (UBC, 2014b). While carshare is described within The Transportation Plan as a relatively new area for transportation planning, it has the opportunity to become a popular transportation mode and act as an alternative to private vehicles. Policies and actions within The Transportation Plan favour the development of carshare, including:

- D3.1 – Support car sharing and electric vehicles as alternatives to conventional single occupancy vehicles.
    - ◊ D3.1.1 – Expand car sharing parking locations across campus to meet demand.
    - ◊ D3.1.2 – Expand electric vehicle charging stations in academic and residential areas (UBC, 2014b).

Project stakeholders requested that this study examine broader sustainability elements associated with carshare. The literature demonstrates that carshare provides significant potential for emissions reductions when compared to private vehicle ownership (Namazu & Dowlatabadi, 2015; Vancity, 2018). Membership with a carshare organization is shown to reduce the use of private vehicles by individuals (Millard-Ball, 2005; Namazu & Dowlatabadi, 2015; Vancity, 2018). These findings are reinforced by the survey data, with 35.37% of survey respondents indicating they have shed a vehicle because of carshare. Of these individuals, 85.96% indicated that carshare services on campus had influenced their decision to shed their vehicle. If carsharing where no longer available on campus, 66.67% of respondents indicated they would purchase another vehicle to compensate for the services removal.

Scoping interviews indicated an interest in studying the potential for an electric carshare vehicle pilot project on campus. The literature examined the potential considerations and benefits provided by electric vehicles. Sources discussed the lower environmental impacts in terms of energy use and vehicle emissions (Kukreja, 2018). When survey respondents were asked if they would be interested in accessing electric vehicles if made available through carshare, 92.51% of residents indicated they were interested. Provided this, an electric vehicle pilot project on campus would be of benefit to the residents of the NHAs and is deemed a suitable next step for the program.

Recommendation: Conduct an electric vehicle pilot study within the Neighbourhood Housing Areas.

There is a need to consider the future electricity demands resulting from the influx of electric vehicles in the NHAs. More consideration should be given to charging infrastructure on-site and on-street, especially if electric vehicles is an area of sustained interest for the community carshare credit. Consideration should be given to using credit funds for financing additional electric vehicle charging stations on campus similar to the level-three charging station that currently exists on Webber Lane.

Recommendation: Permit the community carshare credit for financing electric vehicle charging infrastructure within the Neighbourhood Housing Areas.


STOP
4 WAY
Car Share Parking Only
VEHICLES WILL BE TOWED
THULE
evo
CAR SHARE

Conclusion

The community carshare credit within REAP has been a successful tool for advancing sustainability and transportation initiatives on campus. The program's primary successes have been in expanding the knowledge and use of carshare, increasing the availability of carshare vehicles, and reducing the number of private vehicles within the NHAs. As it currently exists, the partnership between Campus + Community Planning, The University Neighbourhoods Association, UBC Properties Trust and Modo has been of great benefit for all organizations. For the continued success of the program, it is imperative that this partnership remain strong provided that each organization has an important role to play in the credit's functioning

With these successes in mind, there are areas within the credit that need revitalization. Accordingly, several recommendations have been provided that, if implemented, could make the credit more effective. These updates will allow the community carshare credit to branch into exciting new avenues for the program's continued growth and success in future. It is intended that these recommendations be worked upon jointly between the different organizations to ensure policy continuity and to strengthen collaboration.

In summary, the following twelve recommendations have been made to update the community carshare credit:

1. **Partner with carshare operators and developers to finance carshare memberships through the community carshare credit that target low-income categories.**
2. **Permit developers to provide dedicated carshare parking stalls in exchange for reduced on-site parking requirements.**
3. **Continue to utilize the community carshare credit funding for two-way carshare only.**
4. **Consider adopting Points 1, 2, 3, 4 & 5 from Lempert's (2018b) best practices into carshare and parking policy within the Neighbourhood Housing Areas.**
5. **Coordinate parking policies between The University Neighbourhoods Association and UBC to ensure parking policy continuity.**
6. **Continue the partnership between Campus + Community Planning, The University Neighbourhoods Association, UBC Properties Trust and Modo.**
7. **Enhance marketing efforts to educate residents on carsharing and demonstrate its benefits.**
8. **Conduct a statistically valid follow-up study to explore how carshare can better meet the needs of residents within the Neighbourhood Housing Areas.**
9. **Conduct a follow-up study to analyze the usage patterns of carshare vehicles on campus.**
10. **Evaluate the placement of carshare vehicles on an annual basis and reallocate accordingly.**
11. **Conduct an electric vehicle pilot study within the Neighbourhood Housing Areas.**
12. **Permit the community carshare credit for financing electric vehicle charging infrastructure within the Neighbourhood Housing Areas.**

References

Abbott, N. (2015). From follows parking: Using shared parking to mitigate negative impacts of excess parking. Retrieved from https://sustain.ubc.ca/sites/sustain.ubc.ca/files/GCS/2015%20Project%20Reports/Using%20shared%20parking%20to%20mitigate%20negative%20impacts%20of%20excess%20parking%20-%20GC%20Scholars%202015.pdf

Firnkorn, J., & Shaheen, S. (2016). Generic time-and method-interdependencies of empirical impact-measurements: A generalizable model of adaptation-processes of carsharing-users' mobility-behavior over time. Journal of Cleaner Production, 113, 897-909.

Kukreja, B. (2018). Life cycle analysis of electric vehicles: Quantifying the impact. Retrieved from https://sustain.ubc.ca/sites/default/files/2018-63%20Lifecycle%20Analysis%20of%20Electric%20Vehicles_Kukreja.pdf

Lempert, R. (2018a). Supporting carshare vehicles for the City of Vancouver: Benefits of corporate carshare. Retrieved from https://sustain.ubc.ca/sites/sustain.ubc.ca/files/GCS/2018_GCS/Reports/2018- 56a%20Benefits%20of%20Corporate%20Carshare_Lempert.pdf

Lempert, R. (2018b). Supporting carshare vehicles in the City of Vancouver: North American parking policies. Retrieved from https://sustain.ubc.ca/sites/sustain.ubc.ca/files/GCS/2018_GCS/Reports/2018- 56b%20Supporting%20Carshare%20North%20American%20Parking%20Policies_Lempert.pdf

Lempert, R., Zhao, J., & Dowlatabadi, H. (2019). Understanding carsharing demand: A lifestyle choice or an economic necessity? Unpublished manuscript, Institute of Resources, Environment and Sustainability, University of British Columbia, Vancouver, Canada.

Meijkamp, R. (1998). Changing consumer behaviour through eco-efficient services: an empirical study of car sharing in the Netherlands. Business Strategy and the Environment, 7(4), 234-244.

Millard-Ball, A. (2005). Car-sharing: Where and how it succeeds (Vol. 108). Transportation Research Board.

Metro Vancouver. (2010). Metro Vancouver 2040: Shaping our future. Retrieved from http://www.metrovancouver.org/services/regional-planning/PlanningPublications/RGSAdoptedbyGVRDBoard.pdf

Metro Vancouver. (2014a). Integrated air quality and greenhouse gas management plan. Retrieved from http://www.metrovancouver.org/services/air-quality/rQualityPublications/2014IAQGGMPProgressReport.pdf

Metro Vancouver. (2014b). The Metro Vancouver carshare study: Technical report. Retrieved from http://www.metrovancouver.org/services/regional-planning/PlanningPublications/MetroVancouverCarShareStudyTechnicalReport.pdf

Namazu, M., & Dowlatabadi, H. (2015). Characterizing the GHG emission impacts of carsharing: a case of Vancouver. Environmental Research Letters, 10(12), 124017.

Namazu, M., & Dowlatabadi, H. (2018). Vehicle ownership reduction: A comparison of one-way and two-way carsharing systems. Transport Policy, 64, 38-50.

Namazu, M., MacKenzie, D., Zerriffi, H., & Dowlatabadi, H. (2018). Is carsharing for everyone? Understanding the diffusion of carsharing services. Transport Policy, 63, 189-199.

Plug In BC. (n.d.). EV101. Retrieved from https://pluginbc.ca/ev101/

The University of British Columbia. (2005). Policy number 5: Sustainable development. Retrieved from https://universitycounsel.ubc.ca/files/2018/09/policy5.pdf

The University of British Columbia. (2014a). 20-Year sustainability strategy for the University of British Columbia Vancouver Campus. Retrieved from https://sustain.ubc.ca/sites/sustain.ubc.ca/files/uploads/CampusSustainability/CS_PDFs/Plans Reports/Plans/20-Year-Sustainability-Strategy-UBC.pdf

The University of British Columbia. (2014b). UBC Transportation Plan: Vancouver campus. Retrieved from https://planning.ubc.ca/sites/planning.ubc.ca/files/documents/transportation/plans/UBC-Transportation-Plan-2014_Oct.pdf

The University of British Columbia. (2015). Land use plan. Retrieved from https://planning.ubc.ca/sites/planning.ubc.ca/files/documents/planning-services/policies-plans/01-Land%20Use%20Plan-2015.pdf

The University of British Columbia. (2018a). Residential Environmental Assessment Program (REAP 3.1). Retrieved from https://planning.ubc.ca/sites/planning.ubc.ca/files/images/planning-services/policies-plans/REAP%203.1%20Reference%20Manual.pdf

The University of British Columbia. (2018b). Shaping UBC's next century: Strategic Plan 2018-2028. Retrieved from https://strategicplan.ubc.ca/wpcontent/uploads/2018/04/2018_UBC_Strategic_Plan_Full-20180425.pdf

The University of British Columbia. (2019). UBC Vancouver Transportation Status Report – Fall 2018. Retrieved from https://planning.ubc.ca/vancouver/transportation-planning/research-and-reports/transportation-status-reports

TransLink. (2013). Regional transportation strategy: Strategic framework. Retrieved from https://www.translink.ca/-/media/Documents/plans_and_projects/regional_transportation_strategy/rts_strategic_framework_07_31_2013

Rogers, E. M. (2010). Diffusion of innovations. Simon and Schuster.

Shaheen, S. A., Sperling, D., & Wagner, C. (1999). A Short History of Carsharing in the 90's. Retrieved from https://www.researchgate.net/publication/254396812_A_Short_History_of_Carsharing_in_the_90's

Statistics Canada. (2016). Custom basic profiles of British Columbia, City of Vancouver and neighbourhoods at the University of British Columbia, Census year 2016. Retrieved from http://dvn.library.ubc.ca/dvn/dv/ABACUSPD/faces/study/StudyPage.xhtml?globalId=hdl:11272/10724

Vancity. (2018). Changing gears: Exploring the carsharing culture in Metro Vancouver. Retrieved from https://www.vancity.com/AboutVancity/News/MediaReleases/CarSharing2018/f?la=en&hash=0A459174FB44A8870D00EFCE54124A01078D0698

Rogers, E. M. (2010). Diffusion of innovations. Simon and Schuster.

Shaheen, S. A., Sperling, D., & Wagner, C. (1999). A Short History of Carsharing in the 90's. Retrieved from https://www.researchgate.net/publication/254396812_A_Short_History_of_Carsharing_in_the _90's

Vancity. (2018). Changing gears: Exploring the carsharing culture in Metro Vancouver. Retrieved from https://www.vancity.com/AboutVancity/News/MediaReleases/CarSharing2018/

Appendices

Appendix A - Stakeholder Interviews

REAP Community Car-Sharing Credit Exploratory Study

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November Project Update

This document is intended to provide all stakeholders with a progress update on the project. This report begins with a short background information section followed by an outline of the project's methodology, information from the scoping interviews, a summary of the literature reviewed to date, and the proposed next steps.

Background

As a reminder, this was the initial project description provided to all stakeholders:

> In 2004, UBC Properties Trust brought community car sharing to campus residential neighbourhoods. Modo was chosen at the time as a partner given its fleet size. Modo Vehicles were purchased by UBC Properties Trust in exchange for a guarantee of availability of cars on campus due to the University of British Columbia's (UBC) geographical isolation and smaller population size. UBC Properties Trust finances carshare purchases with a development fee of $200 per unit for. Presently, 15 Modo cars have been purchased and 5 more are to come; with opportunity for future fleet expansion to include electric vehicles. Past spending has also included car-share signage and recently funding supported installation of a Level 3 EV charging station. The community car-share program is generally thought to be a success, but has not been reviewed since its inception. This proposed project provides an opportunity to provide a review that can support update of the credit and fund.

Following an initial meeting in early-August to discuss the project's scope, the group reconvened for a second meeting in mid-September to finalize details and kick-off the project. In the time between mid-September and now, I have crafted a project methodology, interviewed stakeholders, and have begun and am continuing to work on the literature review. Listed below are my preliminary findings.

Methodology

The methodology consists of the following fives sections:

1. **Scoping Interviews** – In meeting with each of the community stakeholders, my goal was to gain a better sense of their specific interests in relation to the project as to ensure that each organization's interests are represented within the scope of the project.
2. **Literature Review** – As a result of the scoping interviews, I was provided several articles and documents to begin the literature review. My research is currently focused upon topics such as car-shares, parking regulations, electric vehicle infrastructure, and intermodality. To date, the literature I have reviewed includes a number of technical documents, policy documents and peer-reviewed literature. I also intend to research best practice guidelines and case studies of other municipalities at a later date.

3. **Data Analysis –** This section will occur beginning in January when I will begin collecting and analyzing data from stakeholders to gain a sense of what transportation patterns are occurring within the university neighbourhoods, who is utilizing car-shares, and what general trends can be extrapolated from this information. I will be performing these analyses with the assistance of my supervisor Martino Tran.
4. **Survey** – Whether or not the survey will be conducted has yet to be determined. Should time allow for it, I will be developing and delivering a survey for residents to gain a better understanding of their thoughts and feelings towards car-shares in their respective neighbourhoods.
5. **Final Report and Recommendations** – The final report is tentatively scheduled to be delivered by the end of April. This will include all my findings to date and a set of policy recommendations for changes to be made to the program.

Scoping Interviews

Listed below are my preliminary findings from the scoping meetings. I have organized, edited, and added emphasis to answers for clarity as needed. Please note that answers are listed alphabetically and not by any measure of significance.

Questions and Answers:

1. What aspect of this research is more important or beneficial to your organization?

- **Affordability** – Increasing affordability for residents on campus through transportation cost savings. Focusing on how car-share and electric vehicles can help to address affordability on campus. Consider decoupling parking from the purchase/rental cost of rentals and condos on campus to disincentivize single occupancy vehicles and increase affordability.
- **Community Impact** – Modo is interested in how this research may impact their users, including providing a clear scientific justification for the benefits of the program. Consider what modes of transportation car-share users are switching over from. Research should be conducted to identify what the impact of car-share is on residences.
- **Decarbonization** – Lowering the overall greenhouse gas emissions of users transiting to campus by reducing the number of single occupancy vehicles and promoting the use of car-share.
- **Future Developments** – Look to apply these recommendations to new neighbourhoods including the upcoming Stadium District.
- **Parking** – Reducing the number of cars and parking spots found at UBC. This project should work to address the concern of parking amongst residents knowing that there is already limited street parking in university neighbourhoods and that there is a lot of stress placed upon this parking by outside users. As it currently stands, there is no ticketing within the neighbourhoods as the University Neighbourhood Association does not have the authority to do so. As a result, vehicles that are improperly parked in the university neighbourhoods are immediately towed at the owner's expense. Car-shares have resulted in a spillover effect, where car-share vehicles are occupying spots not designated for them and limiting the parking offered to residents. Car-shares can, however, help to reduce the need for private parking and private automobiles in the neighbourhoods.

- **Partnerships** – Focusing on working with developers to utilize and promote the car-share credit as they are somewhat resistant currently. Modo is interested in partnering with UBC Properties Trust to finance a number of memberships through a form of community contribution. Look to the potential of developers providing marketing collateral for Modo. Consider expanding the program to include other service providers and services.
- **Program Effectiveness** – Consider how successful the car-share credit has been to date in reducing greenhouse gas emissions and the usage of single occupancy vehicles on campus? Have there been any environmental assessments conducted? It is important to understand that visibility is key for car-shares to be effective, preferring to be in central locations with high traffic volumes.
- **Implementation** – Focus on practical results that are easy to implement.
- **Infrastructure** – Working to develop a large infrastructure network for electric vehicles to employ. Explore the notion of what an electric vehicle pilot study would look like.
- **Intermodality** – Offering additional options for mobility to neighbourhood residents provided that public transit is not always readily available to them, especially after working hours and on weekends. Look to further diversify transportation options by promoting car-share and expanding intermodal usage.
- **Quantitative Analysis** – Look for a better understanding of usage patterns amongst residents and patrons of the neighbourhood.
- **Shifting Transportation Preferences** – Assisting in the transformation of the transportation market. Reducing the number of single occupancy vehicles on the road. Work to develop car-share as a more prominent mode share for travel to and from the university. There is a difference between one-way and two-way car-share services. One-way car-share services don't provide the same utility to the communities as two-way car-share. With one-way car-share, there is a mass influx of cars arriving on campus from 8:00 to 11:00 AM and then departing between 2:00 to 4:30 PM every day, leaving few options for community users to use after working hours. This phenomenon is most notable within the Hawthorne and Wesbrook neighbourhoods.
- **Sustainability** – Examining broader sustainability elements, such as looking to lower negative externalities and consider product life cycles. There is an interest in delivering the best environmental practices to the university. The project should try to link to UBC's climate change and sustainability mandates.

2. Asides from the stakeholders that are already engaged on this project, what other key stakeholders should I be in contact with?

- Alex Bigazzi – Assistant Professor, School of Community and Regional Planning
- Brian Jones – Director, UBC Parking
- car2go, Evo, and Zipcar
- Developers
- Existing car-share users
- Hadi Dowlatabadi – Professor, Institute for Resources, Environment and Sustainability
- Krista Falkner – Transportation Engineer, Campus and Community Planning
- Larry Frank – Professor, School of Community and Regional Planning
- Sylvain Celaire – Business Development Manager, Modo

3. Are there any articles or publications produced by your organization that would help inform this project?

- Annual survey – Modo
- Green building action plan – UBC
- Parking data – University Neighbourhood Association
- Parking permit data – University Neighbourhood Association
- UBC transportation plan: Vancouver campus – UBC
- Wesbrook Place neighbourhood plan – UBC

4. Are there any additional resources from your organization or others that I can employ for this project?

- Case studies of other municipalities
- Dropbike information – Alex Taciuk, Campus and Community Planning
- E-blasts, social media and weekly newsletters available to disseminate information or survey to neighbourhood residents – University Neighbourhood Association
- GIS parking locations files – Alejandro Cervantes, Campus and Community Planning
- Parking by-law updates to achieve transportation 2040 actions – City of Vancouver
- Scraping project – Adam Hyslop, Campus and Community Planning

5. What are your expectations for this project? What deliverables would you like to see in the final outcome?

- **Data Analytics** – Establish usage patterns amongst residents and extrapolate this information to understand how we can meet the needs of the community for both private vehicle ownership and car-share. Analyze patterns to see if car-sharing has increased carpooling.
- **Infrastructure** – Conduct a pilot study to establish a car-share electric charging station in a university neighbourhood. Anticipate the future need for condos to provide electric charging on-site and the importance of providing on-street electric vehicle charging infrastructure.
- **Recommendations –** Specific and concrete recommendations to update the program. As the program has been around for 15 years, it is important to consider how effective the program has been, whether or not the program should evolve, and if so, how should it and to what benefit

Literature Review

To date, the following articles have been studied:

- Changing gears: Exploring the car-sharing shift in Metro Vancouver – Vancity
- Characterizing the GHG emission impacts of carsharing: a case of Vancouver – Michiko Namazu & Hadi Dowlatabadi
- Form follows parking: Using shared parking to mitigate negative impacts of excess parking – Neal Abbott
- Impacts of car2go on vehicle ownership, modal shift, vehicle miles traveled, and greenhouse gas emissions: An analysis of five North American cities – Elliot Martin & Susan Shaheen
- Is carsharing for everyone? Understanding the diffusion of carsharing services – Michiko Namazu, Don MacKenzie, Hisham Zerriffi & Hadi Dowlatabadi

- Life Cycle Analysis of Electric Vehicles Quantifying the Impact – Balpreet Kukreja
- Metro Vancouver car share study: Technical report – Metro Vancouver
- Modo annual member satisfaction survey – Modo
- Nudging for responsible carsharing: using behavioral economics to change transportation behavior – Michiko Namazu, Jiaying Zhao & Hadi Dowlatabadi
- Residential environmental assessment program (REAP) – The University of British Columbia
- Supporting carshare vehicles for the City of Vancouver: Benefits of corporate carshare – Rainer Lempert
- Supporting carshare vehicles in the City of Vancouver: North American parking policies – Rainer Lempert
- UBC transportation plan: Vancouver campus – The University of British Columbia
- UBC Vancouver transportation status report: Fall 2015-2017 – The University of British Columbia
- Understanding carsharing demand: A lifestyle choice or an economic necessity? – Rainer Lempert, Jiaying Zhao & Hadi Dowlatabadi
- Vehicle ownership reduction: A comparison of one-way and two-way carsharing systems – Michiko Namazu & Hadi Dowlatabadi

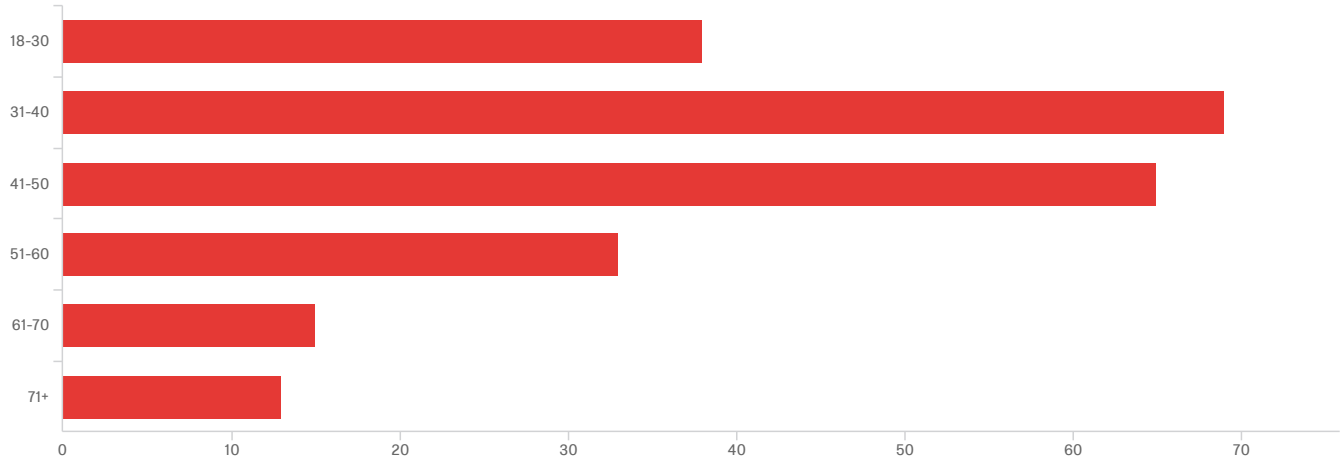
Next Steps

- Continue, complete and disseminate **literature review** by mid-December.
- Host a **check-in meeting** with all stakeholders in early January.
- Begin and finish **data analysis** by the end of March.
- Produce **final recommendations** by early April.
- Complete and disseminate **final report** by the end of April.

Appendix B - UNA Carshare Survey

UNA Carshare Survey
April 4, 2019 10:21 PM MDT

Q3 - 1. What is your age?

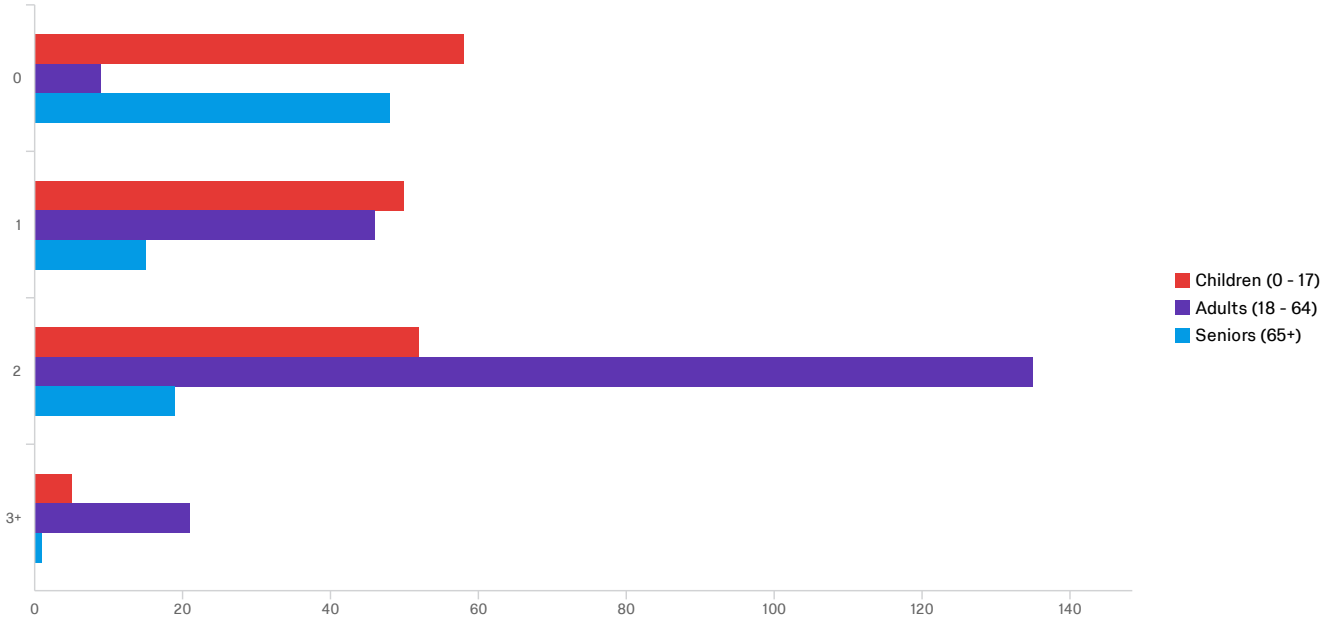


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	1. What is your age?	1.00	6.00	2.82	1.35	1.82	233

#	Field	Choice Count	
1	18-30	16.31%	38
2	31-40	29.61%	69
3	41-50	27.90%	65
4	51-60	14.16%	33
5	61-70	6.44%	15
6	71+	5.58%	13
			233

Showing rows 1 - 7 of 7

Q3#1 - 2. How many family members live in your household? - Number

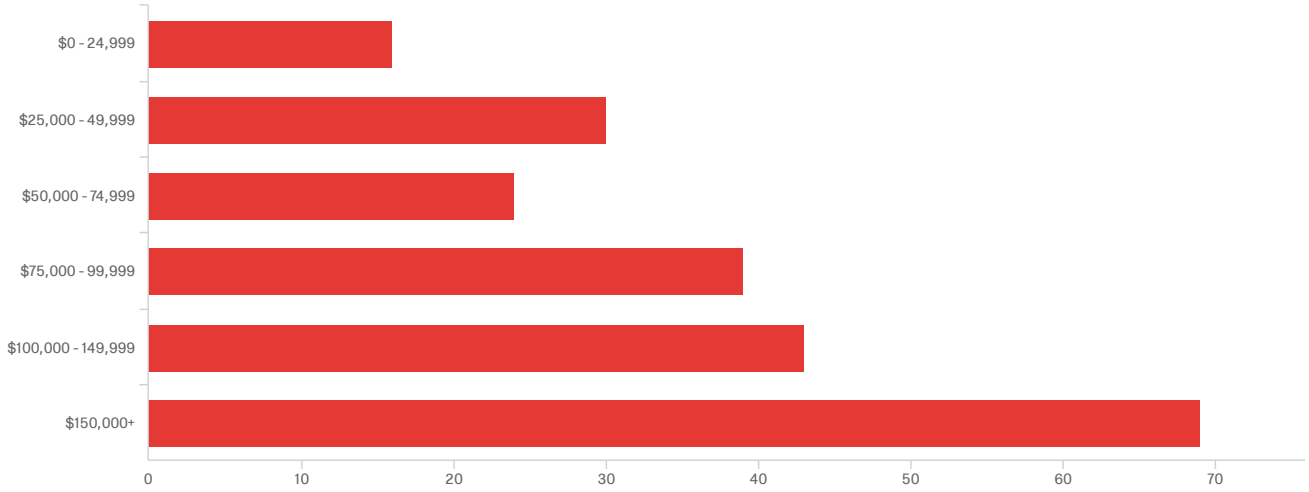


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Children (0 - 17)	1.00	4.00	2.02	0.89	0.79	165
2	Adults (18 - 64)	1.00	4.00	2.80	0.67	0.45	211
3	Seniors (65+)	1.00	4.00	1.67	0.87	0.75	83

#	Field	0		1		2		3+		Total
1	Children (0 - 17)	35.15%	58	30.30%	50	31.52%	52	3.03%	5	165
2	Adults (18 - 64)	4.27%	9	21.80%	46	63.98%	135	9.95%	21	211
3	Seniors (65+)	57.83%	48	18.07%	15	22.89%	19	1.20%	1	83

Showing rows 1 - 3 of 3

Q5 - 3. What is your household's cumulative salary?

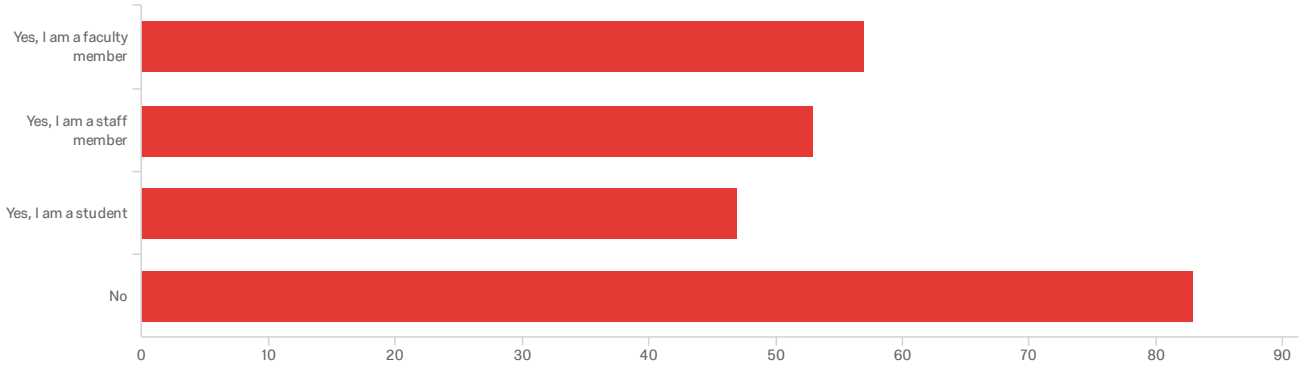


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	3. What is your household's cumulative salary?	1.00	6.00	4.22	1.64	2.70	221

#	Field		Choice Count
1	$0 - 24,999	7.24%	16
2	$25,000 - 49,999	13.57%	30
3	$50,000 - 74,999	10.86%	24
4	$75,000 - 99,999	17.65%	39
5	$100,000 - 149,999	19.46%	43
6	$150,000+	31.22%	69
			221

Showing rows 1 - 7 of 7

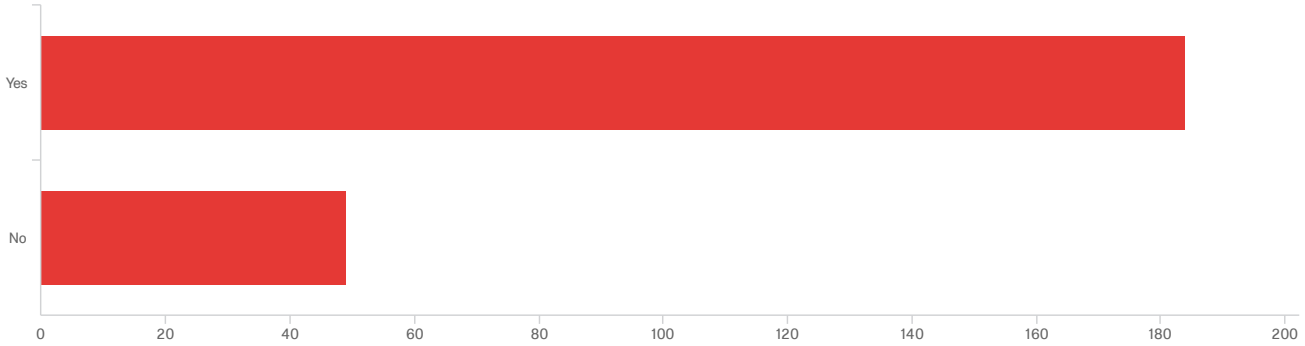
Q6 - 4. Do you have an association with UBC? Select all that apply.



#	Field	Choice Count	
1	Yes, I am a faculty member	23.75%	57
2	Yes, I am a staff member	22.08%	53
3	Yes, I am a student	19.58%	47
4	No	34.58%	83
			240

Showing rows 1 - 5 of 5

Q7 - 5. Are you resident of the UNA for more than 6 months of the year?

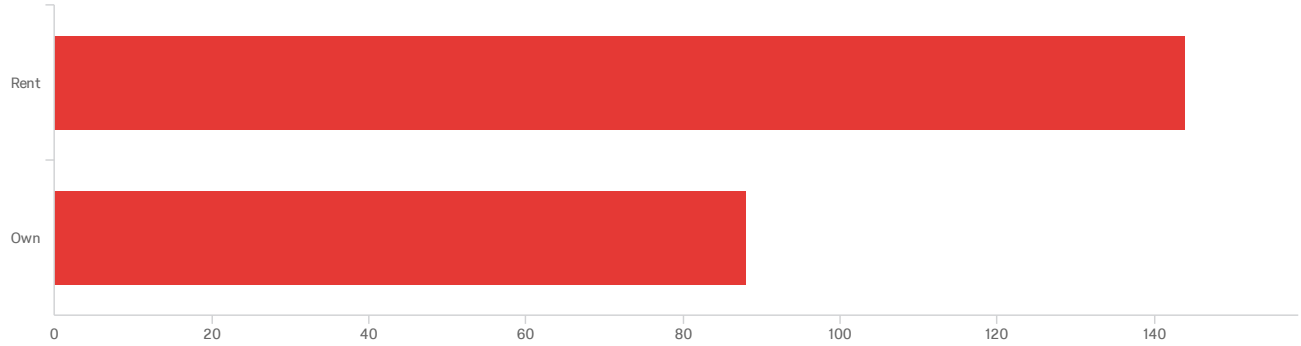


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	5. Are you resident of the UNA for more than 6 months of the year?	1.00	2.00	1.21	0.41	0.17	233

#	Field		Choice Count
1	Yes	78.97%	184
2	No	21.03%	49
			233

Showing rows 1 - 3 of 3

Q8 - 6. Do you rent or own your residence?

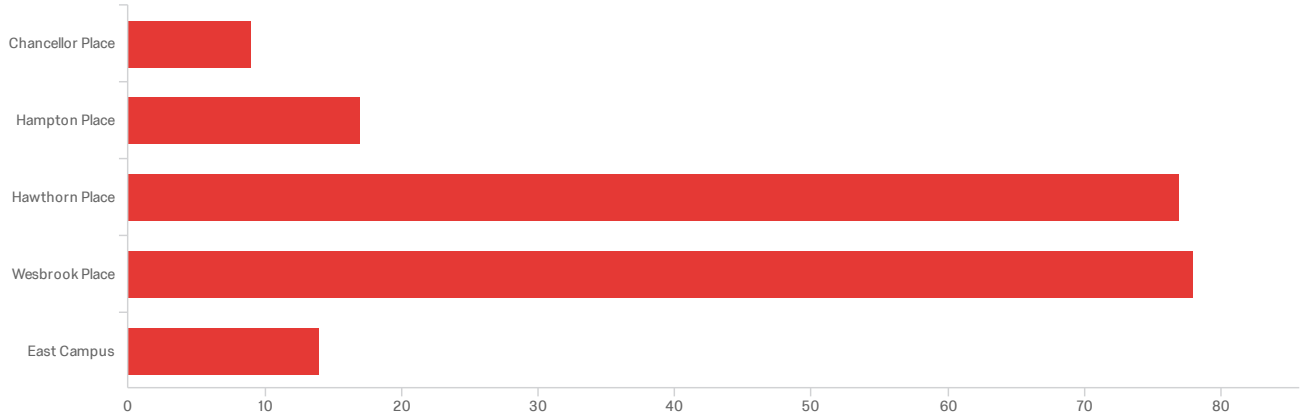


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	6. Do you rent or own your residence?	1.00	2.00	1.38	0.49	0.24	232

#	Field		Choice Count
1	Rent	62.07%	144
2	Own	37.93%	88
			232

Showing rows 1 - 3 of 3

Q9 - 7. In which of the five UNA neighbourhoods do you reside?

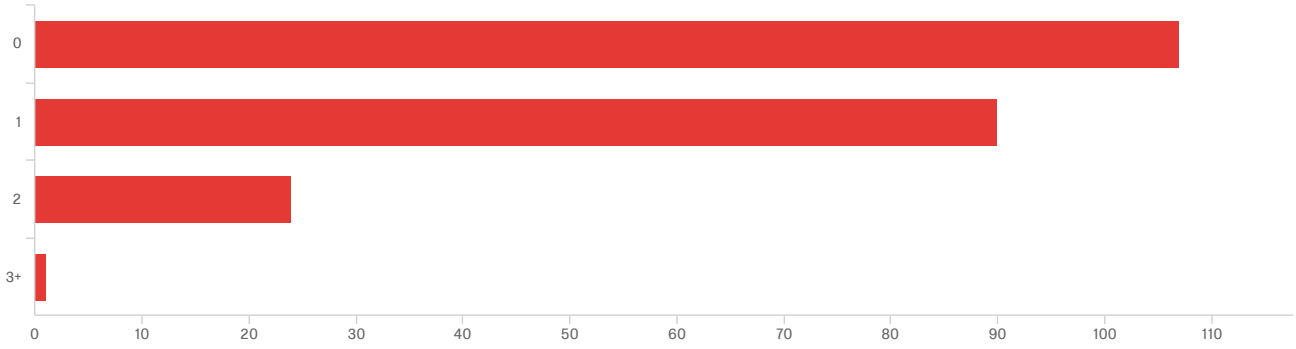


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	7. In which of the five UNA neighbourhoods do you reside?	1.00	5.00	3.36	0.91	0.83	195

#	Field		Choice Count
1	Chancellor Place	4.62%	9
2	Hampton Place	8.72%	17
3	Hawthorn Place	39.49%	77
4	Wesbrook Place	40.00%	78
5	East Campus	7.18%	14
			195

Showing rows 1 - 6 of 6

Q10 - 8. How many vehicles does your household own within the UNA?

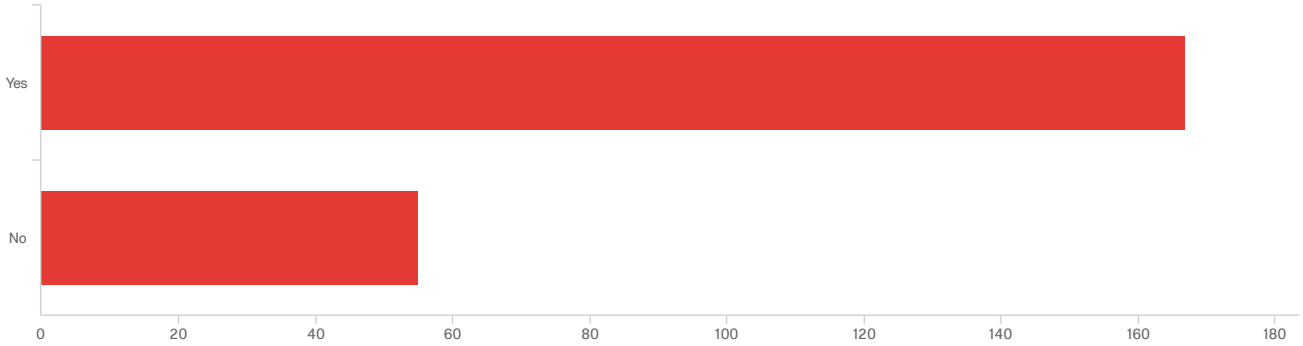


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	8. How many vehicles does your household own within the UNA?	1.00	4.00	1.64	0.69	0.47	222

#	Field		Choice Count
1	0	48.20%	107
2	1	40.54%	90
3	2	10.81%	24
4	3+	0.45%	1
			222

Showing rows 1 - 5 of 5

Q11 - 9. Do you have access to underground parking in your building?

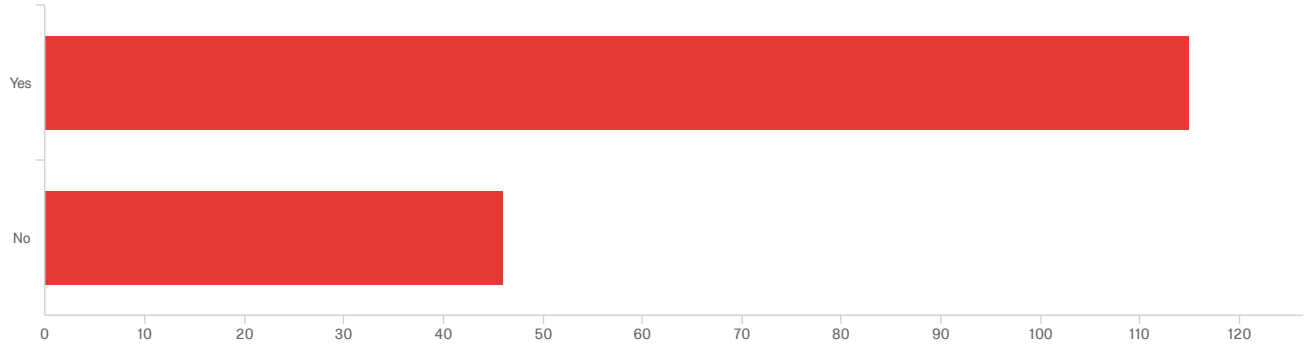


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	9. Do you have access to underground parking in your building?	1.00	2.00	1.25	0.43	0.19	222

#	Field		Choice Count
1	Yes	75.23%	167
2	No	24.77%	55
			222

Showing rows 1 - 3 of 3

Q12 - 10. Do you own or rent a parking stall at your residence?



#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	10. Do you own or rent a parking stall at your residence?	1.00	2.00	1.29	0.45	0.20	161

#	Field		Choice Count
1	Yes	71.43%	115
2	No	28.57%	46
			161

Showing rows 1 - 3 of 3

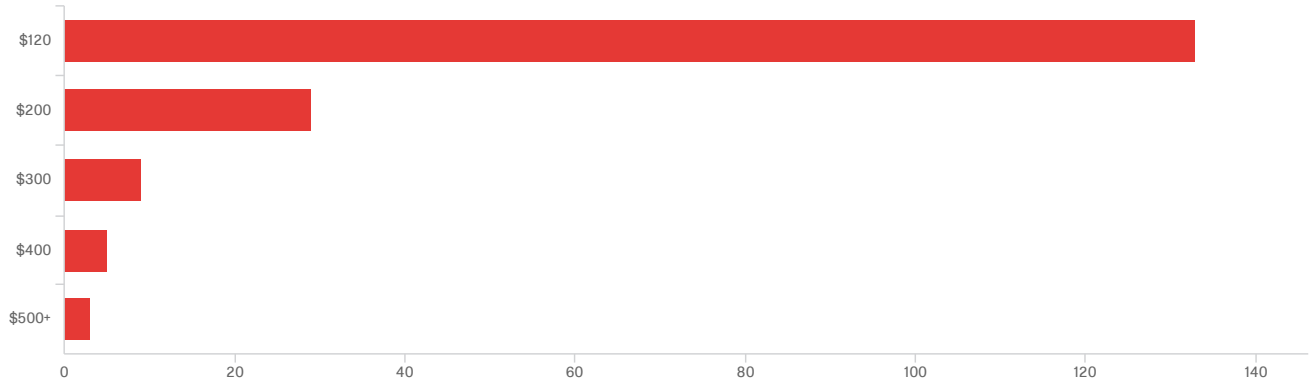
Q13 - 11. In a typical week, where are youtraveling to when you leave campus? Indicate the approximate number of trips to each location.

#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Downtown Vancouver	0.00	17.00	1.26	2.22	4.94	205
2	Vancouver's Westside (Dunbar, Kitsilano, Point Grey, etc.)	0.00	16.00	2.95	3.06	9.37	204
3	East Vancouver / Burnaby	0.00	8.00	0.67	1.37	1.89	205
4	Richmond	0.00	10.00	0.60	1.38	1.89	205
5	The North Shore	0.00	5.00	0.21	0.66	0.43	205
6	South of the Fraser (Surrey, Delta, Langley, etc.)	0.00	2.00	0.09	0.32	0.10	205
7	Northeast Sector (Coquitlam, Port Moody, etc.)	0.00	2.00	0.06	0.28	0.08	205
8	Other	0.00	20.00	0.23	1.53	2.35	203

Q13_8_TEXT - Other

Other
within ubc
Maple ridge
vancouver
Oak and 41
Mountains, Mt Baker
YVR Airport
visit family in Blaine, Wa
around campus

Q14 - 12. Provided a parking permit currently costs $120 for your first vehicle, what is the maximum amount you would be willing to pay for an on-street parking permit per year before you would reconsider purchasing one?

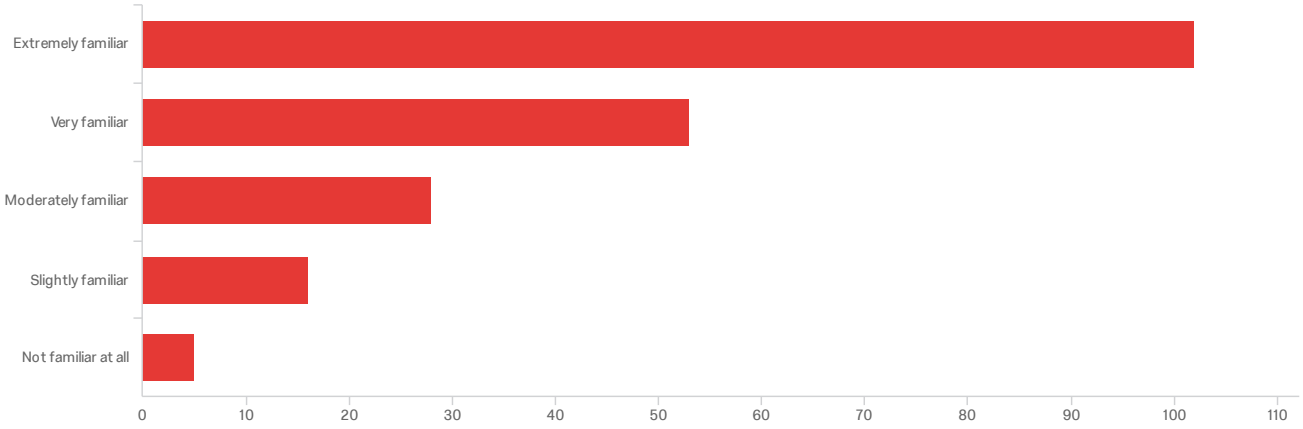


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	12. Provided a parking permit currently costs $120 for your first vehicle, what is the maximum amount you would be willing to pay for an on-street parking permit per year before you would reconsider purchasing one?	2.00	7.00	2.54	1.20	1.44	179

#	Field		Choice Count
1	$120	74.30%	133
2	$200	16.20%	29
3	$300	5.03%	9
4	$400	2.79%	5
5	$500+	1.68%	3
			179

Showing rows 1 - 6 of 6

Q15 - 13. How familiar are you with carshare?



#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	13. How familiar are you with carshare?	1.00	5.00	1.87	1.07	1.15	204

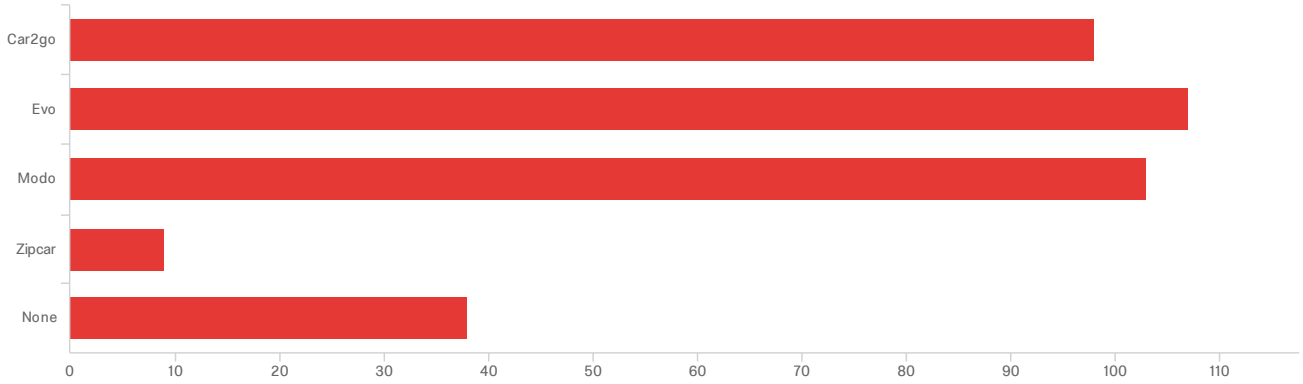
#	Field		Choice Count
1	Extremely familiar	50.00%	102
2	Very familiar	25.98%	53
3	Moderately familiar	13.73%	28
4	Slightly familiar	7.84%	16
5	Not familiar at all	2.45%	5
			204

Showing rows 1 - 6 of 6

Q16 - 14. How do you get around? Provide percentage shares for each option up to a total of 100.

#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Walking / biking	0.00	90.00	29.92	27.03	730.65	204
2	Public transit	0.00	100.00	23.34	25.46	648.08	204
3	Private vehicles	0.00	100.00	30.76	34.48	1188.89	204
4	Carshare	0.00	100.00	15.75	21.20	449.53	204
5	Other	0.00	10.00	0.22	1.31	1.72	204

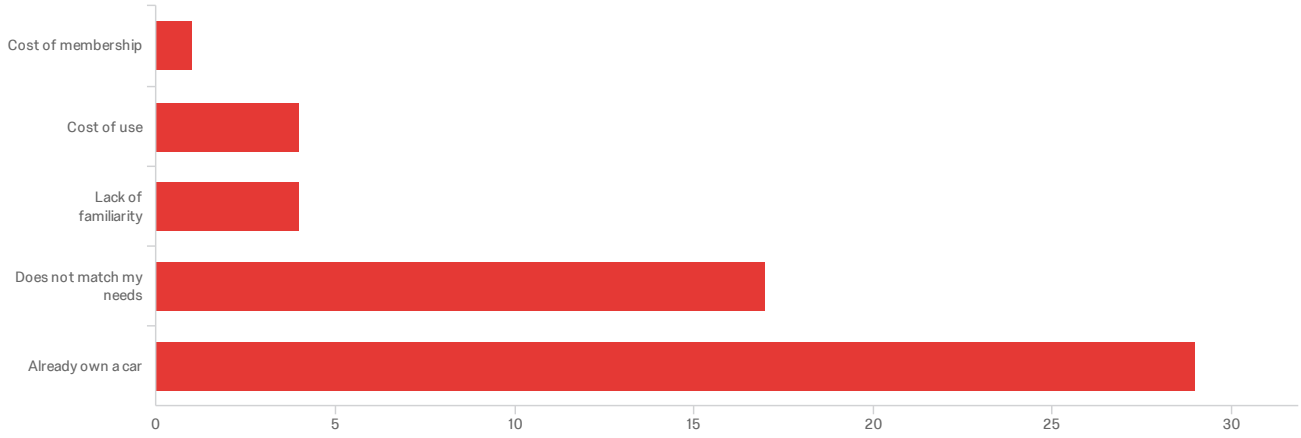
Q17 - 15. Are you a member of a carshare service? Select all that apply.



#	Field	Choice Count	
1	Car2go	27.61%	98
2	Evo	30.14%	107
3	Modo	29.01%	103
4	Zipcar	2.54%	9
5	None	10.70%	38
			355

Showing rows 1 - 6 of 6

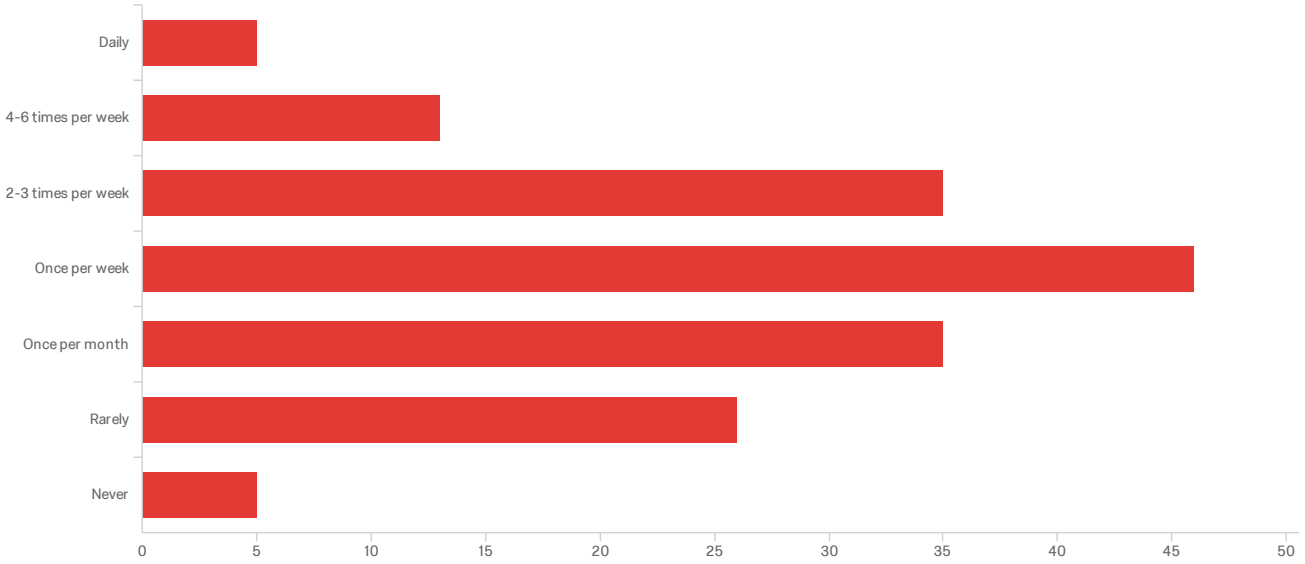
Q18 - 16. What are the main barriers that prevent you from using carshare? Select all that apply.



#	Field		Choice Count
1	Cost of membership	1.82%	1
2	Cost of use	7.27%	4
3	Lack of familiarity	7.27%	4
4	Does not match my needs	30.91%	17
5	Already own a car	52.73%	29
			55

Showing rows 1 - 6 of 6

Q19 - 17. How frequently do you use carsharing?

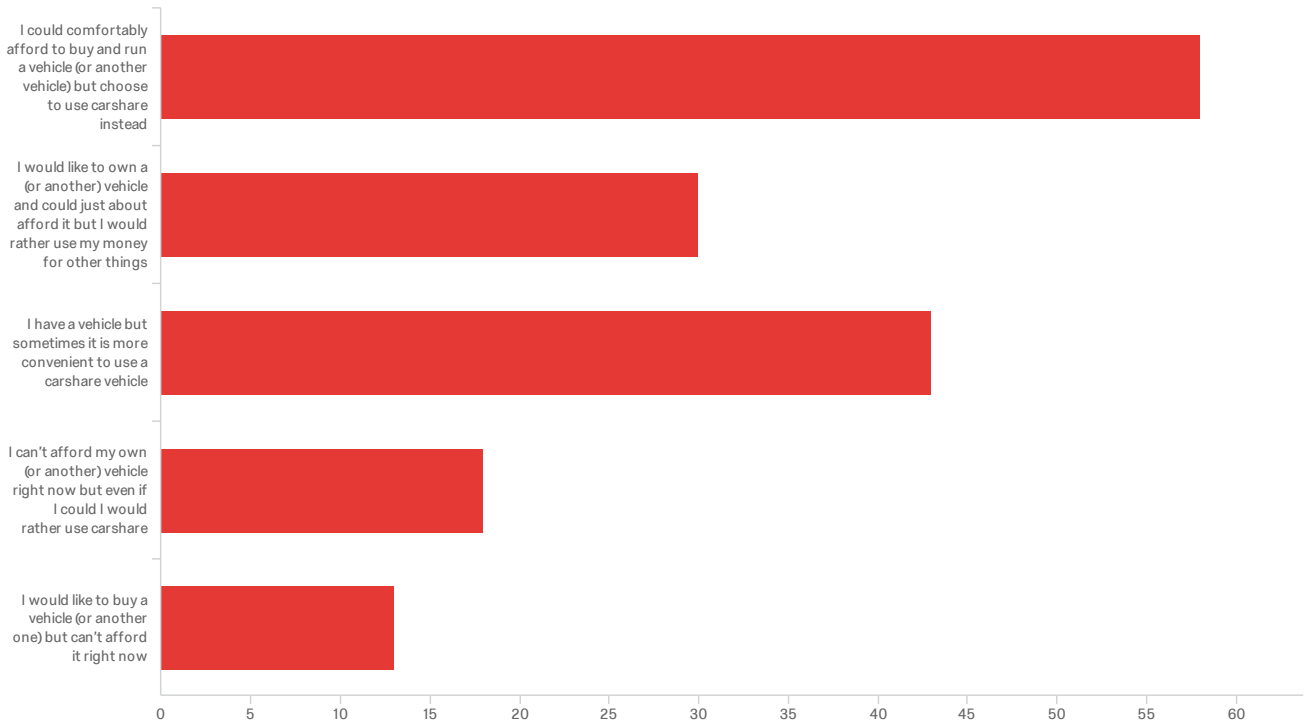


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	17. How frequently do you use carsharing?	1.00	7.00	4.16	1.37	1.89	165

#	Field		Choice Count
1	Daily	3.03%	5
2	4-6 times per week	7.88%	13
3	2-3 times per week	21.21%	35
4	Once per week	27.88%	46
5	Once per month	21.21%	35
6	Rarely	15.76%	26
7	Never	3.03%	5
			165

Showing rows 1 - 8 of 8

Q20 - 18. How does your financial situation relate to your decision to use carshare?



#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	18. How does your financial situation relate to your decision to use carshare?	1.00	5.00	2.37	1.29	1.65	162

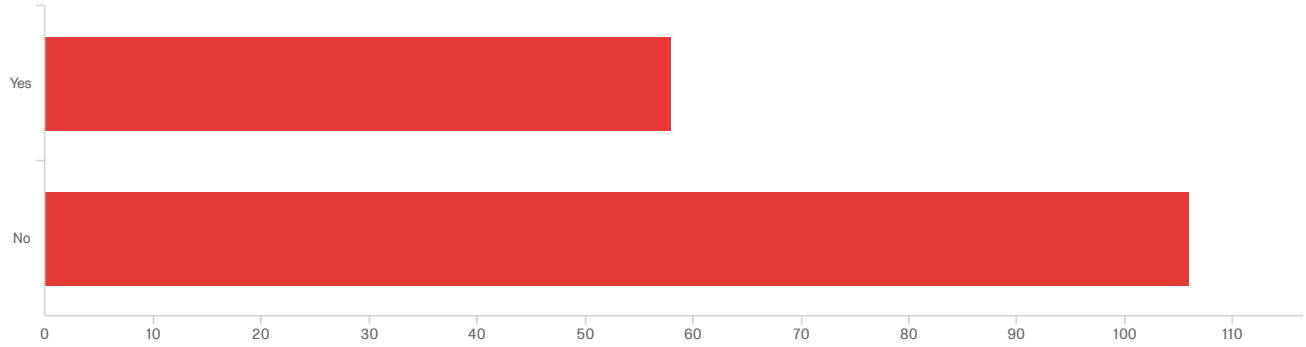
#	Field		Choice Count
1	I could comfortably afford to buy and run a vehicle (or another vehicle) but choose to use carshare instead	35.80%	58
2	I would like to own a (or another) vehicle and could just about afford it but I would rather use my money for other things	18.52%	30
3	I have a vehicle but sometimes it is more convenient to use a carshare vehicle	26.54%	43
4	I can't afford my own (or another) vehicle right now but even if I could I would rather use carshare	11.11%	18
5	I would like to buy a vehicle (or another one) but can't afford it right now	8.02%	13
			162

Showing rows 1 - 6 of 6

Q21 - 19. When using carshare, what is the purpose of your trip? Provide percentage shares for each option up to a total of 100.

#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Errands	0.00	100.00	38.95	36.37	1322.81	165
2	Commuting to work / school	0.00	100.00	14.90	27.28	744.23	165
3	Pleasure (a few hours of use)	0.00	100.00	26.12	30.59	936.02	165
4	Travel (one or more days of use)	0.00	100.00	9.42	20.42	417.09	165
5	Other	0.00	100.00	10.61	27.84	775.04	165

Q22 - 20. Has your household given-up a privately owned vehicle because you use car-sharing instead?

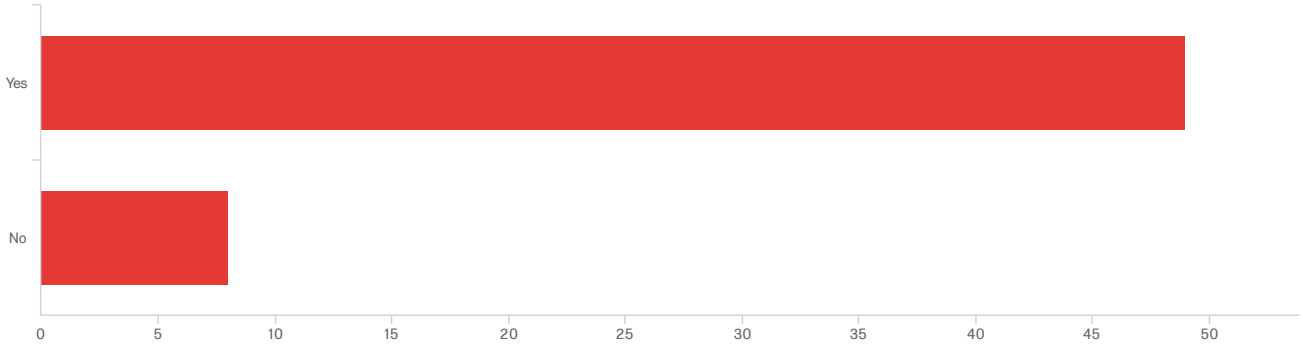


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	20. Has your household given-up a privately owned vehicle because you use car-sharing instead?	1.00	2.00	1.65	0.48	0.23	164

#	Field		Choice Count
1	Yes	35.37%	58
2	No	64.63%	106
			164

Showing rows 1 - 3 of 3

Q23 - 21. Did the availability of carshare services on campus influence this decision?

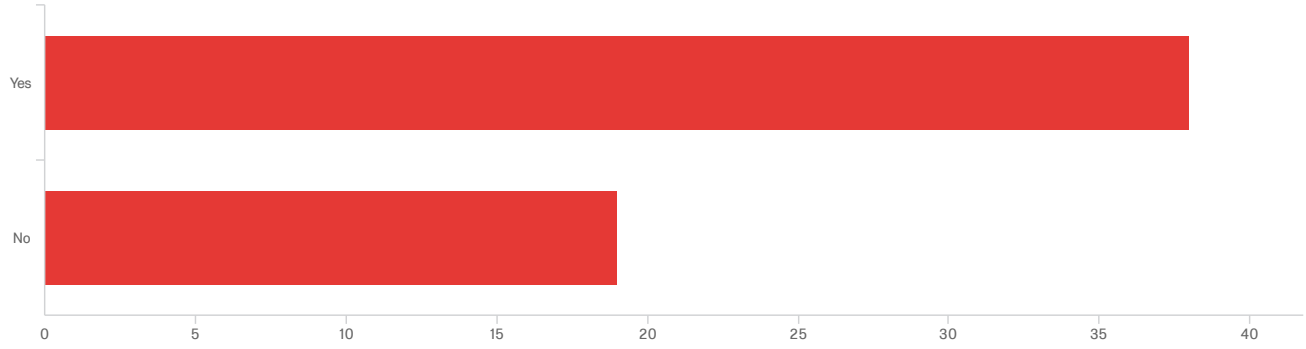


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	21. Did the availability of carshare services on campus influence this decision?	1.00	2.00	1.14	0.35	0.12	57

#	Field		Choice Count
1	Yes	85.96%	49
2	No	14.04%	8
			57

Showing rows 1 - 3 of 3

Q24 - 22. Would you buy a vehicle if car-sharing where no longer available?

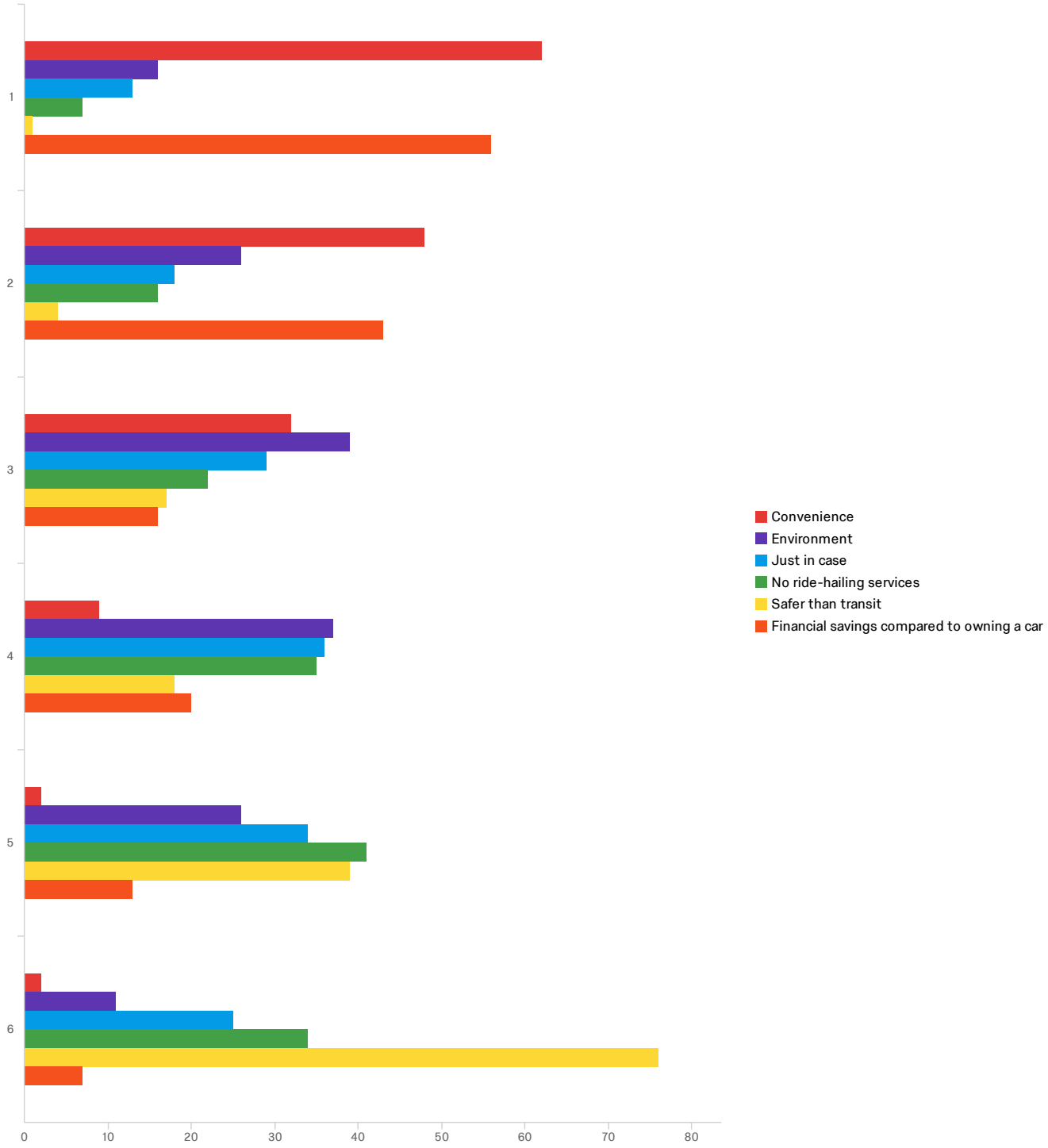


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	22. Would you buy a vehicle if car-sharing where no longer available?	1.00	2.00	1.33	0.47	0.22	57

#	Field		Choice Count
1	Yes	66.67%	38
2	No	33.33%	19
			57

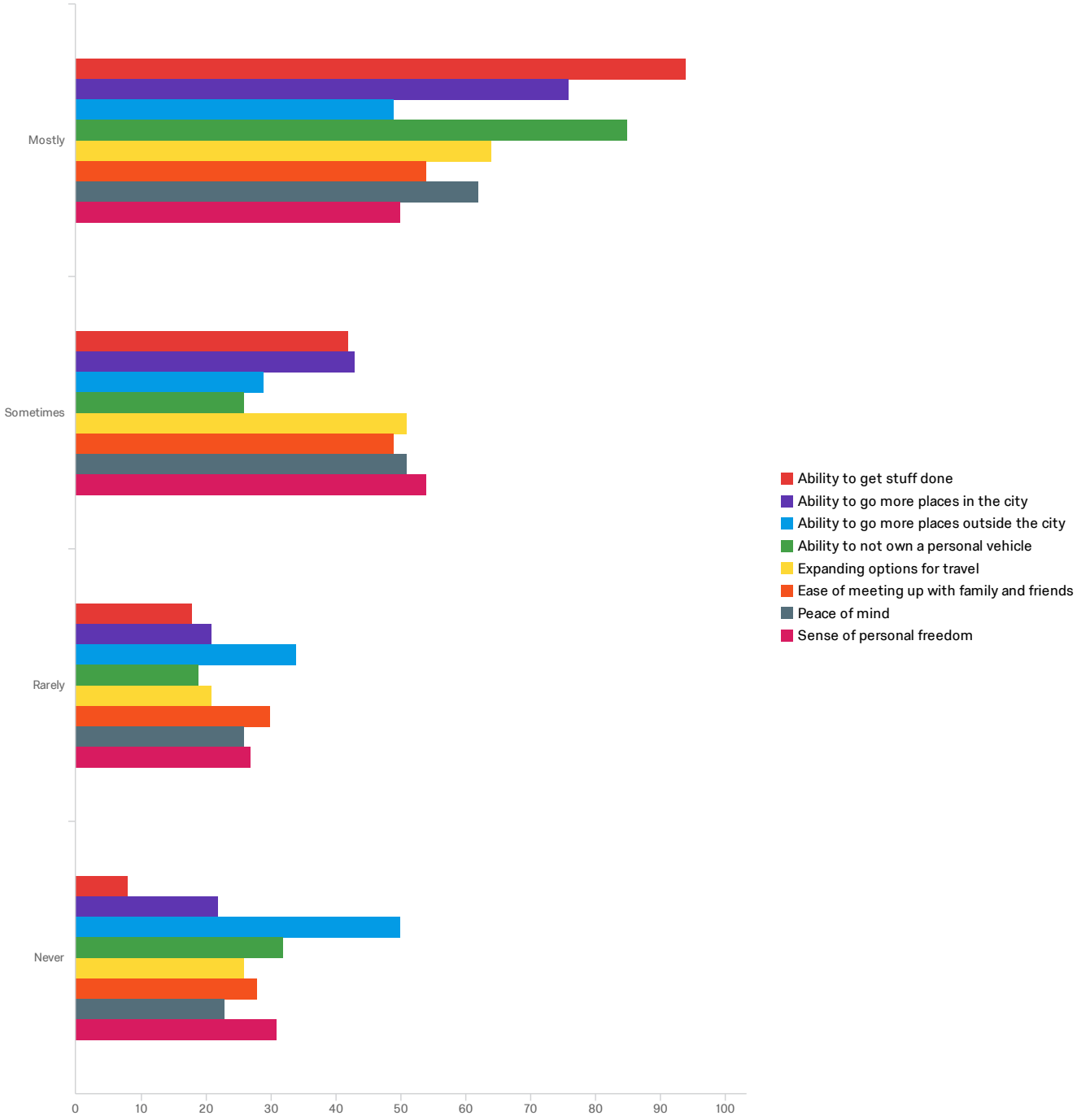
Showing rows 1 - 3 of 3

Q25 - 23. Rank the following factors in terms of importance in your consideration of using carshare, with 1 being the most important and 6 being the least important.



#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count

Q26 - 24. Indicate whether car-sharing benefits you in the following ways.



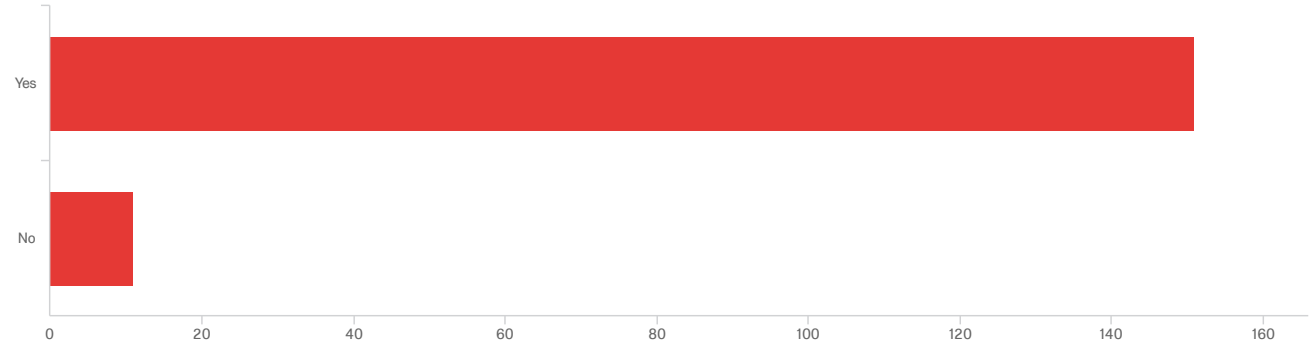
#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Ability to get stuff done	1.00	5.00	1.68	1.02	1.03	162
2	Ability to go more places in the city	1.00	5.00	2.07	1.35	1.82	162

#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
3	Ability to go more places outside the city	1.00	5.00	2.83	1.61	2.60	162
4	Ability to not own a personal vehicle	1.00	5.00	2.19	1.54	2.39	162
5	Expanding options for travel	1.00	5.00	2.22	1.39	1.92	162
6	Ease of meeting up with family and friends	1.00	5.00	2.37	1.40	1.95	161
7	Peace of mind	1.00	5.00	2.20	1.33	1.78	162
8	Sense of personal freedom	1.00	5.00	2.43	1.42	2.01	162

#	Field	Mostly		Sometimes		Rarely		Never		Total
1	Ability to get stuff done	58.02%	94	25.93%	42	11.11%	18	4.94%	8	162
2	Ability to go more places in the city	46.91%	76	26.54%	43	12.96%	21	13.58%	22	162
3	Ability to go more places outside the city	30.25%	49	17.90%	29	20.99%	34	30.86%	50	162
4	Ability to not own a personal vehicle	52.47%	85	16.05%	26	11.73%	19	19.75%	32	162
5	Expanding options for travel	39.51%	64	31.48%	51	12.96%	21	16.05%	26	162
6	Ease of meeting up with family and friends	33.54%	54	30.43%	49	18.63%	30	17.39%	28	161
7	Peace of mind	38.27%	62	31.48%	51	16.05%	26	14.20%	23	162
8	Sense of personal freedom	30.86%	50	33.33%	54	16.67%	27	19.14%	31	162

Showing rows 1 - 8 of 8

Q27 - 25. Would you be interested in accessing electric vehicles if they were made available through carshare?

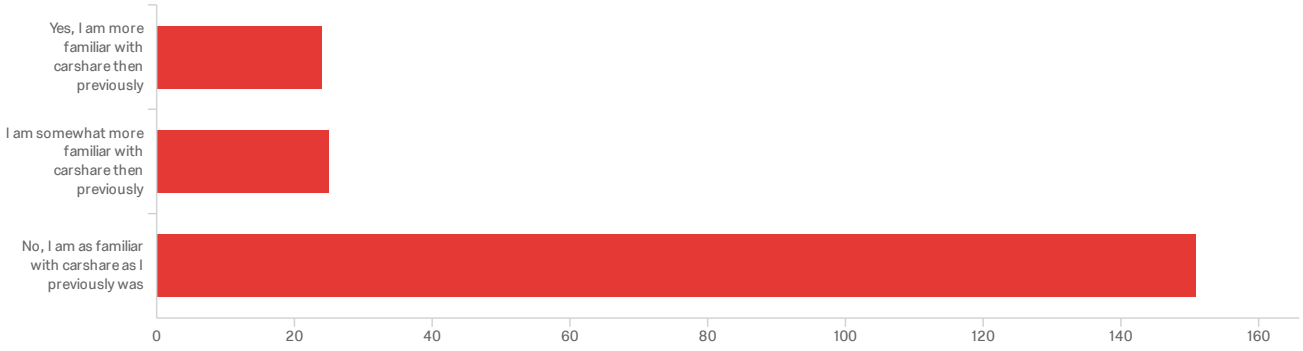


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	25. Would you be interested in accessing electric vehicles if they were made available through carshare?	1.00	2.00	1.07	0.25	0.06	162

#	Field		Choice Count
1	Yes	93.21%	151
2	No	6.79%	11
			162

Showing rows 1 - 3 of 3

Q28 - 26. Are you more familiar with carshare having completed this survey?



#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	26. Are you more familiar with carshare having completed this survey?	1.00	3.00	2.63	0.69	0.47	200

#	Field		Choice Count
1	Yes, I am more familiar with carshare then previously	12.00%	24
2	I am somewhat more familiar with carshare then previously	12.50%	25
3	No, I am as familiar with carshare as I previously was	75.50%	151
			200

Showing rows 1 - 4 of 4


P
2 HOUR
7AM-10PM
modo.
Modo Only
modo.coop
VEHICLES
WILL BE
TOWED
TOWING