CAR SHARING NETWORKS

ROLE OF CAR SHARING IN TRANSPORTATION SUSTAINABILITY

By
SPENCER BROWN
1103-1111 Beach Avenue, Vancouver BC V6E1T9 Canada 778 839 6140

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By SPENCER BROWN
Chairperson of the Supervisory Committee: Todd Litman
Director Victoria Transport Policy Institute 1250 Rudlin Street, Victoria, BC, Canada
V8V 3R7
E-mail: info@vtpi.org | Phone: (250)360-1560

ABSTRACT

Transportation within Canada plays a fundamental role in society; with mobility, people are able to interact (pursue leisure, conduct business, and transport goods), and access services. Personal vehicles are the main mode of transportation today and have many costs on society such as greenhouse gas emissions. Canada has recently ratified the Kyoto Protocol and now faces unique challenges of reducing emissions through encouraging sustainable transportation. Car sharing networks have great potential to sponsor emission reductions through reduced personal vehicle usage, without sacrificing personal mobility. Car Sharing is a sustainable alternative to the traditional personal vehicle. Car sharing is defined by a joint access sharing of automobiles that allow members to rent vehicles on an as needed pay per use basis located in urban dense neighbourhoods. Evaluating the role of car sharing and analysis in regards to sustainable transportation objectives are explored. This research defines sustainable development and its parameters to be inclusive of both a broad and narrow consideration.

Car Sharing offers social, economic and environmental benefits. One social and economic benefit emphasized is an increase in equity within low income users. This equity may be achieved through increased affordability by shifting fixed pricing structures and providing an alternative to costly fixed capital (vehicle ownership) expenditures. Another advantage includes a reduced vehicle ownership/use per-capita and its related infrastructure (road-infrastructure, parking facilities).

(Keywords: Sustainable Transportation, Car Sharing, Infrastructure, Equity, Mobility)

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Acknowledgments

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1. INTRODUCTION

Transportation and personal mobility is essential in ensuring vibrant functioning communities. A variety of transportation modes are required in order to ensure all community members have access to affordable, efficient and reliable means of mobility. Public transit, bicycle/walking and private automobiles are traditional modes of transportation that meet communities mobility needs with varying levels of success. The popularity of private vehicles has risen substantially within the last fifty years. Canada's urban cities transportation networks are increasingly becoming congested with traffic from personal automobiles. These automobiles emit air pollution, create noise, incur costs and increasingly require an-ever expanding support of infrastructure development. While automobiles present a number of challenges upon the community, they are also often highly convenient (providing the ultimate expression of personal mobility and spontaneity of travel) and automobiles have become a necessary transportation fixture, embedded within our modern culture and community. Automobiles provide convenience and freedom to travel, work, socialize, access to community services and aid in the transportation of everyday materials. In some cases these personal vehicles can provide, (psychological) personal identity and a sense of comfort of individuality and safety. However, population growth and the associated daily car-commute with these automobiles incur human health costs, and environmental impacts that challenge the very fabric of sustainable transportation.

In giving considerations to both short/long term sustainability, it is desirable then to ensure maximum efficient usage of transportation (mobility) options and to mitigate transportation (emissions) challenges. In reference to transportation sustainability (as narrowly defined), creative ideas and alternative technical solutions can offer innovative ways to solve challenges and meet a communities transportation needs. Transportation with reference to sustainability-broadly defined requires a more integrated vision that incorporates a wider approach and framework that provides feedback of integrated economic, social and environmental analysis. Of these solutions, the role of car sharing will be analyzed. Car sharing can play a larger role in creating a more sustainable transportation system. It has the potential of significantly reducing per capita motor vehicle ownership and travel amongst some groups. It gives people a way to use automobiles when they are needed without the high costs of vehicle ownership and the economic incentive to increase their annual mileage in order to get more value for their high fixed vehicle costs. Car sharing promotes freedom, spontaneity and flexibility within the mobility of transportation networks. Transportation could be defined as a service that ultimately facilitates mobility or the ability to move people and goods between fixed areas. Under this general definition, there are many people that are more interested in the services (convenience, safety, flexibility), transportation provides (getting from place to place with ease) and less interested in the product that does this.[1] Approaching transportation as a service (under this general definition) can be improved by analyzing how particular modes provide service.[2] Car sharing focuses on providing transportation services whilst it mitigates undesirable economic, social and environmental impacts. Car sharing closes the mobility cycle gap for those that do not own a vehicle, by providing an alternative means of transportation for the other modes that are less desirable.

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[1] In reference to pure mobility not in terms of people that have psychological or use transportation for social status symbols. Strictly referencing mobility as a utilitarian service.

[2] The idea of "**products as service**" was coined in 1993 by German chemists Michael Braungart and William McDonough.

Personal Transportation Experience

One of the most compelling reasons why I have chosen to write about the topic of sustainable transportation is because my life couldn't exist as I know it without everyday efficient, safe, affordable and convenient transportation. I have also chosen this topic due to the concern for growing global air pollution. When I first moved to Vancouver in 2003 I had no access to a private vehicle and thus depended primarily upon public transportation and other forms such as bicycling. I accepted a job that posted me to the office located in the Vancouver (Canada), suburb Coquitlam (30km away from my home). Although, I was living in a vibrant community the travel time with public transit took me one hour and fifteen minutes to undertake each way (this is compared to an estimated 39 minutes with a private vehicle). It also included three transfers and walking a distance of over half a kilometer along a highway and often within the rain. I could have moved closer to my office but at a cost of living within low density suburbs (demographically suitable for families) lacking entertainment, and ultimately sacrificing my social life. I then saw some advertisements about a car sharing network within Vancouver, so I called for more information and found it was a perfect match for my needs but couldn't initially afford the unexpected $500 deposit. After a few more months had passed I saved up the deposit money and became a new member of a car cooperative. While this has probably overall raised my greenhouse gas emissions somewhat, it has improved the quality of my life enormously. It is with personal experience over the last year with car sharing and transportation issues that helped fortify this research into sustainable transportation issues. My direct experience also empowers a belief that environmental considerations cannot happen in isolation or at the total expense of social or economic consideration. I have found that car sharing closes the mobility gap between extreme private car use and no car use. Car sharing provides my transportation needs with an added convenience, flexibility and greater travel options for approximately two hundred dollars per month including all costs (gas, administration, usage) and drove an average of three hundred and fifty kilometers on average over a six month period. During these past six months the cost and benefits are listed as the following:

Personal Benefits:

-Greater mobility through mobility access (to large vans and trucks facilitating the move of apartments on three occasions).

-Created job eligibility by having access to use of vehicle for work.

-Empowered day trips out to remote areas of interest (wilderness).

-Facilitated greater mobility and completion of tasks especially during times when transit ran infrequently or when no transit was available.

-Administration facilitated & organized recording of usage which will be used for tax claiming purposes.

Personal Costs:

-An extra '$75-200' dollars per month (although some of this was reimbursed through employment).

-Overall slight increase in personal transportation emissions.

-Some inconvenience of vehicles not being available due to last minute needs and on some occasions while using car sharing vehicles an extension of time was needed to complete my task, and extensions were unavailable due to other member reservations.

1.1 Inquiry

This research has four aims:

(1) Identify the mobility needs, trends and challenges of residential transportation.
(2) Examines how to reduce car usage without sacrificing personal mobility
(3) Examine the costs and benefits of car sharing.
(4) Evaluate the role that car-sharing can play within a sustainable transportation system.

Based on this I will attempt some general recommendations that could be applied in many countries around the world.

This research takes the arduous and challenging task of evaluating the role of car sharing within an interdisciplinary framework of economic, social and environmental consideration of analysis. It aims to address certain key issues related to transportation. In particular the discussion of emissions is chosen to be of key area of interest. This is chosen in part due to the timing and national awareness of global warming. Another key area of focus within this research is in the economics of mobility, in particular analysis between cost differences of personal vehicles and car sharing vehicles. This research discusses the issue of traffic congestion and of livable cities. All of these goals aim to be addressed within a way that minimalizes mobility disruptions. Sustainable transportation analysis aims to be examined through the lens of literature and case study. Sustainable transportation is referenced in terms of broadly defined and narrowly defined sustainable development. Transportation and its effects on human health and the effects of environmental degradation are examined.

1.2 Method and Scope

The purpose of this research is to explore the role of car sharing within a sustainable transportation system. This research uses a transdisciplinary method and analysis from the framework of integrated principals which include economic, social and environmental considerations. Literature review research methods are employed in order to overview car-sharing within a sustainable transport system. Causal Loop Diagrams will be used to aid understanding of many key complex variables within a system. In order to encompass analysis within an ecological sphere, analysis will occur with reference to a broad and narrow sustainability approach.

1.2.1 CLD Methodology

The uses of Causal Loop Diagrams are used to provide a broader understanding and illustration to the interrelatedness within a system. This is ultimately a tool of systems thinking. It allows conceptualization causalities and feedbacks between specific outlined variables within a system. Complex problems can be more simply understood visually with the aid of arrows which show either a positive or negative relationship. The limitation in general with CLD as a tool is that it can be too general or too simple. The strength of this tool lay within its ability to visually present feedbacks and interconnections within systems.

1.3 Limitations

Due to the very nature and complexity of interdisciplinary analysis, many complex transportation issues and subjects necessitate simplification. Due to the scope of this research (see above), only the summary of the consequences of automobile pollution are presented in order to illustrate the importance of this environmental issue within transportation. This research builds on the assumption that the aforementioned consequences and link of automobiles and pollution is understood and generally accepted. It is the aim of this research to analyze the benefit and costs of car sharing with reference to both broad and narrow definitions of sustainable development and to then arrive at collated analysis of these findings with reference to what role car sharing can play within Canada's transportation system.
There are limitations in regards to the complexity, experience and data within this research.

1.3.1 Complexity

Transportation networks are complex systems that are influenced by individual needs, values and technological constraints. Furthermore the local geography and economics also play a crucial role within transportation management. In short, transportation is composed up of the integration between economic, social and environmental considerations. Therefore identifying the role of car sharing within a transportation system involves much unraveling of complex issues. Every effort is made to research the role of car sharing with reference to many of these major influences. However, it is necessary to generalize some of these key issues. Transport demand management, is a key component of sustainable transportation, however; this subject and exploration of policy issues will remain limited. Environmental and health impacts from transportation emissions are discussed only in general. Other alternative transportations including public transit could not be explored in detail. Exploring the role of car sharing within a sustainable transportation system is like an anchor while navigating through a sea of transportation variables. This research paper is only an overall starting point or frame of reference with which to begin inquiry and application of sustainable transportation dynamics.

1.3.2 Experience

It is noted that actual working car sharing networks are a relatively new phenomena and currently operate at a very small fraction of total transportation modalities. There are a very small number of car sharing organizations (world wide organizations approximately five hundred locations and tens of thousands of members), the implications and potential for future expansion or new car sharing schemes are considerable.

1.3.3 Data

A notable limitation within the research of car sharing is the limited availability of independent survey and data collection. Current monitoring and data that assesses car sharing results has originated from surveys of proprietary sources. The data used in this research is meta analysis and secondary data drawn from CAN's case study. The data used in this research and from the case study correlates supportively from the data of other car sharing networks around the world. Qualitative data has not been used.

1.3.4 General Assumptions

A general assumption built into this research is that consumer behaviour allows for the possibility to shift current transportation paradigms. This allows a wider transportation role to encompass car sharing as a feasible concept. This paradigm shift is possible with the right economic, social and environmental educational tools. Car sharing is not an end within itself it has costs and benefits and is a tool that can be used to support the greater transportation network and is interdependent upon other transportation modes.

1.4 Car Sharing Definition

Car sharing will be defined as 'a network of individuals or an organization that shares joint access, ownership and usage of automobiles services'. These vehicles are pay per use and can be rented per hour. The access of the network cars are controlled through an administration organization that could either be based on a profit or not for profit (co-operative network) business model. Car sharing differs from rental cars in that it can be accessed more conveniently (in terms of proximity and location). The roles of car sharing and conventional rental car companies are fundamentally different and do not directly compete for customers. In the case of the Vancouver based car sharing organization a local agreement of mutually shared benefit exists between these two very different businesses and it can be demonstrated that this arrangement garners support in the rental company's favour.[3] Car sharing is different from 'ride-sharing' or car pooling and the main distinction is within ownership and driving arrangements. Ride-sharing/car-pooling has individual proprietorship, ownership or a designated driver and the vehicle use is essentially at fixed route and times.

1.5 Sustainable Development Definition

In order to better determine if Canada has a sustainable transportation system it is important to first define what 'sustainable development' both in principal and in philosophy entails. Much discourse and literature exists upon how we measure sustainable development and many people have articulated comprehensive definitions. Many local communities and urban cities have empowered comprehensive action plans in order to implement sustainable development initiatives.[4] For example the Brundtland, definition is the following "development that meets the needs of the present without compromising the ability of future generations to meet their own needs'[5]. Furthermore others have suggested; 'sustainable development' as a concept is dynamic somewhat changing with time and, "[s]ustainability therefore has physical, material, ecological, social, cultural, psychological, and ethical dimensions."[6] In general, sustainable development discourse includes integration of three key principals. It is not specific enough

[3] These two business models do not directly compete as rental car companies do not rent on an hourly basis, cater to different customers (such as business travelers) and CAN has an arrangement that provides a discount to it's car sharing members if they should wish to rent a vehicle through car rental agencies on a longer term basis.

[4] GVRD *Livable Region Sustainable Development Plan.*-Vancouver Transportation Plan (1997) is one such initiative that creates an action plan and acts as a guide for transportation demand management. http://www.gvrd.bc.ca/growth/lrsp.htm

[5] WCED *World Commission On Environment and Development. Our Common Future.* Oxford and New York: Oxford University Press., p.43

[6] Bossel, H. (1998). *Earth at a crossroads: Paths to a sustainable future.* Cambridge: Cambridge University Press. p7

to state that in developing a sustainable transportation system this concept is contingent upon three components or principles:
1) Economical
2) Social
3) Environmental
Both a broad and narrow definition can fulfill a more complex need to understand what exactly is meant when referencing sustainable development.[7]

1.5.1 Sustainable Development-Broadly Defined

Broadly defined, sustainable development will take into account the macro sphere that includes planning from a broad range of economic, social and environmental considerations of the present and future generations. These comprehensive spheres of influence overlap onto each-other and sustainable development decisions should only become derivative after collating analysis of the best social, economic and environmentally optimal results. A broadly defined approach of sustainable development might arrive at different results than a narrowly defined sustainable development definition. Sustainable development with reference to transportation may include the provision for an equitable, accessible, reliable, efficient, safe and comfortable mobility of people, goods and services.

1.5.2 Sustainable Development-Narrowly Defined

A narrowly defined approach of sustainable development might look predominantly at technical results such as policies that promote switching all new combustion engine vehicles sold on the market in Canada to electric-engine vehicles. This approach may appear attractive as it is easier to quantify and measure success in a relatively quick and fixed time frame. An example is in measuring the results of emission standards. This approach (in exclusion) does not fulfill a broad or deep definition of sustainable development because the aforementioned transportation planning (although addressing environmental air quality well), does not address the issues of traffic congestion or social and economic equity of those that cannot drive (elderly) or those that cannot afford to drive.[8]

1.5.3 Sustainable Development Applied to Mobility

The starting point of reference of sustainable development within the transportation sector (for the purposes of this research), encompasses a necessary mix of transportation options, modalities and policies (Public transit, bike paths, and related green-transportation infrastructure). Ultimately, a reduction in overall emissions and pollution (environmental consideration-narrowly defined) is one of three frames of reference for transportation sustainability. Affordability and costs is the second frame of reference for sustainability within the economic sphere and equity, reliability, safety and accessibility is the final frame of reference within the social sphere of sustainable transportation. When all three of these spheres are

[7]For a comprehensive assessment and definition of transportation sustainability please see: Litman Todd and Burwell David, *Issues In Sustainable Transportation;* Victoria Transport Policy Institute 26 Oct, 2005. www.vtpi.org

[8] For more detailed and comprehensive understanding of broad and narrow sustainability definitions refer to Litman Todd and Burwell David, *Issues In Sustainable Transportation;* Victoria Transport Policy Institute 26 Oct, 2005. www.vtpi.org

incorporated and encompassed then a broader definition of sustainable transportation development can be achieved.

The task of choosing any particular mode of transportation (non-fixed or fixed), is dependent upon many variables and factors. The following nine key points, suggest some of the variables on an individual basis.[9] These variables (listed in no particular order of preference), will have different levels of influence depending upon the individuals travel needs.[10]

1. Time savings of travel.
2. Parking requirements.
3. Required distance or complexity of travel.
4. Budget and affordability.
5. Comfort of travel (weather-rain/sunshine).
6. Security (of person/vehicle/bicycle) and safety.
7. Desired location (is location on a fixed route/non fixed route system).
8. If already have invested and own personal vehicle assets.
9. Environmental commitment

Table 1: Individual Transportation Needs

This presents indicators that represent some mobility considerations that need to be addressed if improvement in transportation is a goal. Individuals within a community have different lifestyles and different needs. This adds to the complexity of transportation issues. Through the aid of this matrix it is possible to use this as a guide to assist in analyzing components of a transportation network. Some of these needs are referenced in discourse throughout this paper to assist in analysis of the role of car sharing.

[9] Needs based on summarized literature and case study within this research.

[10] For a comprehensive list of overall sustainable transportation indicators and discussion see Litman, T; Burwell, D. *(2005), Issues In Sustainable Transportation,* Victoria BC, Victoria Transport Policy Institute (P1-23)

The figure (1) below provides visual representations of the complexity within a sustainable transportation system.

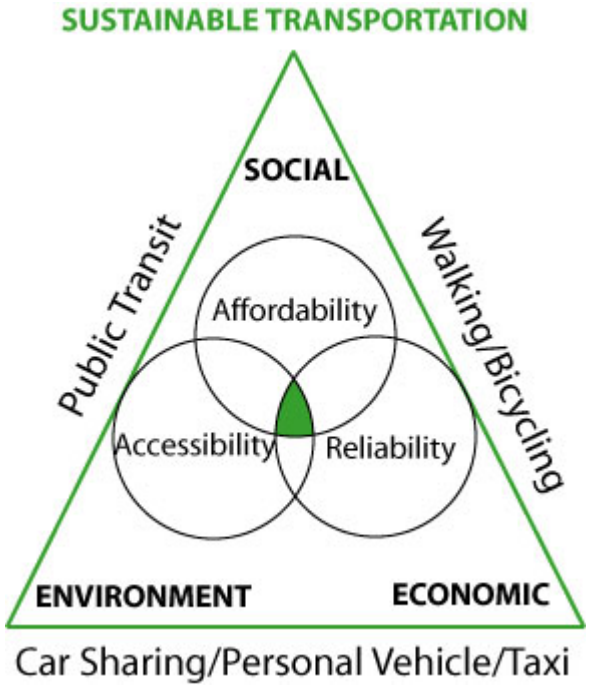

Figure 1: Elements of Sustainable Transportation based on Integrated Principals, Needs and Sustainability (Broadly defined).

This graphic is used to illustrate essential components of sustainable transportation within the community. The pyramid contains three essential pillars (Public transit, walking/bicycling, Car sharing) that unify and bridge transportation carriers. Transportation sustainability occurs within a variety of existing transportation options. The inner spheres (affordability, accessibility and reliability), illustrate that they are key components within a transportation structure which strengthen the flexibility and viability of the transportation mix. For example transportation must be reliable, affordable, but also user-friendly (within acceptable distance). These components are all framed within the backdrop of three integrated Tran disciplinary approaches. Economic, environmental and social factors are the meta-backbone of sustainable transportation and must be given equal consideration and consultation within a community transportation policy.

Price, performance, comfort, reliability and security are all factors (see sustainability matrix table), and key components considered in sustainable transportation planning. In consideration to

planning implementation of car sharing networks these key components should be considered. For example, analyzing the role of car sharing can be done with the aid of indicators within the sustainability matrix. In doing this we can see the differences between car sharing and private vehicles. Through researching the role of car sharing within a sustainable transportation system, the following question arises: is this the mode to best address emission reductions? Considering this question, perhaps the expansion of rapid public transit may better address emission reduction. The short answer to this pondering is that it really depends upon many variables (see tables 1 and 2). For example, if a community is willing to give up the convenience of door to door mobility that the private vehicles provides, then yes exclusive use of public transit is the best option. Another example can suggest that car sharing may not be necessary because the building of livable cities satisfies most mobility needs with the ability to walk or bicycle. However, this solution does not address the need that perhaps someone has the need to visit a family member and take them shopping or visit a remote area such as a park? Car sharing when used in conjunction with other transportation modes can alleviate these challenges other proposed transportation solutions create. Car sharing provides mobility and seamless service of travel when other modes of transportation don't meet the needs that the personal vehicle provides.

1.6 Key Transportation Requirements and Differences in Sustainable Transportation Planning[11]

Transportation planning requires Transportation delivers various types of services for the user and different travel demands require varying levels of services. It is desirable then for planners to ensure that transportation is not only sustainable but functions as a system and practical for the user. Table 1 can assist in determining the most appropriate mode of travel. These points are not of equal value and are not listed in any particular order of preference. These variables are only general guidelines and it can be assumed that depending upon the community and its circumstances, many compromises may have to be made in order to reach an optimal level.

1. Conserve fuel
2. Convenient travel
3. Promotes intergenerational equity
4. Promotes livable cities
5. Reduce vehicle congestion
6. Reliable mode of travel
7. Reduce vehicle noise
8. Reduce pollution
9. Safe mode of travel

Table 2: Sustainable Transportation Requirements

This list is an overall tool that can guide planning of transportation options and provide feedback into whether sustainability objectives are optimally met. These variables can be cross referenced with different travel modes in order to determine the costs and benefits (or any trade-offs), of any particular mode.

[11] Indicators based on transportation sustainability broad/narrowly defined as outlined in this research.

2. TRANSPORTATION IN CANADA

The majority of Canadians meet current mobility needs with privately owned vehicles as the dominant use of transportation. Canada has a population of 31,946.3[12] with 80% or 23,908,211 living in an urban area[13]. An average Canadian spends between 1.3-1.6 hours a day in travel time[14] and an estimated 182 billion kilometers each year.[15] Canada has a total of 25,100,296 vehicles registered nationally.[16] This mode of transportation currently accounts for 18% of Canada's total Green House Gas (GHG), emissions and according to the government of Canada 'every year, motor vehicles release more than 134 million tones of GHG's into the atmosphere.' [17] According to these government statistics; 49% of the average total produced greenhouse gas emissions in Canada, comes from transportation (all transportation forms). [18] Vehicle passenger travel within Canada has increased since 1990 by 15% increasing energy consumption by 1149.2 PJ to 1322.4 PJ in 2003[19]. The city of Vancouver (one of Canada's largest cities located on the west coast), has an estimated personal vehicle growth rate of one new car being added on the roads every 23 minutes and that "congestion could increase by a whopping 118 per cent by the year 2021"[20]. These statistics demonstrate that there is a transportation trend that requires planning and a need for transportation demand management which might include ways to mitigate negative costs associated (such as lowering GHG emissions). Furthermore, critics suggest that the market assumptions of the growing usage of automobiles reflects true consumer demand, by suggesting that current markets do not include proper cost externalities[21] or a lack of viable alternative transportation opportunities. Implementing a reduction in transportation green house gas emissions must be done with minimal interruption to transportation mobility. Without intervention and wise planning these challenges could affect the very core of Canada's quality of life such as include increased traffic congestion, traffic noise, and environmental pollution.

While addressing the challenges and needs of Canadians, analysis should encompass a broad perspective of sustainability to transportation modes. Canada's urban communities have different travel requirements and therefore, a good mix of viable sustainable transportation options must exist in order to meet the communities' needs. Providing a diverse mix of sustainable transportation modalities and

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[12] 2004 Statistics Canada data Government of Canada (access able on line and on file with author) www.statcan.ca (data on file with author) accessed Oct 10, 2005

[13] Based on 2001 statistics from Government of Canada Statistics Canada accessible online www40.statcan.ca

[14] see report for details:
WHO (2005) *Health Effects of Ttransport-related Air pollution*; P100 Table 3.3

[15] "The Auto$mart Guide: How to buy, drive, maintain your car and save money, energy and the environment Natural Resource Canada 09/09/02 ISBN 0-662-28256-6 Cat. No. M92-87-3-1999E www.nrcan.gc.ca electronic version accessed on Oct 11 2005 and on file with author.

[16] Stats Canada Cansim table 405-0004 www.statcan.ca (data on file with author) accessed Oct 10 2005

[17] Government of Canada 2004; *Your guide to the One-Tonne Challenge booklet* publication March 2004.

[18] Government of Canada statistics

[19] Transport Canada; *Energy Efficiency Trends in Canada, 1990-2003* (P36)

[20] Vancouver Sun Newspaper *Every 23 minutes, another car joins pack.* section B3 Nov 5, 2005

[21] Cost externalities: social cost is greater than the private cost. For example air pollution from personal vehicles are absorbed by the general public not directly by the private car user.

infrastructure is a preliminary step that then allows consumer freedom of mobility choice. Examples are: public transportation, bicycle paths, taxis, car sharing networks, private car ownership, and car pooling. These networks can help alleviate a communities' dependence upon the automobile and empower Canada to develop a car-light relationship. Car sharing is one mode of travel that strengthens access to community's mobility access. Car sharing will be analyzed in depth and public transit, car pooling, car rentals, bicycles and other modalities of travel will only summarized. Although, it is assumed that for car sharing organizations to work, access to other forms of transportation such as aforementioned transportation systems must co-exist and is ultimately interdependent upon such a system. According to the OECD, motor vehicle use in OECD countries is one of the main sources of air pollution than any other single human activity[22] Globally, all forms of transportation accounts for approximately 25% of the total world's commercial energy use and motor vehicles add up to nearly 80% of this figure.[23]

2.1 Freedom of Mobility

Within a broadly defined sustainable transportation system, it is important for a community to have a complex mix of mobility options including cost effective transportation. To meet the criteria of sustainable development (as broadly defined), this mix of transportation must be broadly accessible to include all socio-economic demographics to encourage transportation equity amongst the community. Without cost-effective transportation, individuals may be restricted with work or social activities that are fundamental components of a livable sustainable community. Car sharing may promote this freedom of movement by providing a cost effective alternative to personal vehicle ownership. Considering the following passage on transportation systems:

> "Our transport system provides many benefits, but it also causes many problems. It serves non-drivers poorly. It distributes benefits and costs inequitably. It is financially burdensome to households, governments and businesses. It is increasingly inefficient due to traffic congestion and dispersed land use. It is a major cause of death and disability. It contradicts environmental and quality of life objectives. It relies on non-renewable resources that may become scare in the future."[24]

Car sharing closes the gap and completes the link of a varied transportation mix. For example, someone may be able to get around with public transit but have the rare need for a personal vehicle for a challenging trip (non-public transit routes). According to Government of Canada statistics 12,183,410 people use personal vehicles to commute to work within Canada.[25]

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[22] Organization for Economic Co-operation and Development(OECD) see transportation documents accessible at www.oecd.org (as accessed on June 5, 2005)

[23] World Resource Institute. (2000*) 1998-1999 World Resources: A Guide to the Global Environment* New York: Oxford University Press, 1998. www.wri.org

[24] Litman, Todd (2005), Reinventing Transportation Exploring the Paradigm Shift Needed to Reconcile Transportation and Sustainability Objectives, Victoria BC, Victoria Transport Policy Institute (p1)

[25] See Stats Canada for full statistics and break down of modes of transportation used to travel to work. http://www40.statcan.ca/l01/cst01/labor42_96c.htm

2.2 The Personal Vehicle Demand

The growing popularity and use of personal vehicles often leads to longer commutes to or from suburbs and rapid growth of its related support infrastructure. Personal vehicles offer convenience and flexibility that other mode of transportations lack. This unrestricted travel can lead to urban expansion and the users' transportation commute from suburbs to the city. These land use patterns can create long term effects upon communities. This phenomenon can be best articulated by the following passage:

> *"Less immediate, but no less important over the longer term, are the effects of car ownership and use on the evolution of cities, encouraging the dispersal of land uses and generating inflated travel distances that sooner or later translate into traffic congestion on the arterial network. Finally, car ownership and use affect social welfare, re-distributing the benefits of mobility away from non-car using minorities and eroding the degree of social engagement across communities."* Furthermore, *"low-density suburban housing locks residents into a car-based lifestyle, eroding the demand for public transport and with it, the quality of life for the residual minority (for example, young and elderly dependents within car-owning families) who do not have discretionary use of cars."* [26]

This author suggests that land uses within a community are changed with the increased usage of the personal vehicle lifestyle. Ultimately leading a city into one littered with parked vehicles and a landscape hostile to the quality of life of those that choose to live within urban communities.

2.3 Random Route and Fixed Route-Transportation Systems

The personal automobile provides a strong role of mobility and benefit to the individual. While public transit is designed to also benefit individuals within the collective commons; however, public transit has other added benefits for the community. The private vehicle provides freedom of travel for tasks that are location challenged (non dense/remote area) or multiple tasks that are time sensitive or transit would be convoluted if traveled by other modes. Car sharing also provides these same features with the same level of commitment. Taber Stone classifies two systems of route transportation travel. "The conventional automobile/roadway system is a transportation system with a vast network of roadways (streets, highways and expressways) and a vehicle which acts as a free agent on this network, in the sense that the vehicle, at most times, has a great number of route options. I call this transportation category the random-route system".[27] This system promotes vehicles that ultimately can travel within and between any network of roads and infrastructure. It is this transportation category that dominates Canada's individuals-transportation mobility. The second category involves a more planned or scheduled form of transportation. This is described as a fixed-route system and "the fixed-route system, involves a limited (relatively) number of roadways, with the routes of the vehicle being predetermined".[28] The urban transit system fits under this fixed-route system as it operates under a pre-planned schedule and stops within designated pre planned destinations.[29] Car sharing may be best technically categorized as within the

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[26] Wright, C.; Curtis, B. (2005) *Reshaping the motor car* Journal: Transport Policy Volume: 12 Issue: 1 p 11

[27] Stone, Taber. (1971) Beyond *the Automobile: Reshaping the Transportation Environment*. Prentice Hall pp 6-13, p 6

[28] Stone, Taber. (1971) Beyond *the Automobile: Reshaping the Transportation Environment*. Prentice Hall p 7

[29] Stone, Taber. (1971) Beyond *the Automobile: Reshaping the Transportation Environment*. Prentice Hall P6-13

designated non-fixed route system but it also lends greater support to many other modes of travel taken within fixed-route systems. This is attributable to the fact that car sharing like a private vehicle runs on the individuals needs or schedule and can travel anywhere a road and a gas station is. At the same time, car sharing generally promotes travel within fixed-route systems by allowing a sharing of transportation burden to be split between these two systems. Through this attribute the individual has greater empowerment to decide which mode of travel is best suited according to ever-changing transportation needs. Some occasions may prove to be more optimal to elect travel within a fixed route system such as by taking a public bus, while another occasion may be better suited to choose a personal vehicle.[30]The table sustainable needs matrix summarizes in point form some of the key variables which may empower a decision such as one that solicits travel choice.

Consumer trends show that personal vehicles are a preferred mode of transportation[31]. However this may be due to a combination of distorted market mechanisms and a lack of viable sustainable transportation options. Regardless of the multitude of transportation tasks and challenges that individuals within a community encounter, a good mix and increase of travel opportunities or options can support the individual in making the best possible transportation choice that best suits the individuals' needs. Car sharing may greater provide this choice by creating another transportation option. This benefit that is provided by car sharing in theory plays a role within supporting the implementation of transportation sustainability (addressing in terms of broadly defined sustainability).

As noted in the transportation needs matrix, a variety of economic, social and environmental factors influence the transportation users' decision making process. These factors either promote or dissuade consumers from choosing one particular mode over another. In a Vancouver newspaper report on transportation issues (such as public transit), the following people offered there opinions on some of these factors. Please see table below regarding consumer trends and how the role of transit served them.

Question asked "Is your municipality well served by transit?"
"No. Because where we live, to get anywhere in to the main part of the city, you're going through more than one zone [and that's more expensive.] Even going to Burnaby we have to go through Vancouver to go to Burnaby" Heather Sharpe, 41 Arts administrator, North Vancouver.
"I'm well served by transit. I take it five times a week. It's clean, they show up on time. I've got no problem with transit. It's good." Jake Johnston, 38, fisherman, Vancouver.
"Clark Road is a major throughway. The noise level is too high and it's a major roadway so they are debating on light rail. It's controversial. I would like them to come up with what they're doing and do it." Monica Keller, 31, health-care worker, Port Moody.
"There are too many cars and not enough transit. I'd like to take the bus but it isn't efficient. It takes too long. It seems silly but from where I live, a 15-minute drive takes 45 minutes by bus." Jennifer Mackay, 61, retired, North Vancouver.

[30] Refer to transportation needs tables 1 and 2 within this paper.

[31] Please refer to previous chapter transportation on page 2 of this report for more information and supportive data referenced from government of Canada statistics.

"My community is reasonably well served by transit. I commute to UBC. The B-line is brilliant and they should expand that service. From my place, there aren't enough of them and they run pretty infrequently. From my place, it's consistently faster to take the non-express." Bernard Laval, 35, university professor, Vancouver.

Table 3: Consumer Perspective on Public Transport.[32]

This consumer survey illustrates varying opinions on the issue of public transportation and suggests that a high level of complexity regarding transportation needs exists (see transportation matrix table). One way to optimize these variables and ensure viable transportation, is to utilize tools such as by referencing a sustainability matrix table, when planning or implementing transportation development initiatives. Exploring creation or expansion of a car sharing network within the community could be analyzed with reference to the aforementioned sustainability matrix table. This would better aid in the decision making process for both the consumer or community transportation planners. The question then might be to look at what would be some current alternatives that could help alleviate some of these surveyed consumers' transportation challenges. Different solutions may very in order to best meet individual transportation needs with reference to transportation sustainability-broadly defined. These different solutions may have different advantages depending upon the result of different variable feedbacks; however, optimal solutions (such as car sharing networks), must be entertained should transportation sustainability as broadly defined become fulfilled. The preference of creating car sharing networks within some of these areas may be deemed optimal. Such as in the situation when current conditions (see chapter on car sharing networks) preclude viability of car sharing networks.

3. ENVIRONMENT

Transportation modes present environmental challenges. Technological solutions may be a viable solution; transport demand management and alternative transportation are all likely candidates to be explored. Car sharing may in theory alleviate some of these emissions if it does in practice change individual behaviour which then lowers actual vehicle usage. Should this objective be actualized on a larger scale than is currently present then car sharing can play a limited but key role in the reduction of emissions by encouraging local solutions that mitigate emissions dispersed into the environment.[33] This reduction would be largely credited to car sharing roles in shifting transportation behaviour. Car sharing advocates and literature optimistically states that this occurs by an overall reduction in owning and using personal vehicles. The main distinction with this form of transportation over other forms such as public transit is that car sharing schemes offer consumers access to vehicles (albeit shared access), which doesn't sacrifice the freedom and flexibility needed for some trips that are currently used by personal vehicle.

3.1 Impacts

Transportation demands many kinds of material flows. The majority of personal vehicles require gasoline to fuel the engine. The growing demand and need for gasoline exposes risks to the environment.

[32] Vancouver Sun Tuesday November 1. 2005 B2

[33] Refer to section in this report on car sharing fleet and education.

The risk of oil spills is increased as growth in consumption of oil requires increased shipping and transportation of oil and other related petroleum products. Vehicle creation and disposal is all part of the lifecycle process of personal vehicles. This lifecycle process creates another resource intensive challenge that has impacts upon the environment. Vehicle materials include materials and components made from (metal, rubber, plastic, chemicals, batteries, oil and gas) and when the vehicle is beyond disrepair, must then become recycled or otherwise disposed of in landfills. Should car sharing capture a larger part of the transportation market, significant reductions in material flows as previously outlined may occur.[34]

3.1.2 Green House Gas Emissions

Transportation is an important and necessary component of society however, personal vehicles, create varying amounts of emissions with usage. Carbon Dioxide (CO_2), Carbon Monoxide (CO), Hydrocarbons, Nitrogen Oxides (NOx) emissions are all common during automobile usage. In addition to automobile usage (driving), evaporative emissions also occur through operating a personal vehicle. According to the USA Environmental Protection Agency, these evaporations occur through, running losses, diurnal losses, hot-soak and re-fueling. [35] These automobile emissions contribute significantly to air pollution. CO_2 emissions are one of the largest contributions automobiles emit; in fact an average vehicle produces many times its weight in CO_2 emissions. According to the government of Canada Auto$mart publication "[t]he average car produces about 2.4 kilograms of CO_2 for every liter of gasoline used".[36] All of these aforementioned emissions lead to both direct and indirect undesirable environmental, economic and social challenges.

These concentrations of emissions are dispersed by vehicles into the atmosphere, and are otherwise known as greenhouse gases**.** These varying emissions all result in increasing amounts of greenhouse gas concentrations dispersed throughout the environment. Greenhouse gases, in general promote the trapping of heat near the surface of the earth. This result is then causing global temperatures to rise, which in turn is triggering changes in climate.[37] While localized air quality often suffers from this phenomenon, these emissions contribute to a global problem. Vehicle emissions disperse these greenhouse gasses throughout the environment and can lead to transboundary pollution.

A Type of transport vehicle	B KM per day	C CO_2 grams/km	D Total CO_2 grams per (50km)	E # of people in vehicle	F CO_2 grams per person*
Sm. Truck	50/day	179	3570	1	3570
Bike	50/day	0	0	1	0
Transit	50/day	17	42	30	14.0

[34] Assuming a reduction in overall vehicle creation.

[35] http://www.epa.gov/otaq/consumer/05-autos as accessed Sept 30, 2005 (also on file with author). (P3)

[36] Government of Canada, http://www.epa.gov/otaq/consumer/05-autos as accessed Sept 30, 2005 (also on file with author). (P9)

[37] Please see Intergovernmental Panel on Climate Change reports http://www.ipcc.ch/ for detailed discussion and technical data

Table 4: Illustration of the potential emissions created by various modes of transportation.[38]

It is presumed that not all transportation is equal in function therefore this table only serves a limited function to illustrate that more passengers per single trip equal in a reduction of total trip emissions.

3.1.3 Global Warming

Global Warming as previously mentioned can be defined as, "a warming of the earth's atmosphere as a result of increases in the concentrations of one or more greenhouse gases"[39]. Carbon dioxide, chlorofluorocarbons, methane, nitrous oxide and water vapor, are all cumulative pollutant greenhouse gases that contribute to the greenhouse effect phenomenon. These gases' sources originate both naturally and anthropogenitcally. This greenhouse process is the result of these gases that are near the earth's surface and release heat in the atmosphere by absorbing the solar heat (radiation). Once this infrared radiation has been absorbed it is then re-radiated down towards the earth, however; at this stage it is converted into the form of longer-wavelength (heat), radiation. If this process results in an increase in atmospheric gas concentration greater than the ability of natural absorption then the net result will be gradual warming of the environment.[40]

Increasing certainty amongst international scientists, of the connection of anthropocentric influenced Greenhouse Gas emissions and Global warming have become evident and well understood.[41] Automobile pollution can directly harm humans but also lead to long-term environmental impacts (global warming). An excess of automobiles pollution such as (CO_2, CO, NOx, VOC), can have immediate human-health impacts, Global warming has longer-term ecological global impacts that can result in varying levels of human-health degradation. (See CLD 1). The science behind global warming is best summarized by the government of Canada as this: "The international community has concluded that there is compelling scientific evidence of climate change. While uncertainties exist about the exact rate and timing of future changes, the average global temperature is likely to increase between 1.4 ^{o} and 5.8 ^{o}C by 2100. This may sound modest but during the last ice age, the average global temperature was only 5 ^{o} cooler than it is today. In Canada, we have just completed the 19th consecutive season of above normal temperatures. This is well beyond the range of natural climate variability." [42] Scientists have raised concerns about the growing international phenomena of global warming. Policy makers from many countries joined together to form an international agreement that would lower global emissions throughout signatory countries around the world. This accord was called the Kyoto Protocol to the United Nations Framework Convention on Climate Change.

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[38] Table adapted from climate change north (http://climatechangenorth.ca) as accessed September 03, 2005 (P5-6)

[39] Miller, G. (2002) *Living in the Environment;* 12th Ed. Brooks/Scole, Belmont, USA (G7)

[40] Miller, G. (2002) *Living in the Environment;* 12th Ed. Brooks/Scole, Belmont, USA (G7-8).

[41] Refer to Intergovernmental Panel on Climate Change (IPCC) recent reports. http://www.ipcc.ch/

[42] Government of Canada http://www.climatechange.gc.ca/english/publications/canadascontribution/highlights.html (accessed Aug 20, 2005)

3.1.4 Kyoto Protocol

In 1993, Canada became signatory to the United Nations Framework Convention on Climate Change. Furthermore, it was February 16, 2005 that Canada undertook in taking the next step and level of commitment in reducing Canada's national Green house gas emissions by ratifying the Kyoto Protocol.[43] Canada is currently faced with the environmentally rewarding challenge of meeting the needs and criteria of the Kyoto agreement. This legally biding agreement (to be implemented between the periods of 2008-2012), calls for a reduction of 6% of Green house gasses produced in Canada measured with the 1990 as baseline. How to implement this must now be agreed upon in regards to guidelines and processes.[44] According to the government of Canada, this reduction of six percent when calculated at current (2005) inventory levels of green house gasses translates into much more reductions. Due to the growth of current emissions from the originally calculated 1990 levels, statistics conclude that Canada currently must lower our emissions by an estimated 26% since the level of GHG's have grown significantly since 1990.[45] With the Kyoto Protocol now in force, Canada has to accomplish an emission reduction of approximately 1 ton per capita by the year 2012.[46] Whilst some environmental critics call for larger reductions, Canada negotiated that a fair and optimal pollution level of emissions to be set at the six percent reduction level. Optimal pollution can be defined as: the pollution level that maximizes net social benefits.[47] The Canadian government in 2003 has invested in a budget of close to four billion dollars for the purpose of taking action on climate change.[48] A range of options for meeting emissions targets exist, as the ultimate goal of the Kyoto protocol is to reduce GHG emissions. While it is recognized that the measured reduction of emissions is an issue of sustainable development-narrowly defined, actual implementation of how reductions occur can come from the roots of a broadly defined perspective of sustainable transportation development. Car sharing on average has a ration of ten members to one vehicle, therefore it can be said that nine vehicles are prevented from being used for transportation. It is also assumed that car usage is reduced. Several studies have shown that former car owners had reduced the vehicle mileage within a range between 33-58%[49] Car sharing supports the goal of reaching this target implementation by providing strengthened mobility options while achieving an emissions reduction in overall private car ownership and usage.

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[43] Government of Canada http://www.climatechange.gc.ca/english/newsroom/2005/kyoto_feb16.asp ministry of environment(accessed Aug 20, 2005)

[44] Refer to Kyoto protocol agreement

[45] Government of Canada (2005) *office of energy efficiency* http://oee.nrcan.gc.ca

[46] As of the year 2004 the government of Canada sponsored a challenge to all Canadians to reduce emissions by one tonne (on average Canadians create 5 tonnes of greenhouse gases annually). For more info visit http://www.climatechange.gc.ca/onetonne/english/

[47] Harris J. (2002) *Environmental and Natural Resource Economics*: A Contemporary Approach. Houghton Mifflin, Boston

[48] See Environment Canada for data and publications also available online http://www.ec.gc.ca/climate/home-e.html

[49] See German case study Baum and Pesch as referenced in The Journal of World Transport Policy & Practice. These reductions of driving based on willingness to travel via other transportation modes such as public transit but also some foregone travel.

3.1.5 Emission Reductions Using Technology

The issue of improved technology plays a limited but important role within the transportation sector. 'Material efficiency' and 'resource productivity' are two concepts energy experts Amory Lovins, uses to illustrate where we need to focus upon issues of sustainability and he "contends that resource productivity in developed countries could be improved by 75-90% within two decades using existing technologies" [50]. Conventional cars are inefficient and very inefficient in design. Amory Lovins[51] writes that:

> "The conventional car is heavy, made mostly of steel. It has many protrusions, edges, and seams that make air flow past it turbulently. Its great weight bears down on tires that waste energy by flexing and heating up. It is powered by an internal combustion engine mechanically coupled to the wheels. Completely redesigning cars by reconfiguring three key design elements could save at least 70 to 80 percent of the fuel it currently uses"

This alternative vehicle technology has limited applications in terms of transportation sustainability when the term sustainability is broadly defined. It is noted that vehicle design has the potential to resolve reduced measurable or quantifiable environmental benefits through emission reductions. This may satisfy sustainability when narrowly defined; however, it does not satisfy the criteria for sustainability as broadly defined. For example, the issue of price affordability comes into question. Some, public financial funding may be necessary or consumers may have to spend a large portion of there income to pay for the fixed capital expenditure of these newly designed vehicles. The problem of increased vehicles within our communities and its related parking infrastructures including traffic congestion is also not addressed within improved vehicle technology. One possible solution to this deeper sustainability challenge is including planning solutions that aims to encompass both a broad and narrow sustainability strategy. Numerous possibilities that could satisfy this criterion exist such as encouraging fleets of more energy efficient vehicles within organizations that already have policies that encourage reduced or shared driving. These fleets could be found within car sharing networks, car pooling organizations, government fleets and other suitable businesses that provide subsidized transit to its employees. This marrying of vehicle technology to policy promotes emission reductions while encouraging other transportation options.

3.2 Emissions and Human Health

Human health impacts from transportation air pollutants are well documented. It is estimated that within Canada 16,000 premature deaths are attributed to air pollutants.[52] According to the World Health Organization "[t]he effects on health of transport-related air pollution are among the leading concerns about transport. Research in recent decades consistently indicates the adverse effects of outdoor air pollution on human health, and the evidence points to air pollution stemming from transport as an important contributor to these effects." (P XIII)

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[50] Miller, G. (2002) *Living in the Environment;* 12th Ed. Brooks/Scole, Belmont, USA (P58)

[51] Hawken P, Lovins A, Lovins H. (1999) Natural *Capitalism: Creating the next industrial revolution,* p 24 California, Little Brown

[52] Suzuki, David (2003) *Climate of Change* (p1-6) accessible online at http://www.davidsuzuki.org/files/health_exec.pdf

The effects of photochemical (suspended particulates) air pollution are chest and eye irritations. These increases in photochemical air pollution put vulnerable people (elderly, asthma sufferers) at disproportionate vulnerability and risk of compromised health.

Air pollution from transportation can cause the following health concerns:
-**Respiratory Diseases (asthma/chronic obstructive pulmonary diseases)**: this can occur by long-term tissue damage or within some cases a limiting of the ability to collect and deliver oxygen.
-**Cardiovascular Disease:** this can occur through pollution (chemicals) becoming absorbed in the bloodstream, thereby up taken and affecting blood vessels and or heart.
-**Allergies:** sensitivities to allergens and infections can be irritated.
-**Neurological Effects:** toxic substances in air pollution can bio-accumulate thereby damaging neurological systems.

Table 5: Air-pollution and health effects [53]

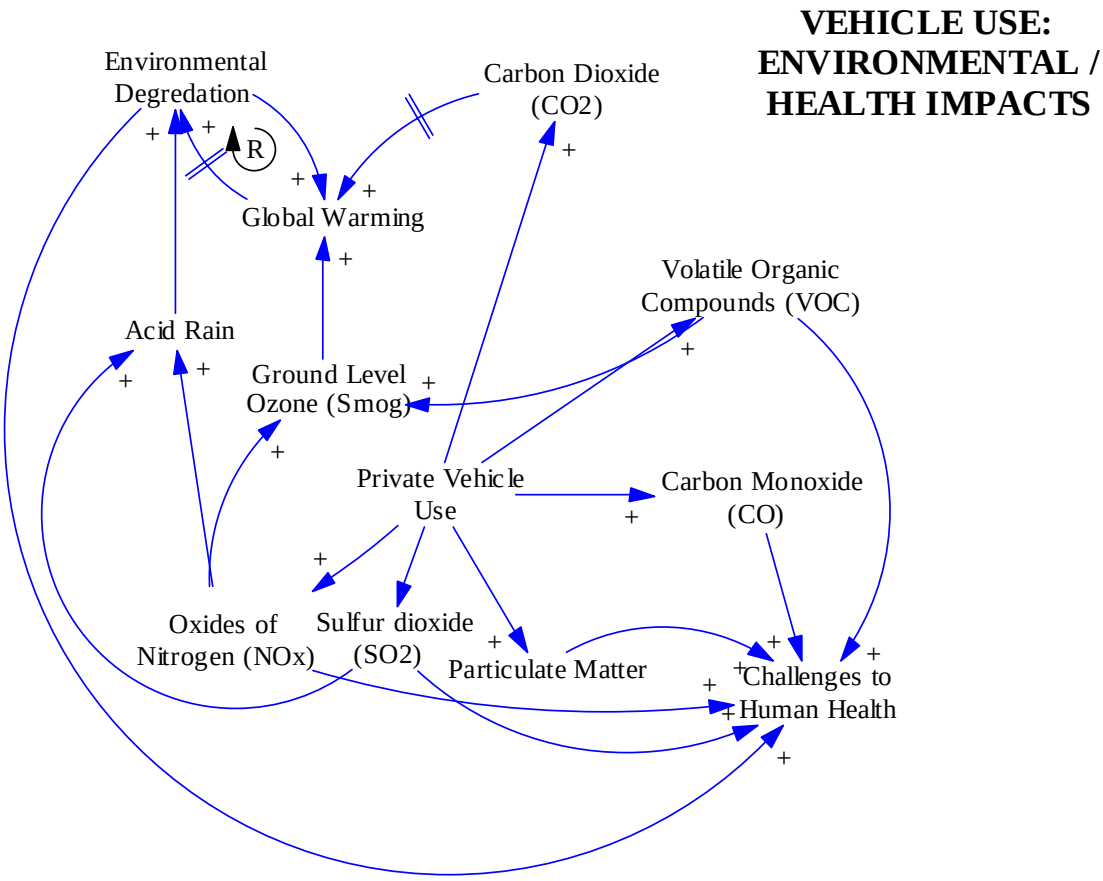

Figure 2: CLD showing Vehicle Emissions and Related Environmental/Health Impacts.

[53] Information adapted from Environment Canada website.

CLD LEGEND: This causal loop diagram illustrates a mental model of several key dynamic forces at play with regards to sustainable transportation. The arrows illustrate causality relationship between one or more variable. The positive or negative (+/-) suggests either a increasing or decreasing correlation and feedback of influence between variables. A thicker arrow correlates a strong connection or factor. The // symbol denotes a delay in time of causality.

Within this CLD is a general simplification of vehicle usage and emission impacts resulting from vehicle use. This model shows (with varying levels of efficacy) that these emissions have a causal relationship with and directly affect human health in a negative manner. These emissions also have a relationship with and lead to environmental damage which then can lead to human health impacts in a negative way. Two time delay marking indicators suggests time delays from the point of emissions released to its impacts upon global warming. This CLD only shows the negative effects and impacts of vehicle usage and does not look at the many beneficial services and conveniences vehicles use incurs. This model assumes current (business as usual) combustion engine vehicles being used and does not include technological solutions or other technology that reduces car emissions.

4. CAR SHARING OVERVIEW

Car sharing functions by having many vehicles located in different geographical areas available and accessible throughout the city. In order to access vehicles, minimal effort is required of members in terms of administration; all that is required is an on the spot telephone call to book the closest available car location. Alternatively, these joint access members reserve any available vehicle by logging in advance onto the internet which creates a reservation for the desired vehicle and time of choice. Other than securing the desired car and designated time, the only other administrative member duty is to write in the cars master-trip generation log book once the trip has been completed. This trip-log includes tracking of all mileage driven and keeps a good administrative paper track of member's usage. Car sharing vehicles are designed with convenience and located locally near urban densely populated areas and communities. Another suitable location can be found near major transit throughways such as major transportation hubs. These vehicle locations are usually either within close proximity of walking distances to member homes or offices and near public transportation areas. Car-sharing networks develop through advertising such as word of mouth despite the fact that almost all or many members do not know each other. The principle of car sharing can best be summarized with the following:

> "Individuals gain the benefits of private cars without the costs and responsibilities of ownership. Instead of owning one or more vehicles, a household accesses a fleet of vehicles on an as-needed basis. Car sharing may be thought of as organized short-term car rental." [54]

The application of car sharing can be summarized as the missing link between private car usage and non car usage and since there is no fixed capital costs it tends to shift the emphasis from product to service.

[54] Britton, Eric, (2000) *Car sharing 2000: Sustainable Transport's Missing Link,* The Journal of World Transport Policy & Practice. Lancaster, UK: Eco-Logica Ltd. (P16-17)

4.1 Suitability

Car sharing is the best option for those who do not depend on a car for daily use. For example, car sharing is not for the individual that (with necessity) drives more than 10,000 kilometers per year or to and from work each day. The typical member is one who lives within a highly dense community and has access to primary transportation modes (transit, bicycling, and or ride-sharing). These networks are clearly not advocated for everyone or every community but there is a growing need for such networks.

4.2 Equity Objective

The issue of equity is of substantial interest and benefits with regards to the role that car sharing plays within transportation. Transportation is considered an essential service and is subsidized to varying degrees within communities. Transportation costs contain externalities and are hidden to the user and local communities. Much of this cost is absorbed by national government bodies that some estimates believe can annually add up to hundreds of billions of dollars.[55] It should be noted that although greater equity through car sharing for poor people has great potential, most car sharing members are Caucasian, well educated and professionally employed.[56]However, this may be due to a lack of knowledge and understanding about car sharing organizations.

Car sharing has the potential to provide increased mobility to those who don't drive because of financial hardship (unable to purchase vehicle/insurance). This is especially important for individuals in lower income categories such as students/elderly/underemployed. The underemployed can benefit in terms of improved quality of mobility and not having to invest in expensive fixed capital which might be a large disproportionate economic expense.

	Hour $	**KM $**	**Yearly $**	**Parking $**	**Convenience**
Car share network	**$2**	**.20**	**$360**	**0**	**High**
Private car	**0**	**.12**	**$2000**	**$300+**	**High**
Taxi	**$25.20**	**$1.41**	**0**	**0**	**Very high**
Transit	**0**	**0**	**$980**	**0**	**Moderate**

Table 6: Economic Cost of Car Sharing Versus other Transportation Modes:
*taxi costs are $1.41 km, initial 2.44 fixed (initial flagging fee) and 25.20 hourly charges, [57]
Public Transit Costs based on city of Vancouver 95$ two zone access. [58] Private car km based on fuel, maintenance, tires. Yearly costs based on insurance and car loan.[59]

[55]For more information refer to Mackenzie James et al. "Research Report: The Going Rate: What it really costs to drive" (P1-32)

[56] Please see research paper: shaheen, Schwartz, and Wipyewski "U.S. CAR SHARING AND STATION CAR POLICY CONSIDERATIONS: Monitoring Growth, Trends & Overall Impacts". August 2003 " (P12)

[57] http://www.city.vancouver.bc.ca/ctyclerk/cclerk/20050315/a5.htm Feb 28, 2005 City of Vancouver administrative reports. As accessed on Oct 1, 2005

[58] http://www.translink.bc.ca/Transportation_Services/Fares_Passes/fare_pricing.asp

[59] See Canadian Automobile Association 2005 edition for a more specific and detailed analysis. http:// www.bcaa.ca

Car co-op yearly costs are administrative costs. These costs are average based and may vary depending upon actual usage over time. Furthermore, it is noted that not all forms of travel are of equal value or service.

4.3 Cooperative Auto Network (CAN) Case Study Background

The Cooperative Auto Network (CAN), launched as the first car sharing network in the English speaking world, in January 1997 in Vancouver, BC Canada. CAN, is a not-for-profit co-operative incorporated to promote car sharing as an environmentally-responsible alterative to personally-owned vehicles. CAN is a debt-free self sustaining car-sharing organization. CAN, has a strong commitment to provide mobility while promoting social, economic and environmental sustainability objectives. [60] CANs' objectives are based on the following:
1) Reduction of anthropocentric contribution to greenhouse gas emissions;
2) Reduce stresses on green space and promote livable cities.
3) To improve the local air quality through a decrease in non-source point pollution amounts released and
4) To promote alternative mobility options such as walking, bicycle, and public transit.
CAN aims to achieve these objectives through ensuring that CAN is more affordable than the personal vehicle option. CAN, addresses the issue of equity and recognizes that it is a serious issue for those people that cannot afford the high fixed costs of private vehicle ownership.[61]

Since the inception of CAN organization the CAN current membership status as of November 2005, reached 2062 active members and 112 automobiles[62] CAN, membership to vehicle ratio is currently at 18.4 to 1. CAN organization, launched with minimal government and public funding[63]. Personal loans were taken out and a friend initially donated a used Pontiac-firefly vehicle to launch the network. The city of Vancouver provided CAN, with parking assistance. This assistance was generally provided through a means of discounts for permits that allow CAN members to park in all residential parking permit zones within the city.[64]

4.3.1 CAN's Results

Quantitative data was not used throughout this research, but secondary data that originates from the car sharing organization themselves was analyzed. Of particular area of analysis was with CAN case study. CAN

[60] www.cooperative auto.net suite 205, 470 Granville St., Vancouver, B.C. V6C 1V5; Tel 604-685-1353

[61] Jensen, Nicole "The Cooperative Auto Network Social and Environmental Report 2000-2001" (P1-16).

[62] Cooperative Auto Network statistics October, 2005

[63] November 10, 2005 interview with CAN founder Tracey Axelsson ($20,000 was amount of government funding).

[64] This permit parking is coveted amongst users and regarded as a large benefit as most of the small communities only allow for parking of residents within that geographical boundary. For example a typical journey as low as two kilometers can result in inter-boundary crossings.

reports to have achieved significant results within a number of key areas and issues this is based on a survey (year 2000) and analyzed in a Social and Environmental report. 370 out of 676 CAN members responded to the survey sponsored by CAN.

Costs:

- Members save money by not having to purchase expensive fixed capital costs of a vehicle; instead members pay a $500.00 refundable deposit to join the car share network.
- Transportation costs can be reduced when compared with owning a personal vehicle and within CAN members pay an average of $75 per month for all driving needs which when compared with private car ownership, is less than the cost of insurance.

CAN Member Kilometers Travel Comparison:

- CAN members report a reduction in total vehicle kilometers traveled as compared to someone who owns and travels with their own vehicle. This may be attributed to members compensating car travel with other modes of travel. For example in the year 2000, CAN members had driven an average of 1,400 km per year, about 10 times less than the average Canadian driver). This reduction of kilometers traveled correlates (although with varying degree) with other studies, for example in Switzerland car sharing members that gave away there vehicle reduced their transportation with cars by 72% (6,700 kilometers).[65] According to the Journal of World Transport Policy & Practice some studies have suggested that

> "Mobility Car sharing Switzerland study (conducted by the former ATG) reported that car mileage for individuals who owned private vehicles was reduced by 33-50 percent after they joined the CSO… In the Netherlands, former car owners reduced car mileage by 37 percent—from 15,907 to 10,095 (9,880 to 6,270 miles) annually. Former non-car owners reduced private vehicle mileage by 29 percent—from 5,394 to 3,800 km (3,350 to 2,360 miles). These numbers are the average of four CSOs that were studied… Similarly, for Germany, Baum and Pesch reported that carsharing reduces private car mileage by 58 percent, from 7,044km to 4,073 km (4,375 miles to 2,530) per year, after membership". (P36)

This data suggests that a reduction in greenhouse gas emissions may occur if members overall kilometers driven are reduced.

Distance Travelled and GHG Emissions for all CAN Vehicles (2000)

	Total	Per Member
Kms Driven[1]	681,727	1,383[3]
GHG Emissions[2]	158.2	0.32

[1] Includes 8,518kms from rental vehicles.
[2] Greenhouse gas emissions in metric tonnes of CO_2 equivalents.
[3] $\frac{total\#kms}{average\#members}$

Personal Vehicle GHG Emissions

Distance Driven	GHG Emissions[1] for 76 Vehicle	GHG Emissions[1] per Vehicle
6,000 km/year	111.8	1.47
12,000 km/year	223.4	2.94
18,000 km/year	335.2	4.41
24,000 km/year	446.8	5.88

[1] Greenhouse gas emissions in metric tonnes of CO_2 equivalents.

[65]Please see Energy 2000, Switzerland 1998 study for more information.

Figure 3 Source: Jensen, Nicole "The Cooperative Auto Network Social and Environmental Report 2000-2001" (P6).

*Personal vehicle GHG Emissions are estimated based on single occupancy usage.

CAN Member Emissions:

- Greenhouse gas emissions (In the year 2000, CAN conducted a member survey and found that its members emitted an average of 0.32 metric tones of CO_2 equivalents, about 10 times less than the average driver). Figure 3 below shows the greenhouse gas emissions comparison between car share members versus Personal vehicle emissions. This data correlates with other case studies. However, some research (in particular-countries in transition or developing countries), suggests that car sharing may enable some communities to increase overall transportation emissions by enabling more personal vehicles usage when otherwise it could not be previously afforded.[66]

CAN Vehicle Ownership:

- According to the member survey 28% of CAN members had sold or given away there vehicle within the previous six months of joining CAN membership and in total up to 50% had sold or retired there vehicles at some point (within previous five year period), before joining CAN membership. Many members report that they would purchase a vehicle if they did not belong to CAN. What this equates to is a reduction in overall vehicles within the community and on the road. CAN organization has a ratio of 18 members to one vehicle.[67]

4.3.2 CAN Business Initiative

CAN, also provides a car sharing project that caters to small businesses. This is called CorpCAN. Some of the potential benefits to CorpCAN members are listed as the following:[68]
1) Less reliance on employees to have to use there own vehicles.
2) Less worries about liabilities when driving CAN vehicles.
3) Benefit of a standardized key system to vehicle (and cost effective means to replace keys if lost).
4) Detailed accounting that includes accurate documentation that includes time used and km's driven.
5) Less aggravation about finding parking spots.[69]
The benefits to CAN regular members include increased usage of vehicles during peak times of need. CorpCAN vehicles are reserved during the business week and only made available to non business CAN members during evenings and weekends. This may assist in providing more vehicles during busy times and satisfy residential CAN members' vehicle needs.[70]

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[66] Some research suggests that countries in transition that previously have relied on modes of public transportation may have the opportunity to drive more with car sharing schemes actually increasing there overall transportation emissions. However, this research and case study experience (in terms of emission reductions) is strictly referring to the experience of Canada.

[67] Jensen, Nicole *The Cooperative Auto Network Social and Environmental Report 2000-2001* (P3).

[68] *These aforementioned benefits are directly from CAN's website and are not evaluated in this research. However, the potential benefits could be desirable for small businesses.

[69] Source reference CAN website: www.cooperativeauto.net/projects/corpcan.html

[70] According to CAN member needs based on trends in some locations.

4.4 Transportation Convenience and User Cost Analysis

Within transportation there are many variables that contribute to the decision of choosing a mode of transportation. Three main variables of dominant influence are; the 'user cost advantage', 'convenience', and 'annual mileage' or stated as distance traveled (including frequency of use).

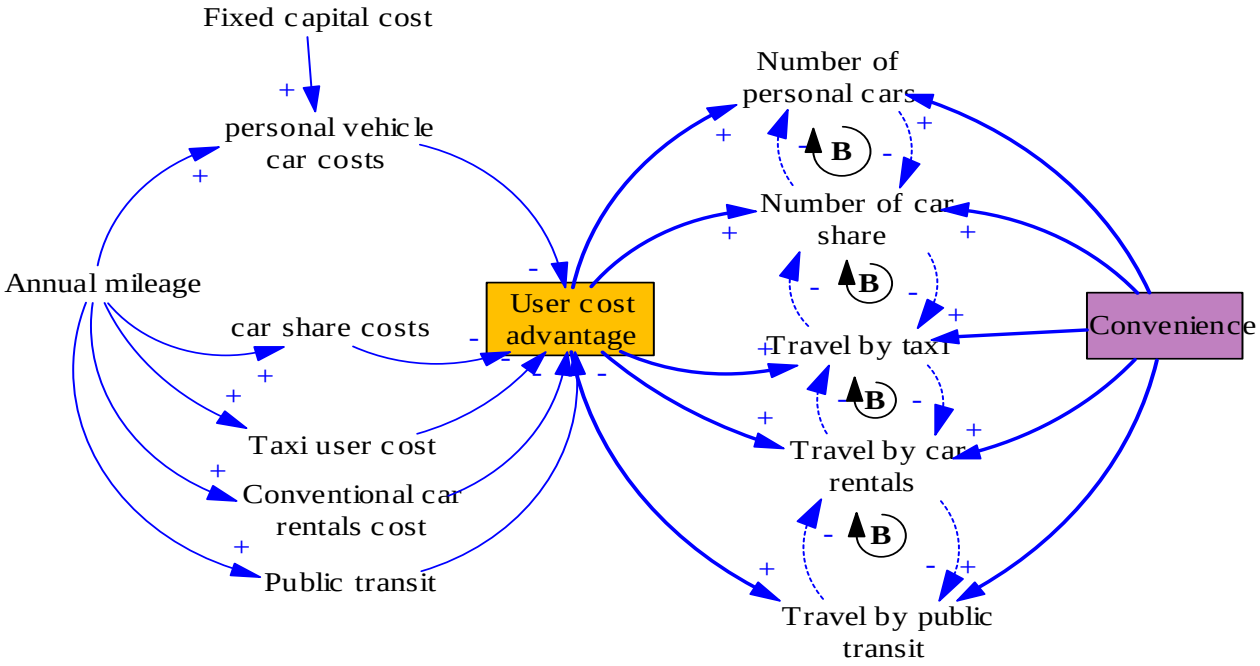

Figure 4: Fixed Car Sharing Costs versus Fixed Personal Vehicle Costs[71]

This CLD is showing some of the key variables that influence the decision of choosing transportation options. It also helps to explain the user expenses for various modes Figure 5 (below). This model shows that the more annual mileage traveled, more costs are incurred. However if we refer to the graph in figure 5, we can see that the potential costs (as well as the service) vary significantly, for example private vehicles costs remain linear and increase only marginally over the travel frequency of use and mileage. However the starting costs are significantly higher for the personal vehicle and this is implicitly due to the high fixed capital costs of purchasing a private vehicle. This can be a barrier for some people in choosing the personal vehicle as a choice and as a mode of travel although many Canadians undergo financial hardship in order to purchase a private vehicle and current trends show that the private vehicle is the dominant mode of travel for Canadians. Fixed cost is a determined cost and includes the following: insurance, vehicle financing costs, vehicle registration and licensing fees. All of these costs must be paid even before transportation or mobility can begin. Non-fixed costs depend upon amount of usage or operating costs. These operating costs depend upon frequency of driving, distance driven, maintenance costs and how the automobile is driven. (Please see table below regarding cost comparison). This greatest cost associated with these private vehicles is the initial purchase capital and insurance costs; thereafter, the gas, maintenance and parking is minor in comparison. This cost relationship can create a

[71] This model is generalized in its approach and ultimately many other factors and variables will also contribute to the decision of travel mode. Some costs (parking, infrastructure, pollution), are still externalized.

psychological car ownership/usage dependence cycle. The private vehicle once purchased can create the need or desire to get full use or maximize the vehicle investment. This cycle can result in reinforcing car ownership, car culture and perpetual car driving as ones primary (or exclusive) mode of transportation. [72] Current market trends of high reliance on personal vehicle mobility may be partially contributed to the phenomena that owning a car encourages driving it (due to the fact that for owners of private vehicles there is no artificially added costs of time or mileage to use their vehicle). Car sharing, taxi and car rentals for example, all become significantly expensive with frequent mileage or usage. Car sharing, for instance is much cheaper than conventional car rentals if used for very short term trips (from a few hours and up to a day or two), it also can have a higher convenience rating over conventional car rentals as it is located in non commercial urban areas. However, car sharing becomes quite expensive if used over extended periods of time, car rentals become more economical if used for several days at a time or longer, however this too becomes a more expensive option when transportation from a personal vehicle is required on a daily basis for an extended period of time (several months). The public transit mileage only marginally increases and remains the most cost affordable of all transportation options. However, the convenience factor plays an important role in transportation choices and many people may choose another mode of transportation due to the very fact that it may have a high convenience rating. Finally users of transportation may lack crucial knowledge of mobility options and or mobility networks may be limited within the community.

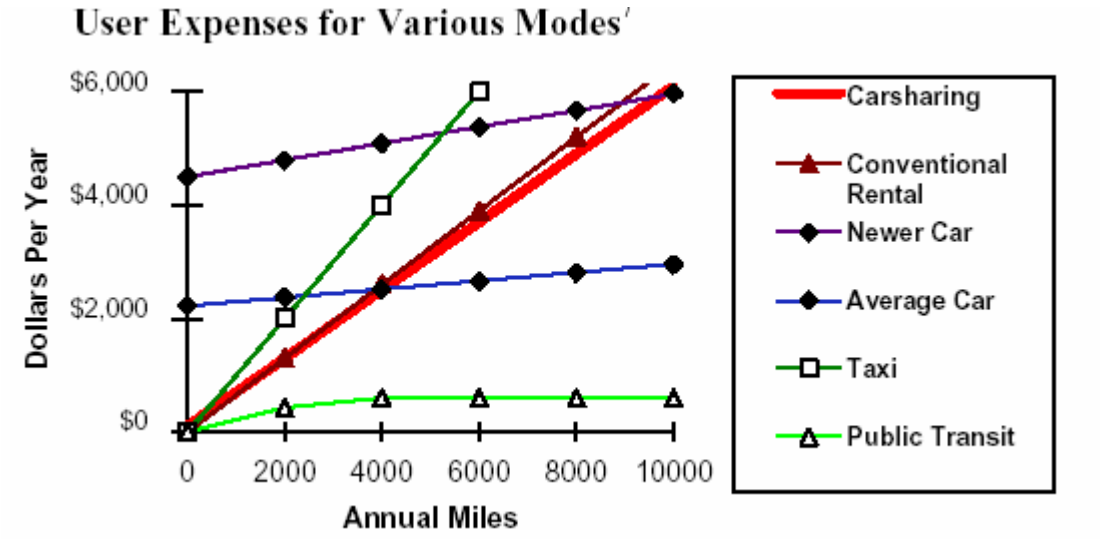

Figure 5: **Transportation Usage Expenses**[73]

This figure illustrates the user costs comparison of different modes of transportation. It shows that personal vehicles (with high fixed costs and low variable costs), have costs that only marginally increase over usage; this is contrasted with car sharing costs (with low fixed costs but high variable costs), have costs increasing significantly over usage. This high/low-fixed/variable cost pricing structure, creates a

[72] Please see limitations outset within the beginning of this research. It is recognized that other factors contribute to the determining factor, such as lack of viable transportation alternatives.

[73] Figure 5 source: Todd Litman, (1999) *Evaluating Car Sharing Benefits* www.vtpi.org (p3 Figure 2)

market incentive to either drive more (personal vehicles) or drive less (car sharing networks). This graph also demonstrates that car sharing has limited usage and becomes more expensive than owning a personal vehicle if used frequently. One significant advantage as illustrated within this graph is the cost differences between the average (used) and new car costs as compared to a car sharing vehicle. Many car sharing networks use new cars exclusively or have a significant portion of new cars within its fleet. What this means is that the car sharing member can have access to new vehicles such as fashionable mini coopers or technologically savvy electric hybrids without having to purchase the high fixed capital costs associated. Many owners of personal vehicles cannot afford newer vehicles and purchase a used vehicle. Whether the vehicle is purchased as new or used, a significant portion of there yearly income incurs costs to own, insure and operate a private vehicle. Therefore the case can be made that if one prefers driving a new vehicle over an older model then the value of using personal vehicles can for some people be increased when switching from an older vehicle of personal use to a newer car sharing vehicle. Of notable interest in figure 5 is the apparent similarity between costs of Conventional rental vehicles and car sharing. It should be noted that these figures are based upon an average use over time. The main difference between these two modes of travel is that with a conventional car rental, the vehicle is rented for longer periods of time such as between 1 to 7 days. This compares to car sharing rentals which are often range between ½ to 3 hours. Furthermore, because the car rental facilities are located within commercial centers, car rentals are not designed for very short trips-usage. Car sharing vehicles have vehicles distributed throughout the residential community and are both convenient and economical for short usages, of even half an hour at a time.

4.5 Transportation Initiatives and Associated Resource Use

Car sharing networks have significant potential to foster greater independence from a car based economy by encouraging alternative transportation while still maintaining the convenience and freedom of occasional automobile travel. This relationship extends its benefits beyond the individual to encompass the wider community. This is done by encouraging independence from a car-based economy/infrastructure and the significant negative social, economic and environmental side-effects that stem from car-culture. Within the bigger picture (ecological footprint)[74], car sharing not only has the potential to reduce gas and oil consumption through reduced use but also personal vehicle creation and disposal. Assuming a ratio of ten car sharing members to one vehicle, demand for creation of nine vehicles is eliminated. Considering all of the flow of resources needed to produce and dispose of a vehicle, a life cycle analysis of the personal vehicle would show all of the energy and materials throughout the lifespan of its use. For instance intensive energy is required to fabricate and assemble the vehicle. Then maintenance and usage creates more resource use. Finally, at the end of its life; the vehicle must be disposed. Car sharing can lead to considerable energy and resource savings since the resource extraction of materials needed to create a vehicle and use it are substantive. Car sharing provides another transportation option of comparison value to the personal vehicle mode of travel. Transportation initiatives can be shifted from the dominant paradigm of car dominated infrastructure development to incorporate greater use of other transportation initiatives.

[74] Wackernagel, M. and W. Rees. 1996. *Our Ecological Footprint: Reducing Human Impact on the Earth*. Gabriola Island, BC: New Society Publishers.

4.6 Barriers to Car Sharing Networks and Organizations

One of the fundamental barriers to car-sharing (within existing car-share network communities), is lack of understanding or knowledge about the existence of a potential network and its benefits within a community. Initiation or expansion of car cooperatives can only move forward and grow, if there is a critical mass interested in joining. This relationship creates a reinforcing loop that reinforces lack of network expansion.

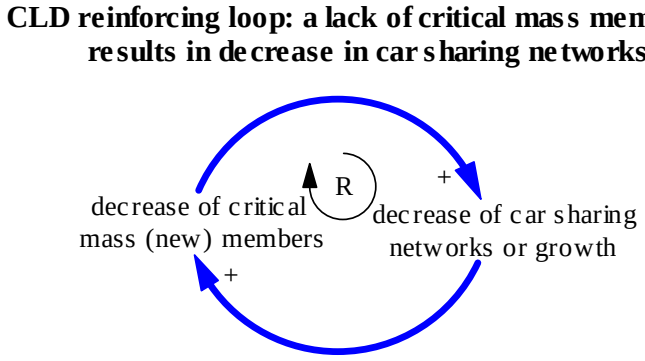

Figure 6: Critical Mass to Car Sharing Growth

Fees, Costs & Subsidies

In order to attract greater membership to car sharing networks, the associated user fees should be of fair market value and generally economical. A foreseeable barrier to increased members may be if prices increase. This may happen with increased competition as the market is fairly young and as it becomes more saturated with car sharing (for profit) organizations then prices may be driven up. Another barrier that deserves consideration is the issue of government subsidies and cooperation. Since car sharing has limited national governmental policy and involvement: it remains a community issue at the local level. Local government involvement remains non-standardized and provides varying support to car sharing networks. A national framework or policy may help to address this barrier. The subsidy of start-up grants may encourage new organizations to invest in businesses, fueling local jobs and greater mobility throughout urban cities of Canada.

The initial start up membership fee may present a barrier to implementing members' interest and with actually joining the cooperative. Emotional factors may play a significant role in potential target market membership interest. For example, individuals may associate cars with status symbols or have an unwillingness to share a vehicle with someone else.

4.6.1 Barriers to Car Sharing Members (Access)

To survive, car sharing networks must maintain fiscal sustainability and ensure that members are safe and responsible while using the organizations' assets (automobiles), therefore many car sharing networks often have a criterion to be met:

- No at fault vehicle insurance claims history (within past several years)
- No Motor vehicle related convictions

- Neutral (good), credit rating
- At least several years driving experience or minimum age requirements

This may be a barrier to some potential members and may affect particular young drivers and economically marginalized. CAN; however, has an initiative that on a one off basis and as needed, relaxes the good credit rating criteria. Knowledge of car sharing organization is of key necessity and if this is lacking then it presents a barrier to potential membership.[75]

5. CAR SHARING - VEHICLE SUPPORT AND SERVICE

Car sharing can play a larger role in managing and maintaining a fleet of vehicles. This allows the potential for the ability to sponsor targeting programs that encourage emission reductions. The challenge to the organization lay within sponsorship administrative costs. However, this can be budgeted and be both included and collected within member monthly administration fees. The car sharing networks could potentially encourage and disseminate driving tips through either invoice method (captive audience), or by offering annual seminars and courses that promote driving safety and driving efficiently. Personal vehicles on the other hand leave maintenance and efficient driving up to the owner.

5.1 Efficient Vehicles

Efficient vehicles can play an important role with both shared and personal vehicles. Many vehicles have different energy consumption patterns and environmental impacts.

> *"The contemporary automobile, after a century of engineering, is embarrassingly inefficient: Of the energy in the fuel it consumes, at least 80 percent is lost, mainly in the engine's heat and exhaust, so that at most only 20 percent is actually used to turn the wheels. Of the resulting force, 95 percent moves the car, while only 5 percent moves the driver, in proportion to their respective weights. Five percent of 20 percent is one percent"*[76].

In response to these energy efficiency patterns transport demand policies at times lobby for either volunteer or mandatory fuel economy standards /emission reduction standards. These policy initiatives can at times be in response to market behaviour. For example, vehicle market trends have recently shown a greater market share in sales towards more fuel intensive vehicles (minivans and sport utility vehicles). This trend has resulted in an energy consumption increase of 18.7 PJ and also a 1.3 Mt related increase of GHG emissions.[77] According to a Natural Resource Canada commissioned Ipsos-Reid survey, data showed that environmental concerns played a small part within any decisions of new vehicle purchases. One reason for this behavior may be that Canadians do not realize their direct effect

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[75] Jensen, Nicole. (2001), *The Co-operative Auto Network Social and Environmental Report 2000-2001* Page 13-14

[76] Hawken P, Lovins A, Lovins H. (1999) Natural *Capitalism: Creating the next industrial revolution*, California, Little Brown chapter 2 *P24*

[77] To access data and trends please refer to Natural Resource Canada: *Energy Efficiency Trends in Canada, 1990-2003* (P37) Cat. No. M141-1/2003 June 2005

of fuel consumption and the impacts upon total GHG emissions.[78] What ever the reasons for these market trends, these statistics provide both a challenge and opportunity for transportation emission reduction initiatives. The challenge lies within implementing tools such within transportation demand management (optimal pricing) and in appealing to consumers about the environmental and economic costs associated within the purchase and usage of high emission vehicles. The opportunity lies within the net environmental benefits of emission reductions that can easily be achieved at minimal cost to the individual. Car sharing networks through design and incentive encourage a reduction of overall kilometers driven per member. However; members can further achieve a reduction of greenhouse gas emissions through access to a ready fleet of fuel-efficient vehicles, made available through the car sharing networks. An ideal example is that of the electric hybrid Toyota Prius. The Toyota Prius 2005 model has a fuel rating of 60mpg-city/51mpg-Hwy and this can be compared to a Toyota Camry which has a rating of 20mpg-City/28mpg-Hwy.[79] Some critics have pointed out that due to the high fixed costs of replacing batteries and other specialized components, electric hybrids are only cost effective and ideal for very persons of very high usage such as taxis.[80] Car sharing organizations fall within this category of very high usage, however because the vehicles are shared only the vehicles result in heavier usage but not the overall km traveled per person.

5.2 Intelligent Driving as Promoted through Car Sharing Education

Engine performance can vary depending on how the engine is driven. For example frequent pumping of the vehicle gas and breaks while driving will result in greater energy expenditure. Certain engine speeds (or reduction in speed), can foster optimal engine efficiency. Driving at speeds of 90 km per hour instead of 100km per hour can often reduce gas consumption by 10 percent. Furthermore, when driving at speeds of 100 km per hour instead of 120 km per, then this can reduce fuel consumption by about 20 percent. [81] Rapid acceleration and breaking can increase fuel consumption and may also lead to an increase in vehicle maintenance. Due to the lack of precise monitoring mechanisms, any changes to this type of driving behaviour, largely remain voluntary. Car sharing organizations do have a distinct advantage at encouraging this behavioral change. It is these organizations that better have an opportunity to sponsor fuel efficiency through driving education campaigns. This campaign would likely disseminate driving in a fuel efficient manner through suitable educational methods (information pamphlets or seminars).

5.3 The Role of Vehicle Maintenance and Fuel Efficiency

Car sharing and personal vehicle use require proper maintenance for greater transportation sustainability. According to Canada's department-office of energy efficiency, "[e]ach tire that is under–inflated by 2 psi (14 kPa) causes a 1 percent increase in fuel consumption."[82] Under inflation can also lead to uneven

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[78] Ipsos-Reid Corporation, (2003) *New Vehicle Owners/lessons – Vehicle Purchase/Lease Behavior*, preliminary report produced for Natural Resources Canada, p. 62.

[79] cars all referenced as mid-sized sedan and accessed data on U.S EPA *GreenVehicleGuides* http://www.epa.gov/autoemissions/all-rank1-05.htm as accessed on Sept 30, 2005

[80] See the UNDP; *world energy assessment*, for a general summary of costs and benefits of alternative vehicles P78

81 Climate Change North; http://climatechangenorth.ca/section-LP/LP_31_HI_S_transportation_SH.html (P3) as accessed Oct 30 2005

[82] Canadian Government Office of Energy Efficiency http://oee.nrcan.gc.ca/transportation/personal/driving/autosmart-maintenance.cfm?attr=8#challenges (as accessed on July 25, 2005)

distributed wear of vehicle tires, thereby decreasing the lifespan of the tire itself. Should this tire experience deterioration through uneven wear, this may result in an increase of tire manufacturing and consumption. Car engine maintenance can play an important role in emissions reductions. A lack of properly maintained engine can lead to inefficient fuel consumption. For example, **"**A poorly maintained car can consume between five and fifty percent more fuel than one that is properly maintained."[83]

Car sharing networks can capitalize on the opportunity of ensuring that vehicles are properly maintained with optimal performance and efficiency of the engine and vehicle. Vehicle maintenance has financial costs associated that will be offset with proper maintenance. This can be implemented through routine scheduling and planning management within the car sharing networks. The economic, social and environmental benefits accrued can potentially reach well beyond the car sharing network. For example, reductions in overall resource will be of benefit to the community. Routine maintenance of vehicles has the potential to achieve sustainability within the narrow sense, so it is again assumed that this initiative should be partnered with the educational component that overall personal vehicle usage should be reduced. The aforementioned reference to a narrow view of sustainability can be best resolved by widening the lens of analysis to better address challenges, such as the challenge of how to achieve transportation sustainability when populations are growing in urban centers.

6. CAR SHARING ECONOMICS

The economic advantages of car sharing can be classified into two categories. The first is to the car sharing member and the second advantage is to the community. The member has minimal upfront fixed capital costs and can save money while still having comparable use of a personal vehicle. Car-sharing networks require an initial nominal fixed refundable deposit (between three to five hundred dollars) from this point after the member then pays per use. This initial deposit is usually held as a deposit or used as a deductible in case of member at fault damage to vehicle. The only other fee which many car sharing organizations charge is the monthly administrative fee which fluctuates between the price points of fifteen-forty dollars range, depending upon member usage category. These costs are inclusive of all insurance, gas and maintenance of the vehicle. This can be compared to someone who drives a private vehicle. Within private vehicle ownership there are costs associated with insurance and with an initial fixed capital cost that can vary within the tens of thousands of dollars range. Significant costs such as monthly payments for parking are also often required of urban dwelling private-automobile users

Car sharing schemes can exist as a business model as a profit or not for profit manner. Either way can result in the same services being delivered in terms of user transportation mobility. Car Cooperatives are in many cases non-profit and prefer to re-invest in the coop's assets, members and community. Although, car sharing can exist viably as a non-profit or for profit organization and is the case with the City of Toronto's Auto share network.[84]

[83] Climate Change North http://climatechangenorth.ca/section-LP/LP_31_HI_S_transportation_SH.html p 3 as accessed on Aug, 20 2005 (and on file with author)

[84] Auto Share network; .Toronto, Canada (2005) http://www.autoshare.com

6.1 Economic Benefits of Community

The second economic benefit rewards the community. This occurs by reducing cost externalities of environmental, social and economical impacts that stems from heavy automobile usage within the community. (See table 1 regarding impacts human health & environment).

Table 7: Potential Benefits to Car Light Communities

1) Safety increases from reduced traffic flow
2) Cost savings of infrastructure development (road maintenance)
3) Local retail and business activities strengthened
4) Additional space for usage
5) Energy saved
6) Noise lowered
7) Aesthetic pleasure
8) Alternative transportation encouraged/accessible (increased exercise)

Table 7 illustrates some of the potential benefits communities have from a car light community. Car sharing networks may promote a community less dependent upon personal vehicles, however; it is assumed that a critical mass of networks or considerable growth would be required in order to achieve significant results.

Table 8: Potential Costs to Car Light Communities

1) Venture capital and subsidies may be needed from the community for a period of time
2) Perceived disproportionate initial costs to renovate towards green infrastructure
3) Initial challenge of thinking (perceived inconvenience), having to plan ahead 'transportation'

This table (8) illustrates some of the potential costs associated with car sharing networks. It is assumed that initial start up capital from within the community or government may be necessary to implement or boost the presence of car sharing organizations although this wasn't necessarily the case with Cooperative Auto Networks organization.

6.2 Livable Cities

Livable cities can play an essential role in improving the quality of life in a community. Transportation affects many components within these cities such as increased noise, pollution and congestion. Despite the amount of time vehicles are used for transportation, they still require parking which takes up valuable land.[85] This use of land is especially important in geographical areas that are limited by land use, for example the city of Vancouver, Canada is largely surrounded by ocean and mountains. These parking spaces are economic assets that could be used to benefit the community. Car sharing can potentially promote green space and reduce parking spaces. Assuming a ratio of ten car sharing members to one vehicle is created; then, nine areas of seven to ten square meters of parking spaces are reduced. These

[85] Vehicles still take up 100% of its parking space the rest of the time despite its not being used.

could be used in a plethora of other ways including promotion of parks, walkways and beautiful neighbourhoods. (See figure 8 Mole Hill case study for case study example).

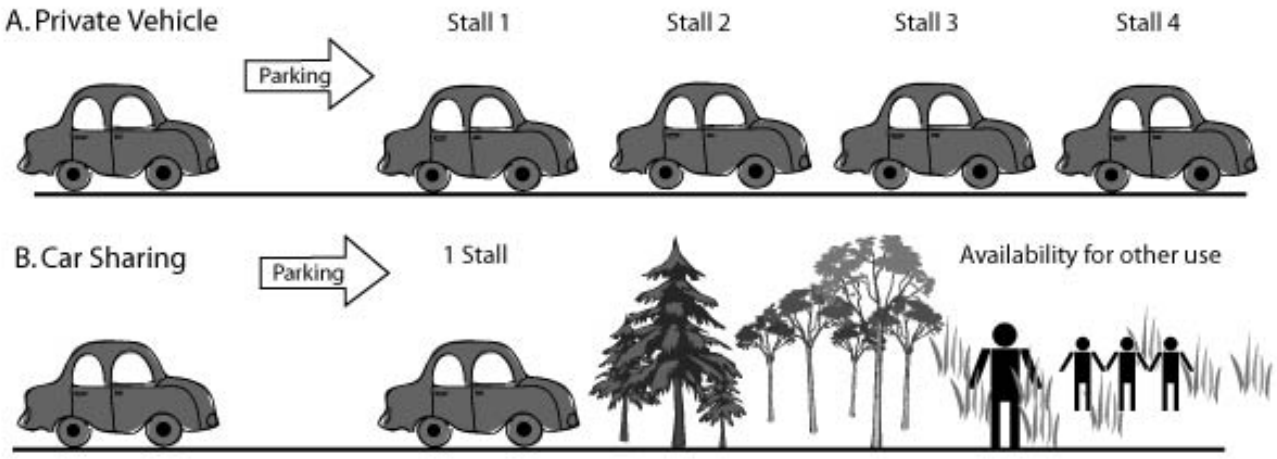

Figure 7: Car Parking Infrastructure vs. Other Uses

Within this picture we see (A) the private vehicle model (representing four cars) and its associated parking requirements. This is contrasted with (B) the Car sharing vehicle (representing four members to one car) and its associated parking requirements. With reference to the case study Cooperative Auto Network, direct experience in reducing parking structures was achieved. CAN, worked with city planners and developers to decrease development of parking structures within a community area called 'Mole Hill'. The area development is located in the downtown city core of Vancouver. Initially developers planned on creating sixty two designated parking areas; however, CAN was able to negotiate a net savings of thirty eight parking spot areas. These savings occurred through the design and implementation of allocating four car sharing vehicles within that same area. The visual benefits from this negotiation have led to an enjoyable area with a stream, parking benches and a green corridor of beauty within the neighbourhood.[86] This parking reduction has estimated Canadian economic savings to be at $746 per house and $743 per apartment.[87]

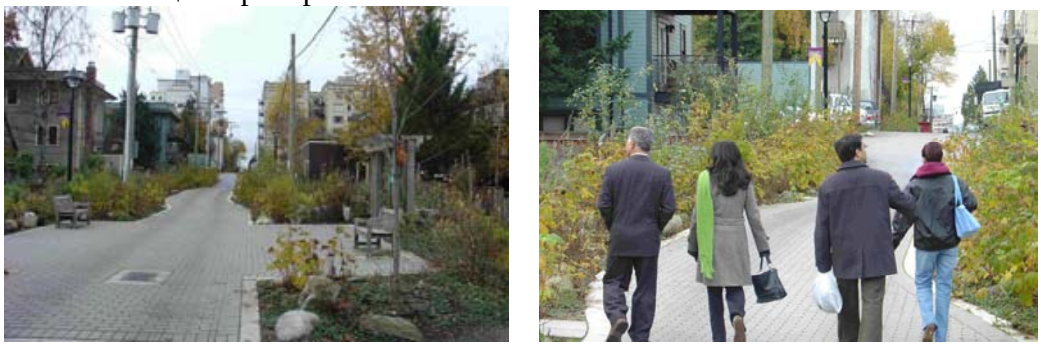

Figure 8. Mole Hill Neighbourhood (Optimum Use and Parking Area).

[86] Based on interview with Tracey Axelsson conducted on Nov 09, 2005

[87] Litman, Todd *(2005); Transportation Cost Analysis, Techniques, Estimates and Implications*. Victoria BC, Victoria Transport Policy Institute 3.4-3-3.4-7

6.3 Parking Flexibility

The advantage to car sharing members' vehicle parking can mean a priority allotment of designated parking. This is the case within Sun Fleet, a car-sharing network located in Sweden and within the city of Vancouver, Canada Cooperative Auto Network (CAN) where members are permitted to park joint access vehicles at designated special areas and permit zones. This access creates a positive incentive to car sharing members and a savings of time and money that would otherwise be allocated to parking. This policy rewards the members behaviour of relinquishing there need to have a private parking space that would otherwise be used permanently for parking a privately owned vehicle.

Figure 9. Image Source from left to right: 1.SunFleet car sharing network; Goteborg, Sweden 2.City of Vancouver, BC, Canada 3. 'CAN' organization, Vancouver BC, Canada

Private vehicle ownership per capita also has commercial/ retail ramifications and affects the physical structure of businesses. For example, commercial and retail businesses perceive the business need to satisfy potential customers growing demand for designated parking structures. This results in the planning and building of vast parking facilities (an extreme example could be malls or big box shopping centers such as Wal-Mart). With regards to empty parking lots and infrastructure development; Cervero, articulates the following:

> "Empty automobile seats, parking lots, and roadway stretches are among the most wasted of societal resources. In the United States, shopping centers are typically designed to serve parking demand at the twentieth busiest hour of the year (during the week before Christmas), which leaves spaces vacant more than 99 percent of the time they are open, and leaves at least half of the spaces vacant 40 or more percent of the time".[88]

6.4 Infrastructure Expansion

Canada has an extensive network of roads and government expenditures on transportation average $18 billion annually. According to Transport Canada's' road transportation infrastructural statistics, "[t]he Canadian road network exceeded 1.4 million two-lane equivalent kilometers. The network consisted of 110,000 kilometers of freeway and primary highway, 115,000 kilometers of secondary highways and other arterial roads, and more than 1.2 million kilometers of local streets and rural connector roads."[89]

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[88] Cervero Robert, (1998) *The Transit Metropolis: A Global Inquiry*; Island Press Washington, D.C. p 83

[89] Cervero Robert, *The Transit Metropolis: A Global Inquiry*; Island Press Washington, D.C p63

Despite all the efforts in developing a spider web network of roads and infrastructure, Canada's cities are often congested. A vicious cycle consists of the following; more cars lead to more roads which then lead to a greater dependence upon cars as a mode of transportation. (See figure 9) This network of car infrastructure reinforces the need to use cars as the primary mode of transportation. This process is further articulated as the following phenomena "car ownership and use affect social welfare, re-distributing the benefits of mobility away from non-car using minorities and eroding the degree of social engagement across communities"[90]. The use and need for multi lane highways and roads displaces those that would like to use other modes of transportation.

6.5 Traffic and Congestion

The growing congestion of private vehicles on Canada's road networks slows down overall travel. Wright, draws awareness to this situation of where "auto mobility dominates other modes of travel by demanding an increasingly large share of the urban infrastructure, and effectively penalizes public transport users and pedestrians"[91]. Within this structure, not everyone benefits from automobile use because not everyone uses automobiles all the time and nor can the infrastructure tolerate usage of such magnitude and manner. So, then this situation touches upon the issues of equity and community social responsibility.

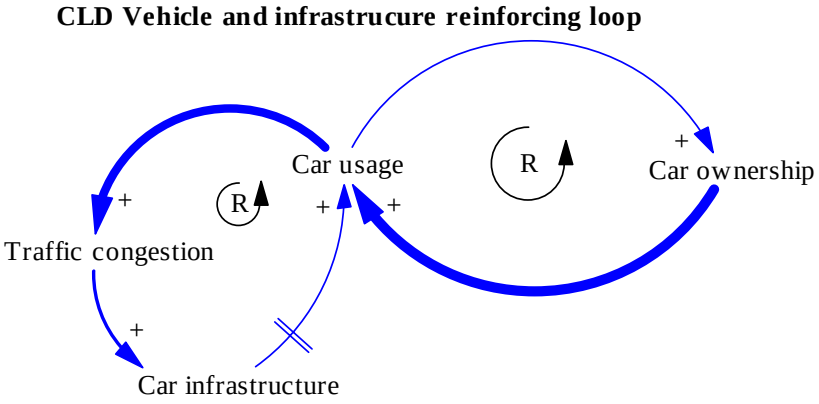

Figure 10: Private Vehicle Ownership Promotes Exclusive Usage – showing the connections between vehicles and infrastructure

This CLD explanation: within this sphere of influence there are two dominant reinforcing forces that this image is trying to show. The first proposes a link between increased car ownership and that it is related to an increase in car usage. Vehicle ownership causes an increase in vehicle usage. One suggestion for this relationship may be due to the fact that automobiles have a high fixed cost (the initial purchase) and artificially low variable costs such as no time charge to use the vehicle or fees per kilometer. (See figure 4) Furthermore, another variable worth mentioning in brief but not detail is the possibility of self imposed psychological pressure (cognitive dissonance) may encourage use of the vehicle purchase in

[90] Wright, C.; Curtis, B. (2005) *Reshaping the motor car* Journal: Transport Policy Volume: 12 Issue: 1 p 11

[91] Wright, C.; Curtis, B. (2005) *Reshaping the motor car* Journal: Transport Policy Volume: 12 Issue: 1 p 13

order to justify owning the vehicle. The second reinforcing causality arrow refers to the principal that more car usage has a direct relationship with creating more congestion which under the current business as usual model then often results in the increase of more related infrastructure. (In the absence of equally expanding alternative infrastructure). This expansive infrastructure then likely fosters or encourages an increase in car usage.[92] The more car usage occurs the more likely is the need to own a vehicle.[93] Therefore car usage and car ownership are mutually serving reinforcing loops.

7. DISCUSSION: CAR SHARING OPPORTUNITIES AND CHALLENGES

In the previous chapters comprehensive interdisciplinary analysis discussed the role that car sharing can play within a sustainable transportation system. However, after analysis of what is the role of car sharing then the question of to how to generate interest and increase participation of car sharing networks exists? While the role of car sharing entails both costs and benefits, it is desirable to promote the benefits while mitigating any associated costs. One major challenge to car sharing organizations may be in the psychological acceptance. This research has not focused attention upon the challenge of any perceived psychological unwillingness to share a vehicle with a complete stranger, nor does it analyze the extent to which private vehicles represent sociological prestige. This has been intentional as it is outside the scope of addressing what the aim of this research is. However, it is recognized that this factor may be a barrier to growth and implementation of car sharing organizations. Greater participation from within communities may be encouraged through policies and creative ways to address this barrier. For example perhaps ensuring that a car sharing network has a fleet of what may be perceived to be cool cars (e.g. mini coopers) may help attract a broader member base. Government economic incentives such as grants to members and networks may also generate interest and encourage membership. Finally, perhaps the greatest challenge lay in educating and advertising the car sharing concept within a simplified way that is both understood and appealing. For example, taking out advertisement space in a newspaper has limited functions as it really doesn't describe the complexity of the concept nor does it address the many questions that individuals may have.

7.1 Global Potential

Car sharing is a world wide phenomenon and can work in many countries. Much potential lies in both developed and non-developed countries. "In the United States, Western Europe, and the rest of the developed world, automobiles and trucks are the two largest sources of carbon dioxide emissions, responsible for 22 percent of the total"[94]. As a business model this network can exist either as for profit or as a non-profit (co-operative) organization. Car sharing is implemented at the local level and therefore can be sensitive to local needs. Car sharing organizations differ in many ways, pricing, type vehicles and administration are some examples. These differences are not negative and may actually better reflect a

[92] Transportation demand management faces the challenge of balancing the needs of private vehicle infrastructure while trying to maintain viable alternatives, although fiscally speaking an empty bus can be an expensive mobility cost.

[93] This is based on theory that borrowing a car from family or friends can on average be available on limited basis and alternatively renting a vehicle for long term duration becomes a very expensive option.

[94] Cervero Robert, (1998), *The Transit Metropolis: A Global Inquiry* Island Press Washington, D.C. p 45

communities needs. Globally, there exists much potential where there is urban areas and demand for private vehicles. One foreseeable limitation is in the poorest of the poor developing communities. A lack of fixed address and telecommunications may present a fundamental challenge in participation of car sharing networks. However, in many developing countries many entrepreneurs exist creating a distant version of car/taxi sharing form of transportation. Mini jeeps or trucks often run on either fixed or non-fixed routes picking up passengers for a small fare. This organization is distinguished as being different from car sharing due to one fundamental difference. The difference is that the individual is still a passenger and does not have the flexibility to drive and rent the private vehicle for designated time.[95]

8. RECOMMENDATION

- Local communities have been instrumental in implementing and managing car sharing organizations. In order to encourage growth and expansion a Canadian national car share organization may be beneficial in a number of ways.

- First, this organization could provide liaison and broader support (counsel), amongst new and existing car sharing networks.[96] This could aid and assist growing networks across Canada's urban cities. It could also undergo further Qualitative research on key issues within Car sharing.

- Second, this national organization could also provide marketing/education and spearhead soliciting of new members/networks. The national organization should consist of experienced, knowledgeable staff and engage and involve government, universities and other stakeholders.

- Government involvement may lead to a number of mutual benefits. First, this may promote job creation and enhanced mobility within Canada. It may benefit car sharing networks by facilitating communication amongst communities within a national scale. The financial costs to governments' involvement may come from the following; grants, research, program costs and administration. All of these potential costs must come from the government budget and tax payers of Canada. However, perhaps some of this money can be allocated through the 'climate action budget'.

- Car sharing networks promote alternative forms of transportation through financial incentive (variable costs increase as more km's accrue) and provides most of the convenience and freedom that personal vehicles offer but at fair equity cost. Collaboration between car sharing networks and with public transit could include free or discounted transit passes to ensure further equity gains.

- Car sharing networks could also benefit Canada through a collective net savings in accrued benefits such as reduction in transportation derived green-house gas emissions.

[95] The author experienced this form of transportation while traveling in developing countries.

[96] It is still crucial to have local involvement, as car sharing organization will vary from community.

9. CONCLUSION

A fundamental feature within transportation sustainability is to have a good variety and mix of public/private transport options (public transit, bike ways and personal vehicles). Car-sharing provides another mobility option for population dense-urban areas. Car sharing supports equity through eradicating the need to purchase the expensive fixed capital costs associated with private vehicles. Since car sharing has low fixed costs, this can lead to greater equity amongst low income members. Car sharing is a more cost effective method of transportation than the personal vehicle when used infrequently. However, driving many kilometers or having the car share vehicle for long amounts of time can add up to more expensive costs than owning a vehicle privately. Car sharing is only economically and environmentally an optimal mode of transportation when used as an infrequent supplement to other (public transportation, bicycling, walking) modes of transportation. Car sharing entails both costs and benefits. Some of the costs to car sharing schemes may mean a change in lifestyle and transportation (psychology), attitudes. Compared to personal vehicle usage, greater planning and reservation is required

Car sharing can lead to a reduction in individual car ownership and in some instances decrease personal vehicle driving while promoting greater mobility access. Although car sharing is a relatively young transportation phenomena; case study has shown that these organizations empower some members within communities to become car-light while it strengthens other types of transportation use. These reductions can lead to many benefits such as the promotion of livable cities. Car sharing networks encourage livable cities by saving space (assuming an average ratio of 18 people to 1 car), that would otherwise be dedicated to parking structures. This space can be used for any other mixed uses such as community gardens or bicycle lanes. Traffic congestion can be eased with the associated decrease in overall personal vehicle usage that car sharing brings. A reduction in personal vehicle usage also mitigates some of the need to build more personal vehicle-supportive infrastructure. Further benefits can be accrued through car sharing emission reduction education campaigns. These campaigns can better be facilitated and disseminate from the organization to achieve desired environmental objectives. While the role of car sharing remains limited in experience and organization the potential for growth is substantial. The role of car sharing supports greater mobility options, by providing a high level of ‘door to door’ service that the personal vehicle otherwise provides and it also supports a reduction in vehicle ownership and use for Canada. Car sharing can play a greater role in creating actively mobile livable cities.

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Personal Communication

Telephone interview and email correspondence with Tracey Axelsson (founder of CAN) conducted on Oct 09, 2005

GLOSSARY:

CAN: Co-operative Auto Network (car sharing non-profit based in Vancouver)

Car sharing: a network of individuals or an organization that shares joint access, ownership and usage of automobiles services

Cognitive Dissonance: Psychologist Leon Festinger (1956) proposed that contradicting cognitions compel the mind to create new thoughts or beliefs in order to limit the dissonance between to cognitions.

CLD: Causal Loop Diagram: a mental model of several key dynamic forces and causality relationship within a system.

Diurnal: A process that creates gasoline evaporation. This occurs when natural warm temperatures causes gasoline tanks to heat up, creating escape of gasoline vapours.

GHG: Greenhouse gas (CO, C02,).

Hot Soak: The process of gasoline vaporization which occurs when the automobile is turned off but the gasoline vapours continue to evaporate since the engine is still warm.

Hyper Car®: An ultra light vehicle designed by the Rocky Mountain Institute. This energy efficient vehicle features; low-drag design; electric-hybrid motor; and other efficient accessories that achieve 3 to 5-fold improvement in fuel economy.

One Metric Tonne = equals 1,000 kilograms.

Products as services concept: This concept was coined in 1993 by German chemist Michael Braungart and William McDonough. It conceives of products as three categories: consumables, products of service, and unmarketables.

IPCC: Intergovernmental Panel on climate change.

Kyoto Accord: A global (United Nations Framework Convention Climate Change) legal framework convention working to reduce GHG emissions.

PPM: Parts Per Million.

Running Losses: The process of gasoline vaporization which occurs when the car motor is active. This occurs because heat within the motor and through exhaust systems.

Sustainability: To meet the needs of the present without compromising those of future generations. Economic, social and environmental considerations must be met with equal consideration and merit. Sustainability can entail both broad and narrow definitions.

TDM: Transportation Demand Management.