Analysis of Consumers' Attitudes towards Purchasing PHEVs in Winnipeg

by

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A Thesis submitted to the Faculty of Graduate Studies of

The University of Manitoba

in partial fulfillment of the requirements of the degree of

MASTER OF SCIENCE

Department of Supply Chain Management

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University of Manitoba

Winnipeg

Abstract

Nowadays, switching to plug-in hybrid electric vehicles (PHEVs) is a promising way to reduce energy consumption and greenhouse gas (GHG) emissions. This research aims to explore consumers' attitudes towards adopting PHEVs in the City of Winnipeg. The study attempts to identify social-technical factors affecting car buyers' intention to purchase PHEVs, along with how attitudes, knowledge and experience affect preference for PHEVs. A further discussion of the Theory of Planned Behavior (TPB) will justify the linkage between attitudes, subjective norms, perceived behavioral control and purchase intentions. Questionnaires were distributed to two groups of people: an expert group familiar with or having experience with electric vehicles and a non-expert group with less knowledge about electric vehicles. Given issues of charging infrastructure and driving range, these vehicles have the potential to alter the urban landscape. Results of the study are expected to provide insight into effective public policy options and PHEV adoption/acceptance by car buyers.

Keywords: PHEVs, attitudes, purchase intentions

Acknowledgements

I wish to express my gratitude to my advisor Dr. Paul D. Larson, for his direction and encouragement in all stages of master thesis. I sincerely thank my committee members, Dr. Adolf K.Y. Ng, Dr. Luming Wang and Dr. Orly Linovski for their valuable suggestions and feedbacks. I would also thank all the people who helped me made this project possible.

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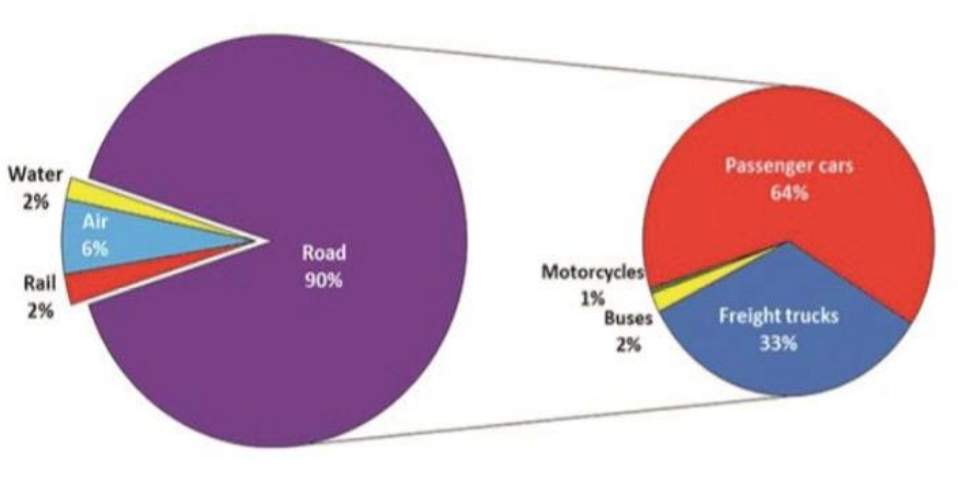
Chapter One: Introduction

Research Background

Vehicles play an important role in transportation. They also consume a large amount of energy. As shown in Figure 1, globally, road transport consumes 90% of energy used in transportation, and passenger cars consumed 64% of this energy (IEA, 2015). Canada has a high penetration of vehicles. In 2015, there were over 33 million vehicles registered in Canada (Statistics Canada, 2016), nearly one per person. These vehicles, especially passenger cars, create problems such as energy consumption, emissions and human health risks.

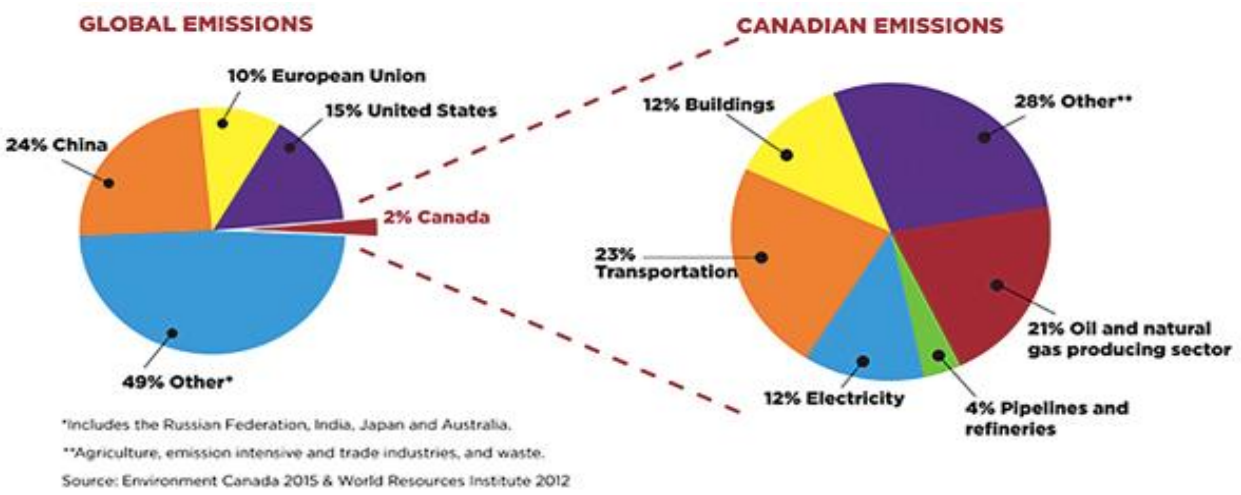
Figure 1 Cars are the dominant energy user in transport



Source: International Energy Agency (IEA) (2015)

Such a large amount of energy consumption also contributed to GHG emissions. Canada has 0.5% of global population but accounts for around 2% of global greenhouse gas emissions (CAPP, 2015). Moreover, 23% of Canadian GHG emissions are from transportation, as shown in Figure 2.

Figure 2 Global emissions and Canadian emissions



Source: CAPP, Canadian Association of Petroleum Producers (2015)

GHG emissions seriously affect human health and may lead to respiratory disease, cardiovascular problems and high risk for some cancers (Government of Canada, 2016a). GHG emissions also lead to unnecessary investment, e.g. providing additional support for improving human health and repairing agriculture and forestry damage (Government of Canada, 2016a).

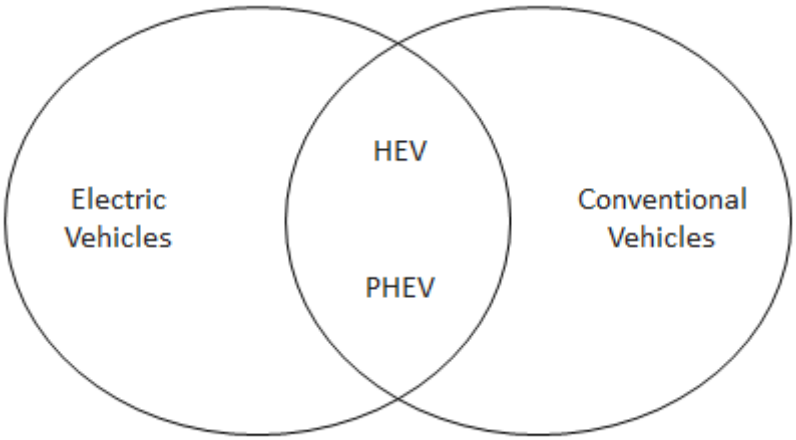
Given the problems stated above, many researchers have suggested that increasing the usage of PHEVs is an efficient way to reduce pollutants and protect the environment. Thus, this research aims to analyze the influencing factors for consumers' PHEV purchase intentions.

What are PHEVs?

People may have heard of electric vehicles but may not be familiar with PHEVs. According to McEachern (2015), the U.S. government (2016) and CAA (2016a), PHEVs are defined as vehicles which utilize both a large battery and a small gasoline engine. They are fueled by both gasoline and electricity but mainly recharge from the power grid. PHEVs use electricity until a predetermined battery state of charge (SOC), then generate power from an

internal combustion engine. Figure 3 depicts the relationships among different types of electric vehicles.

Figure 3 Description of the relationship of vehicles



HEV: hybrid electric vehicle; PHEV: plug-in hybrid electric vehicle

PHEVs have more than a hundred years of history. In 1899, Lohner Posche invented the first PHEV. Many technology breakthroughs such as "charging hydrants (protocol of fast charging)," regenerative braking, and hybrid (a kind of technology) were achieved during this period (1880-1900) (Anderson and Anderson 2005). In 1920s, the electric vehicle (including PHEVs) industry faded very quickly—and lost ground to conventional cars. Many electric car companies went bankrupt. Eventually, some years after the Second World War, the electric car industry recovered. After 1975, a series of well-known PHEVs – Audi Duo, Toyota Prius and Ford Escape hybrid – were launched sequentially (Høyer 2008).

Research objective

Larson et al. (2014) conclude that consumers' knowledge and experience of electric vehicles are important factors influencing their adoption. This result inspired my research interest. After reviewing the literature, I found that many researchers (e.g. Graham-Rowe et al,

2012; Skippon and Garwood, 2011; Ozaki and Sevastyanova, 2011) also tried to find the factors that lead to an increased adoption of electric vehicles. The influencing factors are generally classified into three categories: attitudes, experience and demographics.

As a result, the fundamental research purpose is to analyze consumers' attitudes towards purchasing PHEVs. The following objectives guide this research: (1) to find what factors influence consumers' attitudes towards purchasing PHEVs; (2) to examine whether consumers' environmental concerns and demographic profiles influence their purchase intentions; (3) to understand the benefits of developing PHEVs in Winnipeg; and (4) to confirm or discover ways to encourage PHEV growth.

Chapter Two: Literature Review

This chapter is divided into two sections. The first discusses the importance and benefits of developing PHEVs in Winnipeg. Then, influencing factors for purchasing PHEVs, especially policy incentives in different provinces in Canada, are discussed. The second section describes the theory of planned behavior (TPB), and develops a theoretical framework based on TPB.

Importance of developing PHEVs in Winnipeg

Located in the middle of Canada, Manitoba has around 1.3 million people (Statistics Canada, 2015). More than half of its citizens live in the capital city, Winnipeg. Manitobans own more than 700,000 motorized vehicles and consume 1.5 billion liters of gasoline and 1 billion liters of diesel fuel in a year, costing Manitoba over $2 billion to import fuel (IEM, 2011). Little oil is resourced within Manitoba and the province is not an oil refining center. In addition, transportation accounts for seven million tons of GHG emissions in Manitoba (IEM, 2011).

According to the Government of Canada (2016b), total emissions of Manitoba are lower than other provinces such as Alberta, Ontario and Quebec. However, it can be calculated that Manitoba's GHG emissions/capita are higher than most other provinces (Statistics Canada, 2015; Government of Canada, 2016b). For example, Manitoba's emissions/capita is almost double those in Quebec.

Manitoba: $\frac{30(\text{Megatons of carbon dioxide equivilant})}{1{,}280{,}200\ (\text{population})} = 0.000023\ (individual\ emission)$

Quebec: $\frac{90(\text{Megatons of carbon dioxide equivilant})}{8{,}214{,}900\ (\text{population})} = 0.000011\ (individual\ emission)$

Facing high fuel consumption and individual emissions, the government should consider methods of saving energy. Indeed, Manitoba has many advantages in developing PHEVs. It can

produce enough electricity for residential, commercial, and industrial use; and even export excess electricity to the U.S. With earnings from export sales, Manitoba can maintain the lowest electricity rates in North America (Manitoba Hydro, 2014). Manitoba also has the most renewable electricity in North America (IEM, 2011), because it is largely generated by hydro power. PHEV users should be attracted to low electricity rates and renewable generation. In addition, Figure 4 shows that when considering initial purchase price, gasoline price and driving distance per year, average costs of electric cars are lower than gasoline cars over 8 years. If consumers consider lifetime cost efficiency, electric vehicles become more economic than conventional ones.

Figure 4 Cost comparisons between electric leaf and similar sized ICE

OVERALL "LIFETIME" COST COMPARISON OVER 8 YEARS
based on 12,000 km of average commuter-type travel per year

	Electric Leaf	Similar-sized ICE
Approximate purchase price	$33,000	$26,000
Fuel cost: 7.183¢ per kWh electricity/$1.21 per Litre gasoline	$300/yr * 8 = $2,400	$1,815 * 8 = $14,520
Estimated vehicle maintenance cost	$100/yr * 8 = $800	$300/yr * 8 = $2,400
Total projected "lifetime" cost outlay over 8 years	$36,200	$42,920
Present value of projected "lifetime" cost over 8 years (present value calculation based on 6% and 8 years, and applied to future fuel and maintenance costs)	**$35,480**	**$39,130**

Additional background information:
Average weekly price of gasoline in Winnipeg from Natural Resources Canada
www2.nrcan.gc.ca/eneene/sources/pripri/prices_byfuel_e.cfm?LocationID=15#Glance

GASOLINE	$1.21 per Litre *	12.5 litre/100 km	$1,815 annual	$14,520 over 8 years
ELECTRICITY	$0.07183 per kWh	35 kWh/100 km	$300 annual	$2,400 over 8 years

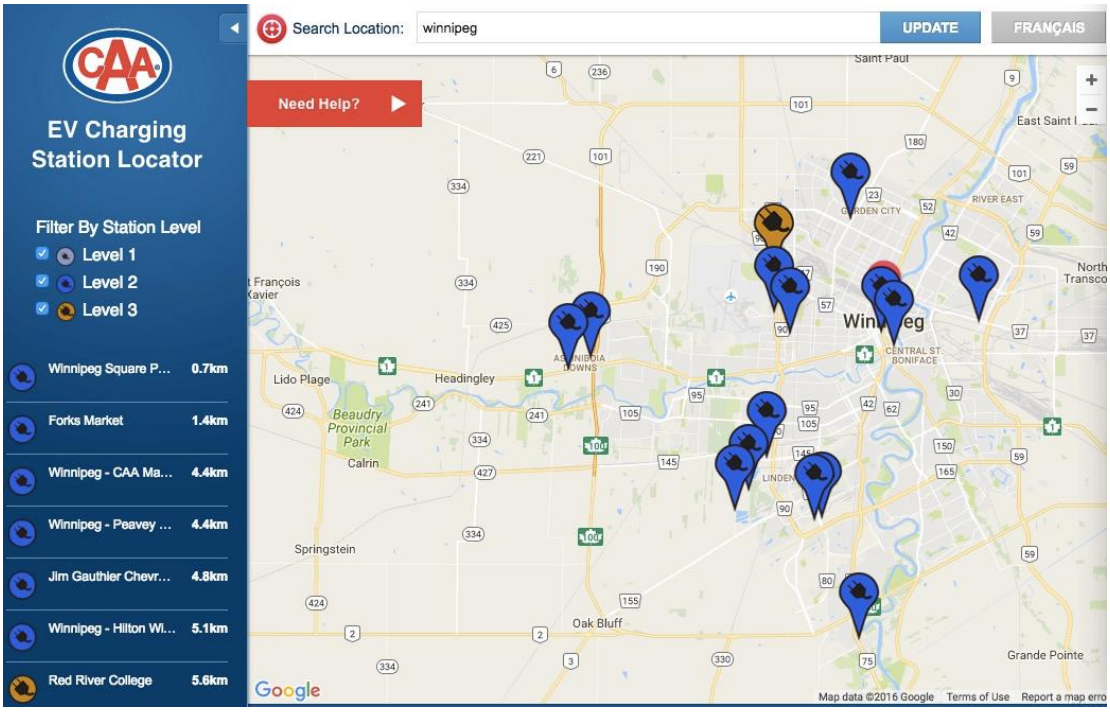
* Gasoline price reflects yearly average for Winnipeg from late 2012 to late 2013.

Source: EV Tools & Resources (www.driveelectricmanitoba.ca/tools.html)

Other services also facilitate PHEV development in Manitoba, including (1) availability of 15 charging stations in Winnipeg, as shown in the Figure 5; (2) an electric bus manufacturer (New Flyer) and the Manitoba Electric Vehicle Association (MEVA) located in Winnipeg,

which can support electric car development; and (3) the fact that Manitoba residents are used to plugging in their engine block heaters in winter.

Figure 5 Charging stations in Winnipeg



Source: EV Charging Station Locator (http://www.caa.ca/evstations/)

Influencing factors for purchasing PHEVs

To increase adoptions of PHEVs, factors influencing consumers' purchase decisions must be known. This section reviews these influencing factors, focusing on consumers' environmental concerns, socio-technical concerns and demographic profiles. Attitudes refer to consumers' perception of socio-technical variables and subjective norms refer to consumers' environmental concern.

Environmental concern

Environmental concern refers to consumers' attitudes towards improving air quality, water quality and the eco-system. A primary aim of producing PHEVs is to achieve sustainability; therefore, environmental concern may significantly influence consumers' purchase intentions. Pradeep (2012) argues that "the environmental concern plays an important role in active environmentally friendly behavioral intentions." Furthermore, Jensen et al. (2013) suggest that environmental concern increases consumers' preference for hybrid vehicles. Consumers show willingness to preserve energy and reduce emissions by adopting electric vehicles (Ozaki and Sevastyanova, 2011).

However, Graham-Rowe (2012) and Lieven (2011) note that environmental concern is a less significant reason to buy electric vehicles compared to technical factors such as driving range and car performance, along with car price. According to Afroz et al. (2015), although many people show willingness to preserve the environment, it is hard to turn willingness into purchase behavior. People appear to care more about economic factors than environmental factors while considering electric vehicles. Inspired by these previous studies, the current study examines the relationship between environmental concern and PHEV purchase intention.

Socio-technical concern

For a long time, social and technical factors were studied separately with regard to electric vehicles. Sovacool and Hirsh (2009) combine these two aspects and describe *socio-technical* factors as a cluster of social, technological, cultural, economic and political factors. This concept provides a comprehensive way to examine variables that influence adoption of PHEVs. Several social-technical factors, such as gasoline price, driving range, availability of charging stations and political concerns, are specifically discussed below. To anticipate, the questionnaire will include these factors, along with other factors, such as vehicle price.

Gasoline price

A number of studies have found that gasoline price influences the adoption of different kinds of electric vehicles. Diamond (2009) believes that higher gasoline price stimulates electric vehicles adoption. Egbue and Long (2012) argue that an average gas price of US$5.42/gallon helps persuade consumers to buy electric vehicles. They also suggest that gas price is not the only determinant. Consumers also consider other factors such as electricity rates and driving range when looking at EVs. However, Gross (2015) suggests that lower oil prices provide an opportunity to stimulate hybrid electric vehicles uptake, since electric vehicle producers will offer better incentives to attract consumers.

Driving range

Driving range refers to the longest distance a vehicle can travel before recharging or refueling. The driving range of a conventional car is usually over 400 km. Some electric vehicles, such as Tesla model S, can exceed this range (426 km.). Compared to conventional vehicles; though PHEVs can save on operating cost and gasoline, their driving range is still a significant factor influencing consumers' purchase decisions (Schuitema, 2013). According to Egbue and Long (2012), driving range is the top factor influencing consumers purchase. Most consumers also believe the range is not sufficient for their daily travel due to limited battery storage (Egbue and Long, 2012). Meanwhile, consumers pay more attention to driving range of family cars and have less concern about range of micro cars (e.g. Smart Fortwo, Fiat 500) (Lieven, 2011). While range is a disadvantage of EVs compared with conventional vehicles (Pearre et al., 2011), Thomas and Josef (2012) found that consumers are satisfied with the range of electric vehicles. Indeed, the range of current electric vehicles is much more than consumers' psychological needs

(they may only expect a range of 200-300km, but the driving range of PHEVs is over 400 km.). Current PHEVs can meet most drivers' range needs, but some consumers still worry about it.

Charging stations

Charging stations refer to infrastructure which can recharge electric vehicles. Charging stations have three levels: Level 1 (120V AC) needs 12-20 hours to fully charge an EV battery; Level 2 (208-240V AC) needs 4-8 hours to fully charge a battery; and Level 3 (DC fast charging system – 400+ V DC) needs only 30-60 minutes. Drivers can also install charging infrastructure at home. However, with urbanization and more single-person households, it is not convenient for people to charge at their apartments or multifamily dwellings (The National Academies Press, 2015, p.45).

Charging infrastructure at single-family houses is naturally available to the residents at any time. At apartment buildings, people would share the charging infrastructure with others, making charging less convenient. For example, for charging at peak times (usually at night), infrastructure may be insufficient for all residents living in the building. Indeed, some buildings may not provide charging infrastructure. Moreover, charging at home comes with the high cost ($2,000 to $4,000) of installing a home-based Level 2 charger (IEM, 2011). Charging stations at work, along the road network, and at public places are critical infrastructure elements influencing uptake of electric vehicles (Jensen et al., 2013). Lack of charging stations are barriers to PHEV development in Winnipeg. Not many charging stations are available in public areas; one Level 3 and fourteen Level 2 charging stations are in the city, as shown in Figure 5 (CAA, 2016b).

Purchase incentives

Different types of policy incentives play an important role in stimulating consumers to purchase PHEVs. Langbroek et al. (2016) found that free parking for electric cars improves consumers' willingness to buy EVs. Hoen and Koetse (2014) also found free parking to be

significant in stimulating consumers' preference for electric vehicles. Free parking may be effective in encouraging electric vehicle uptake, but other policies are also needed. In 2009, the US government put forward tax credits to stimulate PHEV adoption (Skerlos & Winebrake 2010). The Obama administration suggested increasing tax rebates from $7,500 to $10,000 to encourage consumers to purchase PHEVs (Canis, 2013).

Skerlos and Winebrake (2010) suggest that policy variability across jurisdictions could be an important element in promoting PHEVs in different states in the U.S.A. They argue that different states could have their own policy incentives, which would contribute to more social benefits. According to Ozaki and Sevastyanova (2011), consumers who live near London enjoy the benefits of related transport-policy for hybrid cars. With this policy, hybrid car drivers can drive into central London without any charge. (In London, there is a congestion charge, i.e. a fee for driving a car into certain areas in central London. But electric cars are exempt). Meanwhile, Diamond (2009) found that policy incentives (HOV incentive, tax incentives) are weak in stimulating HEV adoption.

To promote electric vehicle development, Ontario, Quebec and British Columbia have put forward a series of policy incentives, which can be classified as rebates, investments in basic infrastructure, and privileges. Regarding rebates, consumers can receive up to $8,500 for buying or leasing eligible electric vehicles. In terms of investment, the provinces are creating networks of charging stations covering working, living and highway areas. Regarding privileges, electric vehicle drivers can use high occupancy vehicle (HOV) lanes in Ontario. Other provinces also support electric vehicles development to some extent. For example, Manitoba offered a $2,000 rebate for purchasing or leasing hybrid electric vehicles from 2009 to 2012, but this policy is no longer available. The specific policy incentives are shown in Table 1.

Table 1 Provincial policy incentives

Province	Type	Incentives	Amount
British Columbia[1]	Rebate	$5,000 for purchase or lease of a new BEV or PHEV; up to $6,000 for a hydrogen fuel cell vehicle	$5,000-$6,000
	Investment	1. $7.5 million for point-of-sale incentives for electric and hydrogen fuel cell vehicles. 2. $1.59 million for charging and hydrogen fueling infrastructure. 3. $1 million for commercial fleet purchases of clean energy vehicles. 4. $500,000 for research, training, and public outreach on clean energy transport technology.	$10.6 million
Ontario[2]	Investment	1. Vehicles with battery capacity of 5 to 16 kWh are eligible for incentives from $6,000 to $10,000. 2. Vehicles with battery capacity larger than 16 kWh are eligible for an additional $3,000. 3. Vehicles with five or more seats are eligible for an additional $1,000. 4. Vehicles with a MSRP of $75,000 to $150,000 at date of purchase/lease are eligible for a maximum incentive value of $3,000.	$1,000-$10,000
	Privilege	EV purchasers are eligible to receive green vehicle license plates, which allow access to provincial HOV lanes with only one occupant.	
	Investment	Electric Vehicle Chargers Ontario (EVCO) is a one-time $20 million grant to create a network of fast-charging electric vehicles stations in cities.	$20 million
Quebec[3]	Rebate	$8,000 to purchase or lease eligible EVs	$8,000
	Rebate	$600 to buy & install home charging stations	$600

1. British Columbia Government (March 2016)

2. Ministry of Transportation Ontario (February 2016)

3. Discover Electric Vehicles (2016)

BEV = battery electric vehicle; kWh = kilowatt hours; MSRP = manufacturer's suggested retail price; HOV = high occupancy vehicle

Experience with vehicles

Experience may change attitudes towards features of PHEVs, and may influence purchase intentions. Jensen et al. (2013) show that hands-on experience with electric vehicles and conventional vehicles changes individuals' preferences and attitudes towards these vehicles. Their participants were more familiar with features of these vehicles, such as driving range, speed, fuel consumption and charging station availability, after experiencing electric vehicles. Moreover, Axsen and Kurani (2009) illustrate that consumers' experience with PHEVs changed their attitudes towards the features of the vehicles and changed their sustainability-oriented values. In addition, consumers' sustainability-oriented values also influenced their purchase behavior. Skippon and Garwood (2011) found that after having a direct experience with battery electric cars, consumers were more willing to pay a slightly higher price for electric vehicles—while expecting to spend less on operating costs. Thus, different levels of experience with vehicles may result in different attitudes and behavior.

Demographics

Age

According to previous research, demographics also influence consumers' intention to purchase PHEVs. Generally, younger consumers are more willing to purchase electric vehicles (Wu et al., 2010; Polatoglu and Ekin, 2001). Morris et al. (2005) suggest that younger people accept new technologies more easily and have stronger intentions to adopt them. Meanwhile, Hong and Abdullah (2013) found that consumers between 29 and 39 are more eager to purchase hybrid vehicles.

Education level and household income

Higher education levels have been found to positively influence consumers' intention to purchase electric vehicles (Potoglou and Kanaroglou, 2007; Wu et al, 2010). Söderholm (2010) observed that consumers with higher education and income show more pro-environmental attitude and behavior, and consumers with high environmental concern have stronger PHEV purchase intentions. This is also supported by Wu et al. (2010), who suggest that consumers' positive attitudes toward purchasing PHEVs depend on their higher education and income levels. On the contrary, Sandahl and Robertson (1989) found that consumers with higher environmental concern often have lower education and lower income. They concluded that relationships are weak between education, income, environmental concern and purchase intention.

Driving pattern

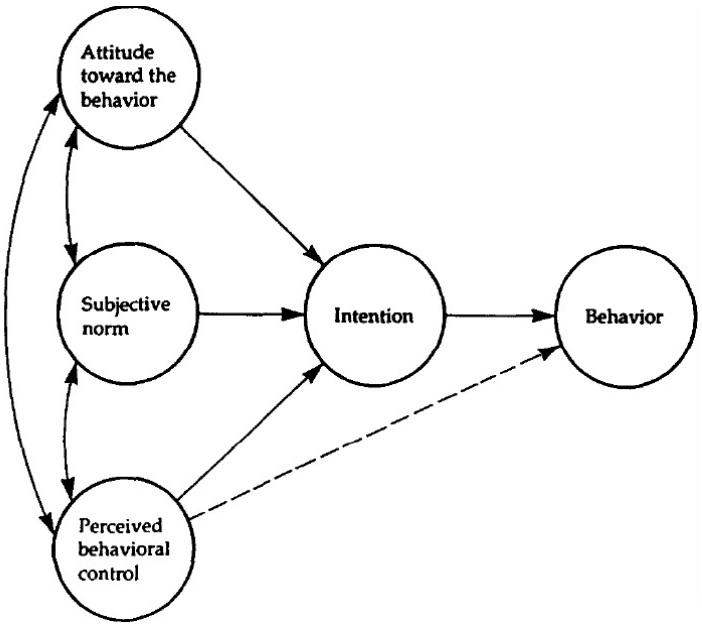
Driving pattern refers to daily or annual driving distance or range. According to Baptista et al. (2012), drivers with driving range lower than electric range (ER) have stronger intention to buy electric cars than drivers with a range higher than ER. However, they found that drivers with a range over 100 km (ER) are still willing to purchase electric vehicles, which may indicate their confidence in charging availability. Hoen & Koetse (2014) found that annual driving range is the most significant determinant of consumers' willingness to buy electric vehicles; higher annual mileage strongly decreases consumers' willingness to pay for electric vehicles.

The theory of planned behavior (TPB)

Factors influencing intentions can be divided into two types: objective and subjective. Objective factors include price and performance of vehicles, economic environments and policy incentives. Subjective (psychological) factors include consumers' attitudes, lifestyle and experience (Choo and Mokhtarian 2004). The current study focuses on subjective factors.

Much of the research on explaining how attitudinal factors influence consumers' decisions to adopt clean fuel vehicles is based on the TPB (Kaplan, et al., 2016; Sang and Bekhet, 2015). Among cognitive behavioral theories, TPB developed from the theory of reasoned action (TRA), which proposes that individuals' behavioral intentions are influenced by their attitudes and beliefs or subjective norms (Ajzen, 2012). Ajzen (2012) also indicated that beliefs are influenced by individual's family members, close friends and workmates. TPB is an extension of TRA, created by incorporating an additional component—perceived behavior control (Ajzen, 1991). Similar to TRA, TPB emphasizes intention as the determining factor of behavior. In addition, TPB proposes that behavioral intentions are influenced by attitudes, subjective norms and perceived behavioral control as shown in Figure 6.

Figure 6 Theory of planned behavior



Source: Ajzen, 1991

Many previous researchers adopt TPB as a theoretical foundation to develop their models. Hong et al., (2013) define pro-environmental factor as an attitudinal component; and facilitating

conditions such as public policy, tax breaks and other financial incentives as perceived behavioral control components. Egbue and Long (2012) also treat the features of cars (e.g. maintenance cost, GHG reduction, battery storage, etc.) as elements of the attitudinal component. They asked participants to rate car features across 5 levels. Ozaki and Sevastyanova (2011) found that people influenced by the same social norms have similar perceptions towards the environment. The current study models environmental concern as being among consumers' subjective norms (Pradeep, 2012; Stern, 2000).

Attitude

Attitude can be defined by two different models. First, the three component model defines attitude as "expressing people's feelings, beliefs, and past behaviors regarding the attitude object" (Zanna & Rempel, 1988). The three component model describes attitudes as being formed by affective, cognitive and behavioral components. This emphasizes that attitude is determined by direct feelings, experience, and perceived expectations from other people. On the other hand, expectancy-value models propose that "attitude is the sum of all the evaluative beliefs regarding the attitude objective" (Kruglanski & Higgins, 2007 p.566). This emphasizes attitude as a result of individuals' comparison of objects.

Subjective norms

Subjective norms refer to the impact of opinions of others' (e.g. family, friends, and workmates) on individuals (Amjad & Wood, 2009). In other words, subjective norms focus on whether the person is affected by the people around them to perform the intended behavior or not (Ajzen, 1991; Pradeep, 2012; Stern, 2000).

Perceived behavioral control

Perceived behavioral control reflects past experience and its impact on intended behavior. It is divided into internal control (self-efficacy) and external control (facilitating conditions). Self-efficacy emphasizes whether or not individuals trust their own ability to perform a behavior. Facilitating conditions explain the external resources in facilitating the intended behavior (Tan and Teoh, 2000). Ajzen (1991) believes that strong perceived behavioral control contributes to a favorable intention in forming behavior or directly influences behavior. In the current study, experience is viewed as a facilitating condition of perceived behavioral control.

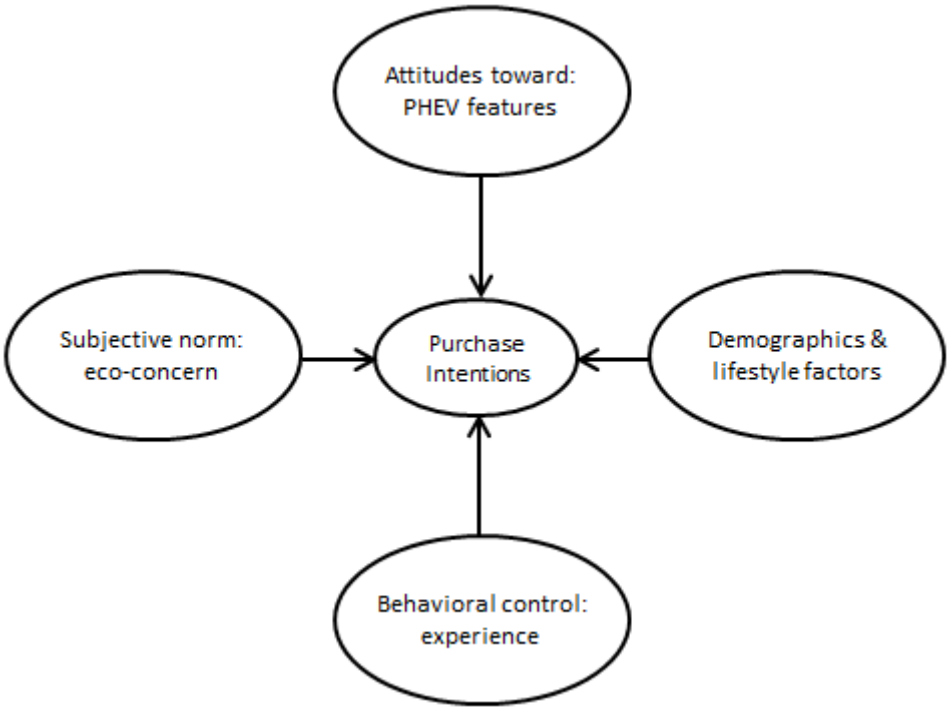
Pradeep (2012) aimed to analyze how environmental concern and other norms influence behavioral intentions. He measured three independent variables (environmental concern, injunctive and personal norms) using five point Likert scale from "strongly disagree" to "strongly agree." Similar to TPB, he found that environmental behavioral intentions were dependent on environmental concern or attitude. Ozaki and Sevastyanova (2011) rated five influencing factors, perceived environmental benefits (subjective norm), technological interest (attitude), social orientation (subjective norm), awareness of policy incentives (perceived behavioral control) and financial benefits (attitude) on Likert scales to analyze consumers' purchase intention towards electric vehicles.

Egbue and Long (2012) found that consumers' perceived behavioral control (knowledge, experience and interest) significantly affects consumers' purchase intention towards EVs. They rated consumers' knowledge, experience and interest of EVs using 4-point scales. Similarly, Hong et al. (2013) rated attitudes, subjective norms, and perceived behavioral control on 7-point scales, and found that these factors positively influence consumers' intention to buy electric vehicles.

Theoretical framework

Adapted from the TPB (see Figure 6), the theoretical framework is shown in Figure 7.

Figure 7 Theoretical framework



There are three reasons for employing TPB to develop the theoretical framework. First, this study aims to analyze relationships between purchase (behavior) intention and influencing factors. Ajzen (1991) indicated that TPB is the most complete model for explaining linkages between beliefs, attitudes, subjective norms, perceived behavioral control, intentions and behavior. Second, purchase intention is not influenced by only one factor but by many factors. Therefore, TPB is suitable as it can explain how different factors influence actions (Lane and Potter 2007). Third, other studies, e.g. Egbue and Long (2012), indicate that behavioral intentions are determined by attitude, which is influenced by experience and knowledge. This study includes two groups of participants with different experience levels. Experience with EVs is also directly measured. Finally, numerous previous studies (e.g. Hong et al., 2013; Axsen and

Kurani,2013; Afroz et al.,2015; Lai et al., 2015; Ozaki and Sevastyanova, 2011; Egbue and Long, 2012) have used TPB as a theoretical foundation for analyzing consumers' attitudes about purchasing clean fuel vehicles.

The TPB explains how attitudes, subjective norms and perceived behavioral control influence consumer purchase intentions toward innovative technical products (Pradeep, 2012). Hong et al. (2013) explored consumer purchase intentions toward hybrid cars in Malaysia by analyzing different factors including attitudes, subjective norms and perceived behavioral control. Their theoretical foundation is adopted from the TPB and they found that these factors played an important role in influencing purchase intentions. The findings showed that consumer purchase intentions can be explained by this theory, therefore the current research will adopt the TPB to analyze purchase intentions toward PHEVs in Winnipeg.

Research questions and hypotheses

Based on the literature, it appears that the top factors consumers consider in purchasing PHEVs include car price, vehicle operating costs, fuel savings, gasoline price, charging station availability, maximum driving range, and policy incentives. In Manitoba, the primary incentive is likely to be a rebate, which would effectively reduce vehicle price. This study will analyze whether or not these factors have an impact on consumers in Winnipeg. Environmental concern and prior experience are also expected to influence consumers' purchase intentions. A questionnaire was developed to explore how socio-technical factors, environmental concern and experience with PHEVs influence purchase intentions.

Several researchers (e.g. Sovacool and Hirsh, 2009; Ozaki and Sevastyanova, 2011; Axsen and Kurani, 2013) posed a similar question: What are the factors that inspire consumers to adopt PHEVs? Inspired by this question, the research questions of this thesis are:

1. Do environmental concerns influence consumers' intentions to purchase PHEVs?
2. What car features influence consumers' intentions to buy PHEVs?
3. Does household income, education level and driving pattern influence purchase intentions?
4. How does experience with PHEVs influence consumers' purchase intentions?

Guided by the research questions, the following six hypotheses are posed for testing:

H1a. Education influences PHEV purchase intentions.
H1b. Income influences PHEV purchase intentions.
H1c. Driving pattern influences PHEV purchase intentions.
H2. Greater concern about environmental issues increases PHEV purchase intentions.
H3. Perceived behavioral control positively influences PHEV purchase intentions.
H4. Greater influence of social-technical factors increases PHEV purchase intentions.

Chapter Three: Methodology

This research developed a survey to explore PHEV purchase intentions. There are several reasons to employ survey research. First, the purpose of a survey is to "learn about the distribution and correlates of attitudes in a population by collecting reports from a representative sample" (Schwartz et al., 1998). The survey is a suitable strategy to assess attitudes of a sample of consumers selected from a population. Surveys typically collect data using questionnaires or structured interviews. Although more in-depth opinions could be gained using interviews, a questionnaire will enable statistical testing of the hypotheses (Ozaki and Sevastyanova, 2011).

The survey was designed based on previous literature. It was distributed to two groups in Winnipeg: a group of people highly knowledgeable about electric vehicles (expert group) and a group comprised mostly of students and staff at the University of Manitoba (non-expert group). The expert group is composed of members of MEVA, who are familiar with PHEVs. The non-expert group includes people who are likely to know considerably less about PHEVs. In the survey population section, these two groups are further described.

Survey design

Questions related to consumers' environmental concerns, experience with PHEVs, attitudes towards PHEVs' features and their demographic profiles were included in the questionnaire (see Appendix B). The first section of the questionnaire asks five questions in the style of 5-point Likert scales, covering environmental concerns; purchase intentions towards PHEVs; and awareness of, familiarity with and knowledge about PHEV features. The second section is a question pertaining to experience with PHEVs. Participants are asked whether they have rented, test-driven, or own a PHEV. The third section concerns participants' attitudes

towards nine features of PHEVs, which may influence purchase intentions. The last part focuses on demographic and lifestyle characteristics.

The questionnaire was created drawing on previous research about electric vehicle purchase behavior and survey design. The purchase behavior questions appear before questions on consumers' attitudes toward PHEV features, so answers to behavioral intentions will not be influenced by attitudinal questions (Brace, 2008). Features of PHEVs in section 3 of the questionnaire were adapted from questionnaires in the literature (e.g. Egbue and Long, 2012; Ozaki and Sevastyanova, 2011). The included features cover most of the attributes that may influence intentions to buy a PHEV. In the current research, questions related to consumers' attitudes towards PHEV features are in the style of 5-point Likert scales, from very low (1) to very high (5) influence.

Based on the TPB, Hong et al. (2013) found that consumers' attitudes, subjective norms, perceived behavioral control and demographic profiles influenced their intentions to purchase PHEVs. They tested consumers' perception of influencing factors (e.g. fuel efficiency, pollution reduction) to measure attitudes. Pradeep (2012) measured subjective norms using consumer environmental concerns. Egbue and Long (2012) used consumers' experience with EVs to measure perceived behavioral control. In the current study, similar measures are used to test H2, H3 and H4. To reiterate, environmental concern (a subjective norm), experience (the perceived behavioral control factor) and perceived influence of social-technical factors (attitudinal factors) are expected to positively impact consumer purchase intentions towards PHEVs. The social technical factors are mainly adapted from Hong et al. (2013); Ozaki and Sevastyanove (2011); Egbue and Long (2012) and Diamond (2005).

Survey population

The survey was targeted at an expert group of participants, members of the Manitoba Electric Vehicle Association (MEVA), and at a non-expert group of participants from the University of Manitoba. MEVA provides information and promotes electric vehicle development in Winnipeg. The group has around 40 members of various ages and backgrounds. (For further information about MEVA, go to http://manitobaev.ca/). Members tend to be familiar with electric vehicles and a few of them have already owned hybrid electric vehicles and PHEVs. The non-expert group is composed mostly of students and staff working at University of Manitoba. Most of them are less familiar with PHEVs, compared to the expert group.

Survey distribution

The survey employed two methods of distribution: group-administered and online. The group-administered questionnaires were distributed to individual MEVA members during their monthly meeting (May 26, 2016). There were 20 attendees at the meeting and 16 responses were received for a response rate of 80%. An online questionnaire was created using Qualtrics, and distributed to the remaining MEVA members and non-expert group participants. The secretary of MEVA helped e-mail the electronic questionnaires to members. As a result, another 10 members completed the questionnaire by the end of May. A *snow-ball* sampling method, adapted from Potoglou and Kanaroglou (2007), was used to distribute electronic questionnaires to the non-expert group. A link to the questionnaire with notification that only Winnipeg residents should participate was posted on chatting software WeChat and Facebook. Through social networks, participants can share the link with their own chatting software, then eligible respondents can fill in the online questionnaire. Between May 30 and June 15, 2016, 42 respondents completed questionnaires (7 responses were omitted because 3 IP addresses were not in Winnipeg and 4

other responses missed many questions). As a result, 60 completed surveys were accepted for further analysis, 25 from the expert group and 35 from the non-expert group.

Respondents remained anonymous during data collection, and they were free to abandon the questionnaire any time. Questionnaires were accepted for analysis only if less than 4 item responses were missing in the first three sections. Questionnaires were accepted even if the demographic questions in section four (gender, age and household income) were unanswered.

Chapter Four: Results and Discussion

Demographic profile by group (non-expert vs. expert) – Sample description

This section profiles the respondents in terms of the following demographic and lifestyle characteristics: gender, age, education, household income and car driving patterns.

The sample is comprised of 24 MEVA members and 35 other people, mainly from the University of Manitoba. There were 41 males and 18 females in this sample. Table 2 classifies the respondents by gender and expert group. While Chi-square is not significant, the experts are more likely to be male, compared to non-expert group members.

Table 2 Gender by Expert Group

Group	Female	Male	Total
Non-expert	13 (37.1%)	22 (62.9%)	35
Expert	5 (20.8%)	19 (79.2%)	24
Total	18	41	59

Chi-square = 1.79 (p-value = .181)

The age categories with the most expert group respondents are 55-64, followed by 25-34. On the other hand, 25-34 is by far the most common non-expert group age category. Very few respondents in either group are under 25 or over 64. Non-expert group respondents tend to be much younger than those in the expert group (see Table 3). Note the significant Chi-square. The fifth row in Table 3 shows population over 18 years old for the Winnipeg census metropolitan area (CMA) in 2010. For both surveys groups, the sample under-represents the youngest and oldest age categories. Further, the non-expert group is considerably younger than Winnipeggers in general.

Table 3 Age by Expert Group

Group	18-24	25-34	35-44	45-54	55-64	65+	Total
Non-expert	2 (5.7%)	24 (68.6%)	6 (17.1%)	2 (5.7%)	1 (2.9%)	0 (0.0%)	35
Expert	1 (4.2%)	6 (25.0%)	2 (8.3%)	3 (12.5%)	10 (41.6%)	2 (8.3%)	24
Total	3	30	8	5	11	2	59
Winnipeg*	12.6%	17.1%	16.8%	19.6%	15.9%	17.9%	99.9%

Chi-square = 21.39 (p-value = .001)

*Winnipeg CMA 2010 Population over 18 years old, Statistics Canada

Education level of both groups is shown in Table 4. Respondents in the non-expert group have higher education levels (all but one has a university or master's degree). Expert group respondents have a wider range of education levels, from high school to one person with a Ph.D.

Table 4 Education Level by Expert Group

Education*	Non-expert Group	Expert Group	Total
Low	1	10	11
Medium	16	7	23
High	18	7	25
Total	35	24	59

*Low = high school or college diploma; medium = university degree; high = Master's degree or Ph.D.

Chi-square = 14.17 (p-value = .001)

Both groups report a wide variety of household income levels. However, while the medium category is the least common for non-expert group members, it is the most common category for the expert group (see Table 5). Based on the Chi-square test, there is lack of a significant relationship between income level and group membership. The fifth column in Table 5 shows 2010 household income for the Winnipeg census metropolitan area (CMA). Note that both surveys groups are relatively more affluent than Winnipeg households in general.

Table 5 Household Income by Expert Group

Income*	Non-expert Group	Expert Group	Total	Winnipeg**
Low	13 (37.1%)	5 (20.8%)	18	49.9%
Medium	8 (22.9%)	11 (45.8%)	19	25.7%
High	14 (40.0%)	8 (33.3%)	22	24.3%
Total	35	24	59	99.9%

*Low < $60,000; medium = $60,000-$100,000; high > $100,000

Chi-square = 3.75 (p-value = .154)

**Winnipeg CMA 2010 Household Income, Statistics Canada

Table 6 reveals a significant relationship between group membership and driving pattern. Non-expert group respondents tend to drive fewer km. per day compared to the experts.

Table 6 Driving Pattern by Expert Group

Driving Pattern*	Non-expert Group	Expert Group	Total
Low	25	10	35
High	10	13	23
Total	35	23	58

*Low: $\leq$ 30 km. per day; high: > 30 km. per day

Chi-square = 4.53 (p-value = .033)

Awareness, intentions, etc. by group

As expected, expert respondents are significantly more aware of, familiar with, and knowledgeable about PHEVs and their features compared with the non-expert group (see Table 7). Also as expected, awareness is greater than familiarity, which is greater than knowledgeability. To be knowledgeable about something, one must be familiar with it; to be familiar, one must be aware. Note that the experts also express greater concern about the environment. Perhaps this concern inspires their membership in a group like MEVA.

Contrary to expectations, the two groups are not significantly different in terms of PHEV purchase intention. Since the sample is rather small and the two groups do not significantly differ on the dependent variable, they are mostly combined for hypothesis testing.

Table 7 Awareness, Familiarity, etc. by Group

Items*	Mean		t stat.	p-value
	Expert	Non-expert		
Eco-concern	4.54	3.91	2.59	.006
Awareness of PHEVs	4.50	3.34	4.28	.000
Familiarity with PHEVs	4.27	3.06	4.27	.000
Knowledgeability about PHEVS	3.85	2.46	4.49	.000
Purchase Intention**	2.77	2.31	1.45	.151

*1 = strongly disagree; 2 = disagree; 3 = neutral; 4 = agree; 5 = strongly agree

**"My next car will definitely be a PHEV."

Intentions and education, income, driving pattern

H1 hypothesizes that (a) education, (b) household income and (c) driving pattern impact consumers' purchase intentions. These three hypotheses were tested using independent samples t-tests and ANOVA procedures. Based on three education groups (high, medium and low), the relationship between education level and purchase intention (H1a) is not significant ($F = 0.789$; p-value = .459) and average intentions are rather low (less than 3.0 on a scale from 1 to 5), as shown in Table 8. Thus, H1a is not supported.

Table 8 Purchase Intentions by Education Group

Education Group*	Mean Intention	Standard Deviation	N
Low	2.73	1.42	11
Medium	2.22	1.13	23
High	2.52	1.12	25
Total	2.44	1.18	59

*Low = high school or college diploma; medium = university degree; high = Master's degree or Ph.D.

The relationship between income level and purchase intention (H1b), based on three household income groups (high, medium and low), is not significant (F = 0.351; p-value = .705). Again, note that average intentions are rather low (see Table 9). The data do not support H1b.

Table 9 Purchase Intentions by Income Group

Income Group*	Mean Intention	Standard Deviation	N
Low	2.56	1.04	18
Medium	2.53	1.17	19
High	2.27	1.32	22
Total	2.44	1.18	59

*Low < $60,000; medium = $60,000-$100,000; high > $100,000

The results presented in Tables 8 and 9 are in contrast to the results of Wu et al. (2010), but in concurrence with Sandahl and Robertson (1989).

The relationship between driving pattern and purchase intention (H1c) for the full sample of respondents, based on two driving pattern groups (high and low), is not significant (see Table 10). However, as shown in Table 11, this relationship is significant for the non-expert group. Those who drive fewer kilometers (< 30 km per day) have significantly greater intention to

purchase a PHEV. Perhaps this is attributable to their lack of knowledge—and undue concern about driving range and charging station availability, since PHEVs become more economic with longer daily driving distances.

Table 10 Purchase Intentions by Driving Pattern Group – Full Sample

Items	Driving Group Means*		t stat.	p-value
	High	Low		
Purchase Intention	2.22	2.57	-1.11	.135

*Low: ≤ 30 km. per day; high: > 30 km. per day

Table 11 Purchase Intentions by Driving Pattern Group – Non-expert Group

Items	Driving Group Means*		t stat.	p-value
	High	Low		
Purchase Intention	1.70	2.56	-2.33	.013

*Low: ≤ 30 km. per day; high: > 30 km. per day

For the expert group, the relationship between driving pattern and purchase intention is not significant.

Determinants of intentions (eco-concern, experience, attitudes toward car features)

H2, H3 and H4 are tested using a multiple regression model, with purchase intentions as the dependent variable. H2 argues that greater concern about environmental issues increases the intention to purchase a PHEV. The first item in the questionnaire (see Appendix B) asks survey participants whether they agree with the following statement across five levels (from strongly disagree to strongly agree): "I am very concerned about global warming and the environment." The dependent variable (purchase intention) comes from extent of agreement to the statement: "My next car will definitely be a PHEV."

H3 asserts that consumers' perceived behavioral control (operationalized as experience) will positively influence PHEV adoption. The question in the second section of the questionnaire (see Appendix B) classifies participants into three categories, based on experience with PHEVs. Finally, H4 proposes that greater perceived influence of social-technical factors increases the likelihood of PHEV adoption. The questionnaire includes nine items that indicate the influence of various socio-technical features, measured across 5 levels from very low (1) to very high (5).

Table 12 presents participants' influence ratings of the nine features. Note that driving range and fuel savings are the two most influential features, followed by vehicle price, charging station availability and operating costs. In the middle are reduced GHG emissions and rebates/ incentives. It is interesting that Manitoba currently offers no financial incentives to car drivers who purchase PHEVs. The least influential features are gasoline prices and better parking. It is notable that current gasoline prices remain relatively low compared to prices several years ago. Further, the City of Winnipeg offers little in the way of more convenient parking for PHEV and other electric car drivers.

Table 12 Perceived influence of socio-technical features

Car Feature	Mean rating	Std. deviation	n
Driving range	4.07	0.907	59
Fuel savings	4.07	0.989	58
Vehicle price	3.92	0.970	59
Charging station availability	3.90	1.103	58
Operating costs	3.88	0.993	58
Reduced GHG emissions	3.64	1.270	59
Rebates and incentives	3.63	1.032	59
Gasoline prices	3.37	1.158	59
Better parking	3.03	1.231	59

Principal components analysis is used to explore the association among the nine survey items and to reduce dimensionality into interpretable factors (Ozaki and Sevastyanova, 2011). As shown in Table 13, the Kaiser-Meyer-Olkin measure of sampling adequacy (KMO) is 0.702, which is higher than 0.6; and the p-value of Bartlett's test of sphericity is 0.000. These results indicate that factor analysis is appropriate with this data set (Hair et al., 2010).

Table 13 KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		.702
Bartlett's Test of Sphericity	Approximate Chi-Square	183.72
	d.f.*	36
	p-value	.000

*d.f. = $(v^2 - v)/2 = 36$, where v = number of variables.

The factors were extracted using principal components analysis, and then subjected to Varimax rotation with Kaiser Normalization. A three-factor solution was adopted based on study of the scree plot (see Figure 8) and the eigenvalue $\geq$ 1.0 criterion (see Table 14). Note that the eigenvalue of the third component is .998, which was rounded up to 1.0.

Figure 8 Scree plot

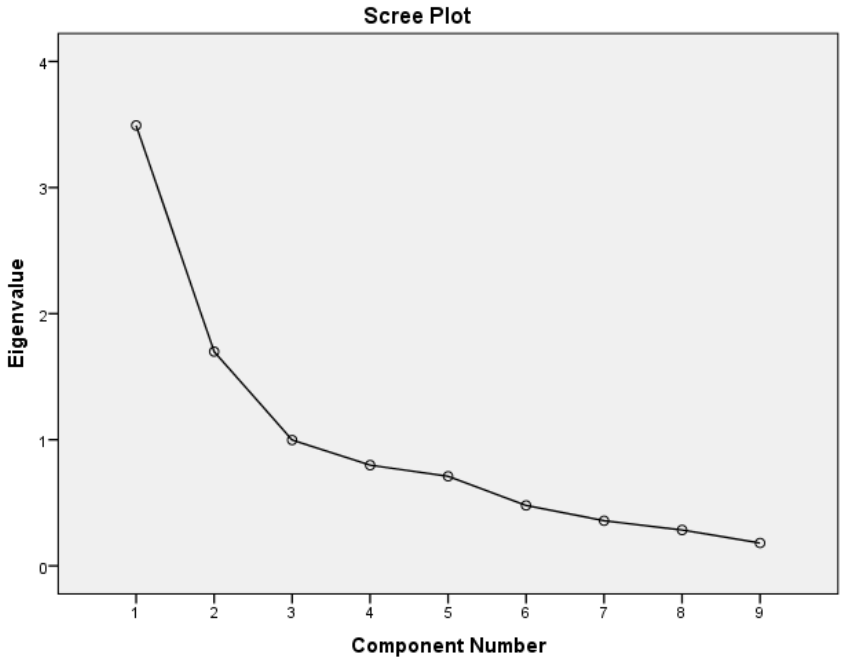


Table 14 Eigenvalues

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.493	38.810	38.810	3.493	38.810	38.810	2.369	26.318	26.318
2	1.699	18.879	57.689	1.699	18.879	57.689	2.042	22.688	49.007
3	.998	11.087	68.776	.998	11.087	68.776	1.779	19.769	68.776
4	.798	8.872	77.648						
5	.710	7.890	85.538						
6	.479	5.322	90.860						
7	.358	3.973	94.833						
8	.284	3.159	97.992						
9	.181	2.008	100.000						

Extraction Method: Principal Component Analysis.

Hair et al. (2010) suggest that factor loadings should be higher than 0.40 to be worthy of consideration. In the current study, only loadings above 0.60 were used to assign variables to factors (see Table 15). After rotation, the three factors (components) were interpreted as follows. Component 1 describes car driver consideration of *economic* attributes, specifically car price, operating costs, rebates and parking. Component 2 represents *environmental* attributes, i.e. fuel savings and reduced GHG emissions. Finally, component 3 can be interpreted as a *convenience*

dimension, including driving range and charging station availability. Note that gas price was the only feature or item not clearly aligned with one of the three factors. Perhaps this is because gas prices are largely determined by global market forces.

Table 15 Classification of car feature variables

Rotated Component Matrix[a]

	Component		
	1	2	3
Car price	.740	.402	-.048
Operating costs	.687	.495	.150
Fuel savings	.257	.872	.162
Reduced GHG e.	.002	.777	-.267
Gas prices	.171	.494	.433
Charging sta. avail.	.275	-.044	.770
Driving range	.053	.010	.884
Rebates/incentives	.788	.130	.242
Better parking	.744	-.097	.190

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 5 iterations.

Table 16 shows the regression results, testing H2, 3 and 4. The three independent variables explain nearly 25% of the variance in purchase intentions, and the overall fit between the data and model is significant (F = 6.597; p-value = .001). H2 is supported by the data, i.e. environmental concern is significantly related to PHEV purchase intentions. Note that the t-statistic (2.878; p-value = .003) is significant at the .05 level of alpha. This result is consistent with McGregor's (2006) finding that environmental concern builds moral consciousness and contributes to "green" behavior. The result also aligns with the findings of Graham-Rowe (2012) and Lieven (2011). They found environmental concern to influence purchase intentions, though such influence may not be as important as certain features of PHEVs.

H3 explores whether the participants' experience with PHEVs affect their purchase intentions. As shown in Table 16, H3 is also supported by the data. As expected, intention to purchase a PHEV increases with experience with these vehicles (t = 2.544; p-value=.007). This confirms the prior findings of Franke and Krems (2013), i.e. that consumers are more satisfied with electric vehicles and have stronger purchase intentions after some direct experience. It can be concluded that experience with PHEVs increases purchase intentions and likelihood of adoption.

Table 16 Regression of Intentions on eco-concern, experience and vehicle features

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	21.723	3	7.241	6.597	.001[b]
	Residual	58.172	53	1.098		
	Total	79.895	56			

a. Dependent Variable: Intention

b. Predictors: (Constant), REGR factor score 1 for analysis 1, Eco-concern, Experience

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	.438	.643		.682	.498		
	Eco-concern	.429	.149	.340	2.878	.006	.982	1.018
	Experience	.572	.225	.305	2.544	.014	.958	1.044
	REGR factor score 1 for analysis 1	.446	.144	.374	3.093	.003	.942	1.062

a. Dependent Variable: Intention

Results of testing H4 are also shown in Table 16. Recall that the nine vehicle feature variables were reduced to three factors using principal components analysis. These three factors were interpreted as economic, environmental and convenience influencers of PHEV perceptions. The environmental and convenience factors were found to be insignificant, and they are not present in the final regression model. Only the economic factor (see Table 15) remains in the

regression equation, having significant influence on purchase intentions (t = 3.093; p-value = .002). Thus, the economic variables appear to trump the influence of energy conservation, emission reduction and convenience, as Winnipeg drivers form PHEV purchase intentions.

Chapter Five: Conclusion

This study provides insight into PHEV purchase intentions. The results show that PHEV purchase intentions are not high in Winnipeg. Participants were asked to indicate their degree of agreement with the following statement: "My next car will definitely be a PHEV," scaled from 1 (strongly disagree) to 5 (strongly agree), with 3 = neutral or (neither agree nor disagree). The average agreement/intention was 2.77/5 for the experts and 2.31/5 for the non-expert group, i.e. on the disagree side of neutral. As expected, compared to the expert group, the non-expert group was significantly less aware of, familiar with, and knowledgeable about PHEVs an d their features.

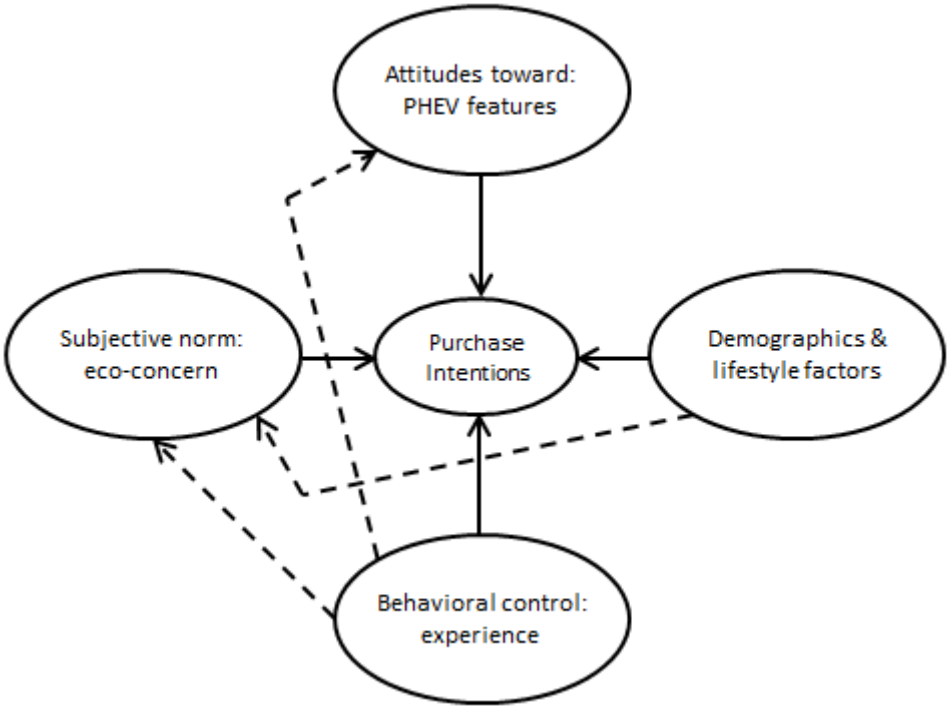
The demographic/lifestyle hypotheses, e.g. that drivers with higher education and income levels have higher PHEV purchase intentions, were not supported by the data. However, other predictors – environmental concern, experience with PHEVs, and perceived influence of certain economic features of PHEVs – were found to have positive impact on purchase intentions.

Recall that the model was essentially a test of the TPB, shown again as Figure 8. Support was found for links between purchase intention and attitudes (influence of economic features of PHEVs), subjective norms (operationalized as environmental concern) and perceived behavioral control (indicated by experience with PHEVs).

Though beyond the scope of the current study, further research is needed to test possible links between experience with PHEVs and both environmental concern (Axsen and Kurani, 2009) and driver attitudes toward PHEV features (Jensen et al., 2013). Another link investigated elsewhere in the literature is between demographics, e.g. education and environmental concern (Söderholm, 2010). Environmental concern may be a mediator in the relationship between

education and purchase intention. A more complete model could be tested with a larger data set, perhaps using structural equation modeling.

Figure 9 Theoretical framework



Practical implications

This research indicates that socio-technical features of PHEVs significantly influence consumers' purchase intention. Features pertaining to economic efficiency seem to be especially influential. Thus, car manufacturers and dealers should focus on vehicle price and operating costs in designing and promoting PHEVs. Secondarily, they should work to improve PHEV design to extend driving range, and decrease fuel consumption and charging time. In addition, the government may have a role in raising general public awareness of PHEVs and their features. PHEVs are promising cars which could replace the conventional cars in the future, reducing fuel consumption and GHG emissions.

This study found only moderate awareness of PHEVs and their features, among a proxy group for the general population in Winnipeg. While the expert group was highly aware (average of 4.5/5), the non-expert group was much less aware (3.34/5). The survey respondents were considerably less knowledgeable about PHEVs (average of 3.85/5 for the experts and 2.46/5 for the non-expert group). There seems to be an opportunity to increase general interest in PHEVs and their share of the car market by facilitating consumer learning about these cars.

Environmental concern was found to be positively related to PHEV purchase intentions. The media play an important role in disseminating information about features of PHEVs such as saving fuel, improving air quality, reducing noise, etc. Television advertisements, magazines and car company websites should transmit messages about electric vehicles, emissions and climate change. Various levels of government should help schools implement environmental education programs. This might encourage students, as future car buyers, to adopt low emission vehicles.

Since consumer experience with PHEVs impacts their opinions of PHEVs, as well as their purchase intentions, car companies could create activities designed to attract individuals to test-drive PHEVs. The government could also encourage car rental companies to offer PHEVs.

Financial incentives could also be offered to promote PHEV adoption. From November 2006 to October 2010, Manitoba offered a $2,000 rebate for the purchase of certain models of electric vehicles (Antweiler and Gulati 2013). Unlike some other provinces, Manitoba currently offers no financial incentives for purchasing a PHEV. Therefore, Manitoba should consider resurrecting tax rebates to reduce effective car purchase price. Recall that Manitoba generates low-cost electricity from largely renewable sources. Therefore, free public battery charging may be an effective and efficient way to attract consumers to PHEVs. Free parking downtown and/or during events such as football games may be another way to promote PHEVs.

Limitation and future study

There are several limitations to this study. The sample may not be representative of the Winnipeg population, in terms of income, education, age and gender. In future research, more people across different age and occupation groups should be surveyed. A special effort to include more female car drivers should be made. The current study results may also not be generalizable to cities other than Winnipeg. Thus, to expand the study Canada-wide, data should be collected from car drivers in Edmonton, Vancouver, Toronto and other Canadian cities. These jurisdictions differ in terms of government incentives offered, low winter temperatures, electricity generation methods, etc.

Design of the questionnaire could also be improved. For instance, differences between PHEVs and other kinds of vehicles (e.g. BEVs and HEVs) could be described more completely. This may have confused participants who are not familiar with various kinds of electric vehicles. In addition, most questions were close-ended, which may not cover all participants' thoughts. Future research might identify participants who have test-driven PHEVs and/or other electric vehicles, then interview them for more detailed comments.

Finally, the current study found an interesting relationship between household income and environmental concern. Both high income (4.00/5) and low income (4.06/5) participants expressed lower environmental concern compared to middle income (4.58/5) participants. Perhaps low income earners are too busy "making ends meet" and high income earners are too busy making money to have a high concern about environment. In a future study, it would be interesting to investigate the reason for this phenomenon.

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Appendices:

Appendix A: Informed Consent

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Faculty of Management

Department of Marketing
448 Drake Centre
181 Freedman Crescent
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Informed Consent

Research Project Title: Analysis of consumers' attitudes towards purchasing (plug-in) hybrid electric vehicles in Winnipeg, Canada.

Principal Investigator and contact information: Xun Jiao; E-mail: jiaox@myumanitoba.ca
Supervisor: Paul D. Larson E-mail: Paul.Larson@umanitoba.ca

Sincerely, you are welcome to participate in this project for Xun Jiao (a master student of the Department of Supply Chain Management of the I.H. Asper School of Business of the University of Manitoba, Canada)'s research. This research aims to collect data for Xun's thesis. Now Xun is working with Paul D. Larson (CN professor).

Recently, environmental problems relate to even every person in the world. So we should make every effort to protect our broken environment. Adopting and using hybrid electric vehicles is a kind of efficient way to protect the environment. This project aims to find consumers attitudes towards purchasing hybrid electric vehicles in order to help improve HEVs adoption. This questionnaire includes three sections. The first section is to know participants' demographic information and travel patterns. Then, this survey is to know the consumers' attitudes towards the benefits and weakness of HEVs. The last part gets access to consumers' willingness to buy these cars.

There are about 18 items in the questionnaire, and participants need less than 15 minutes to finish it. This questionnaire is anonymous and no recording device is irrelevant. This thesis research is a student

Xun Jiao will administrate the questionnaire. The participants will receive a result of this project and they can acknowledge the consumer's perception towards buying HEVs in Winnipeg. I believe this result is a great value for participants to be more familiar with the consumers' attitudes towards purchasing HEVs.

There are no obvious risks to you participants. You can decide by yourselves and you are free withdraw at any time in the procedure. The participants do not need to inform others and can directly withdraw by themselves at any time. All participants will have the option of receiving a summary of research results by e-mail.

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The research results will be disseminated in my master's thesis and in manuscript prepared to publication However your identity might be participants and never be shared without your permission

participants and share with my advisor (Paul D. Larson). Indeed, the results will also be discussed with my thesis committee members.

All the collected data will be analysed and coded by myself only for purpose of thesis. All the collected data will be preserved in my USB and there is no hardcopy of them. Only my advisor and I will have access to the data, which will be destroyed after my graduation, expected..

In the end, if you are willing to complete the questionnaire, please sign and send this consent form back to investigator Xun Jiao.

Your signature on this form indicates that you have understood to your satisfaction the information regarding participation in the research project and agree to participate as a subject. In no way does this waive your legal rights nor release the researchers, sponsors, or involved institutions from their legal and professional responsibilities. You are free to withdraw from the study at any time, and/or refrain from answering any questions you prefer to omit, without prejudice or consequence. Your continued participation should be as informed as your initial consent, so you should feel free to ask for clarification or new information throughout your participation.

The University of Manitoba may look at the research records to see that the research is being done in a safe and proper way.

The Joint-Faculty Research Ethics Board has approved this research. If you have any concerns or complaints about this project you may contact any of the above-named persons or the Human Ethics Coordinator (HEC) at 474-7122. A copy of this consent form has been given to you to keep for your records and reference.

Participant's Signature _____ **Date** _____

Researcher and/or Delegate's Signature _____ **Date** _____

Appendix B: The Questionnaire

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ASPER SCHOOL OF BUSINESS

Click to write the question text

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
I am very concerned about global warming and the environment	○	○	○	○	○
I am aware that PHEVs are available for purchase in Winnipeg	○	○	○	○	○
I am familiar with PHEVs and some of their features	○	○	○	○	○
I am knowledgeable about PHEVs and all of their features	○	○	○	○	○
My next car will definitely be a PHEV	○	○	○	○	○

Please describe your experience driving PHEVs (check all that apply)

I have no such experience	I have test-driven/rented a PHEV	I own a PHEV

Imagine you are shopping for your next car.Rate the influence of the following factors on your intention to buy a PHEV

	Very low	Low	Moderate	High	Very high
Car purchase price (sticker price)	○	○	○	○	○
Vehicle operating costs (maintenance, insurance fuel etc)	○	○	○	○	○
Fuel savings	○	○	○	○	○
Reduced GHG emissions	○	○	○	○	○
Gasoline prices	○	○	○	○	○
Charging station availability	○	○	○	○	○
Maximum driving range between charges	○	○	○	○	○
Tax rebates or government cash incentives	○	○	○	○	○
Free or more convenient parking	○	○	○	○	○

Please list any other factors that would influence your intention to purchase a PHEV

What is your gender

- Male
- Female

How old are you in years?

- 18-24
- 25-34
- 35-44
- 45-54
- 55-64
- 65+

What is your highest educational level?

- High school
- College diploma
- University degree
- Master's degree
- Ph.D.
- Other

Please estimate your annual household income

- less than $40,000
- $40,000-49,999
- $50,000-59,999
- $60,000-79,999
- $80,000-99,999
- $100,000-124,999
- $125,000-149,999
- $150,000 or more

How many kilometers do you drive your car during a typical day?

- 0-10km/day (0-3,999km/year)
- 11-20km/day (4,000-6,999 km/year)
- 21-30km/day(7,000-9,999km/year)
- 31-40km/day(10,000-14,999km/year)
- 41-50km/day(15,000-17,999km/year)
- more than 50km/day (over 18,000km/year)